Malocclusion
Causes, Complications and Treatment

Mohammad Khursheed Alam
Irfan Qamruddin
Kathiravan Purmal
Editors
DENTISTRY AND ORAL SCIENCES

MALOCCLUSION

CAUSES, COMPLICATIONS
AND TREATMENT
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MALOCCLUSION

CAUSES, COMPLICATIONS AND TREATMENT

MOHAMMAD KHURSHEED ALAM
IRFAN QAMRUDDIN
AND
KATHIRAVAN PURMAL
EDITORS
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Most people have some degree of malocclusion. Malocclusions have a strong hereditary component as an etiologic factor, both in families and in ethnic and racial groups. This phenotype can be recognized at an early age and becomes progressively more evident with growth, appearing as one of the main factors that force patients to seek orthodontic treatment. The goal of orthodontic treatment is not only ensuring the alignment of the teeth, jaw relationship, function and aesthetic but also improving self-esteem and quality of life. This e-book about orthodontics will describe such information and knowledge concerning malocclusion in a logical way that can generate better knowledge regarding the treatment effectiveness of malocclusion, facilitate assessment and provide the momentum needed for a sustained upgrade in the standards of care of patients in daily orthodontics.

The authors of this book have worked hard to manifest their ideas scientifically. Reading the works of all of these authors has been educating and has exposed the depth of their understanding and abilities. Though this book is anticipated for general dental practitioners and undergraduate students in the field, it will also act as a convenient compendium for postgraduates as well.

There may be errors of omission and commission. Any comments and suggestions for improvement are cordially welcome.
Chapter 1

MALOCCLUSION: AN INTEGRAL PART OF ORTHODONTIC LEARNING

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ABSTRACT

The relationship of maxillary and mandibular teeth in functional contact during mandibular movement is called occlusion. Occlusion comprises the entire knowledge of the interrelationship between the teeth, periodontal tissues, bones, joints and muscles during the complete mandibular movements as well as the normal functional movements. The study of occlusion is important for the appropriate understanding, and for attaining the objectives of orthodontic treatment.

The purpose of this chapter is to present the concepts of malocclusion and relationships of the teeth to be existent for an occlusion

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to be known normal, as well as help in achieving a functional occlusion. The establishment of a functional occlusion is one of the primary aims of the orthodontics.

**HISTORY**

Crowded, spaced, irregular, protruding and retroclined teeth have been a problem for many individuals since ancient times, and challenges to overcome this disorder go back at least to 1000 BC. Various orthodontic appliances have been found in both Greek and Etruscan materials. With the development of dentistry in the eighteenth and nineteenth centuries, various devices were introduced for aligning teeth and apparently used sporadically by the dentists of that era.

After 1850, Kingsley’s on oral Deformities became famous for describing orthodontics appeared. He had great impact on American dentistry in the latter half of the nineteenth century by using extra oral force to correct protruding teeth. He was also an inventor (of devices used) in the treatment of cleft palate and related problems.

Despite the contributions of Kingsley, their importance in orthodontics endured the alignment of the teeth and the improvement of facial proportions. Minimum consideration was given to the dental occlusion, and meanwhile it was common practice to extract teeth for many dental problems, extractions for crowding or malalignment were infrequent. In an era when an intact dentition was a scarcity, the details of occlusal relationships were considered unimportant.

To make good prosthetic replacement teeth, it was essential to develop an idea of occlusion, and this occurred in the late 1800s. As the ideas of prosthetic occlusion established and were refined, it was natural to outspread this to the natural dentition. Edward H. Angle, whose inspiration began to be felt about 1890, can be attributed with much of the development of a concept of occlusion in the natural dentition. Angle’s original concentration was in prosthodontics, and he taught in that department in the dental schools at Pennsylvania and Minnesota in the
1880s. His increasing attention in dental occlusion and in the treatment required to obtain normal occlusion led directly to his development of orthodontics as a specialty, with himself as the “father of modern orthodontics.”

In 1980s, Angle’s classification of malocclusion made a good impact in the development of orthodontics because it not only classified the major types of malocclusion but also comprised the first clear and simple definition of normal occlusion in the natural dentition.

The word malocclusion refers to the misalignment of teeth and/or an improper relation between the teeth of the maxilla and mandible [6]. Father of modern orthodontics, Edward H. Angle, was the first to classify malocclusions based on the first permanent molar relationship in 1980s [1]. According to Angle, when the mesiobuccal cusp of the maxillary first molar occludes with the mesiobuccal groove of the mandibular first molar is considered as normal occlusion (Figure 1). Any variation from this will caused in different types of malocclusion [6]. Severely misaligned, uneven, and maloccluded teeth may cause many problems for people. They can cause difficulties with oral function (e.g., swallowing, speech, chewing) [8], increased risk for oral disease and less appealing facial aesthetics, increased risk of trauma [7], tooth decay [4], and periodontal disease [9]. Even though some negligible malocclusions might be an aesthetic apprehension, this may have a tough psychosocial effect on the individual, including altered self-esteem, social and interaction responses, and increased consciousness of people’s observations [3]. Malocclusions can also affect the oral function including the temporomandibular joint complex, speech modifications, adaptive functions of swallowing, muscle fatigue and mastication inefficiency. While the tongue, lips, and masticatory complex are adaptive in nature, severe malocclusions can present extreme circumstances where these structures cannot be recompensed. Finally, malocclusions can upsurge the individual’s risk for disease. Protrusion of the upper jaw and retrusion of the lower jaw can intensify the risk for trauma to the maxillary incisors [7]. Oral hygiene and plaque control can be changed due to misalignment and crowding of the dentition, which can increase the risk for periodontal disease and caries [4].
According to Angle, malocclusion can be classified in 3 types:

1. **Class I malocclusion**: Class I malocclusion may be defined as when a normal molar relationship exists but there is crowding, misalignment of the teeth, crossbites etc (Figure 2).
2. **Class II malocclusion**: When the mesiobuccal cusp of upper permanent first molar is placed mesial to the Class I relation then it called Class II malocclusion.
3. **Class III malocclusion**: A malocclusion when the buccal groove of the mandibular first permanent molar is mesially positioned to the mesiobuccal cusp of the maxillary first molar, it is called Class III malocclusion (Figure 5).

Class II malocclusion subdivided into Class II Division 1 and Class II Division 2.

1. **Class II division 1**: Condition when Class II molar relationship is present with proclined upper central incisors is called Class II Division 1 (Figure 3).
2. **Class II division 2**: Condition with same molar relation with retroclined upper central incisors is called Class II Division 2 malocclusion (Figure 4).

![Figure 1. Normal occlusion (Photo adopted from web).](image-url)
Figure 2. Class I malocclusion (Photo adopted from web).

Figure 3. Class II Division 1 (Photo adopted from web).

Figure 4. Class II Division 2 (Photo adopted from web).
Angle’s classification of malocclusion was standard for classifying occlusion, however, there were some deficiencies in the Angle system [2]. One of the most severe shortcomings was the fact that Angle’s methods did not identify the relationship of teeth to the facial profile neither did they evaluate the wide differences in the character of definite malocclusions which have the same distomesial occlusion of the buccal teeth. Additionally, although malocclusion is a three-dimensional problem, in the Angle’s system only anteroposterior (Sagittal) deviations were taken into consideration and that it does not explain the possibility of arch-length problems as well as to indicate the complexity of the problem, and it did not include a diagnosis. Regardless of limitations, Angle’s classification is still reliable, applicable and widely used in worldwide. Due to the definite drawbacks in Angle’s classification, occlusal indices were often settled to extend this method and to standardize the standards through which judgments are made in the profession, and allow individuals with the greatest need to be consigned priority.

To minimize the limitations of Angle’s classification, British incisor classification was established in 1992. According to British classification malocclusion can be classified in following ways [10] (Figure 6):

- **Class I malocclusion**: The lower incisal edges occlude with or lie immediately below the cingulum of the upper incisors.
• **Class II division 1:** The lower incisal edge occludes behind the cingulum of the upper central incisors and the upper incisors are proclined.
• **Class II division 2:** The lower incisal edge occludes behind the cingulum of the upper central incisors, and the upper incisors are retroclined (the lateral incisors may be proclined).
• **Class III malocclusion:** The lower incisal edge occludes in front of the cingulum of the upper incisors.

Detailed aesthetic judgments can only be made by viewing the patients from front, in conversation, using facial expressions and smiling.

**Evaluation of facial and Dental appearance:**

• Face in three planes of space (Macro aesthetics)
• Smile frame work (Mini aesthetics)
• The Teeth (Micro aesthetics)

![Figure 6. British standard incisor classification of malocclusion (Photo adopted from web).](image)
Macro aesthetics composed of:

- Asymmetry
- Excessive or deficient face height
- Imbalance in the facial profile

Mini aesthetics composed of:

- Gingival display on smile
- Anterior tooth display
- Gingival height
- Buccal corridor

Micro aesthetics composed of:

- Crown length of upper and lower incisors
- Incisal edge contour
- Midline

Symmetry is assessed on the frontal exposure of the face and should be studied through photographs. First divide the face into 2 halves tracing from center of the glabella. Equidistant to both medial canthi and perpendicular to the bipupillary plane (Figure 7).

For the sake of analyzing symmetry in depth, the face is divided into fifths, this is called the rule of fifths. In this case tracing lines parallel to the midline go through medial and lateral canthi and most lateral points at the level of the parietal bones. The nasal width measure from ala to ala, involves the central fifth, thus it is equal to the inter canthal distance. The lip width is measured from commissure to commissure and equal the distance between the medial limbi of the eyes (Figure 8).
Figure 7. Assessment of symmetry (Photo adopted from web).

Figure 8. Assessment of symmetry (Photo adopted from web).
The position of the teeth is determined mostly by underlying skeletal and the soft tissue pattern. The purpose of extra oral examination is to assess their relative influence in the etiology of a malocclusion and the degree to which they can be corrected by treatment [5].

**Skeletal Pattern**

The patient should be comfortably seated in upright position. Tilting of the head upwards or downwards can mislead the examination. Therefore, it should be confirmed that the patient is in correct positioned so that his or her Frankfort plane (uppermost aspect of the external auditory canal to the lowermost aspect of the orbital margin) is horizontal. The teeth should be together in maximum inter digitation.

The skeletal pattern should be assessed in all three planes of space:

**Anteroposterior**

The patient should be viewed from the side and the relative position of the maxilla and mandible assessed (Figure 9). It is important to take at the region of the dental base rather than the lips, as position can be influenced by proclination or retroclination of the incisors. The following classification of skeletal pattern is universally recognized:

- **Class I**: the mandible is 2-3 mm posterior to maxilla
- **Class II**: the mandible is retruded relative to the maxilla
- **Class III**: the mandible is protruded relative to the maxilla

It is important to note that this classification only gives the position of the mandible and the maxilla relative to each other and does not indicate where the discrepancy lies. A lateral cephalometric radiograph is required for further assessment of the skeletal pattern.
Vertical

For vertical examination, the patient is viewed from the side. The vertical assessment comprises two separate evaluations.

- Facial height (Figure 10): the distance from the eyebrow to the base of the nose should equal the distance from the base of the nose to the lowermost point on the chin.
- Frankfort mandibular planes angle (FMPA) (Figure 11): Assessment of the FMPA is helpful to assess this angle by placing one hand level with the Frankfort plane (external auditory meatus to the lower border of the orbital margin) and the other hand level with the lower border of the mandible. This angle between these two planes is around the average of 28°, then the lines would intersect approximately at the back of the head. The lines would meet before the back of the head if the FMPA is increased, and reduced if they would cross beyond.

Figure 9. Assessment of anterior posterior skeletal pattern (Photo adopted from web).
Transverse

For transverse assessment, the patient should be viewed anteriorly and, if an asymmetry is noted, also examined by looking down on the face from
above. The extent of the asymmetry and whether only the lower facial third or the maxilla or orbits are involved should be recorded. This assessment should be done by asking the patient to bite onto a tongue spatula and observe whether the occlusal plane follows the asymmetry and goes down to one side to another (Figure 12).

![Figure 12. Transverse assessment (Photo adopted from web).](image)

**SOFT TISSUE**

Assessment of the soft tissues should be checked as soon as the patient enters for the orthodontic treatment to be able to observe normal function. The following should be considered:

**Lip**

*Competent/Incompetent*

When the lips are able to maintain a lip seal together it is called competent lip. On the other hand, lip incompetence is an inability to maintain a lip seal, closed mouth posture at rest and showing strain in the muscles around the face when a lip seal is attempted. Lip incompetence
can result in changes in facial development, tooth eruption and alignment, breathing, swallowing and jaw joint function (Figure 13).

- The form, tonicity, and fullness of the lips. e.g: full or thin, hyperactive, or with little tone
- Lower lip position relative to the upper incisors
- The smile aesthetics

**An Aesthetic Smile**

An aesthetic smile is considered to show the following features:

- The whole height of the upper incisors with only the interproximal gingivae visible
- The upper incisors do not touch the lower lip
- The upper incisor edges run parallel to the lower lip
- The width of the smile displays at least the upper first premolars (Figure 14)

![Figure 13. Lip position a) Competent Lip and b) Incompetent lip (Photo adopted from web).](image)

![Figure 14. Aesthetic smile (Photo adopted from web).](image)
Tongue

**Tongue Thrust**

Tongue thrusts are usually adaptive, i.e., the tongue is placed forward between the teeth to help achieve an anterior oral seal during swallowing. Rarely, patients are encountered who appear to have a habit of pushing their tongue between the upper and lower incisors when swallowing; this is described as an endogenous or primary tongue thrust. The significant difference between the two is that an adaptive tongue thrust will cease following treatment when a lip-to-lip contact can be achieved, whereas an endogenous tongue thrust will not and this often leads to relapse (Figure 15).

![Figure 15. Tongue thrusts (Photo adopted from web).](image)

For any orthodontic treatment, proper assessment along with the knowledge of types and cause of malocclusion is mandatory. These classifications also need to be discussed with the patients during treatment for getting proper satisfaction from the patients after finishing the orthodontic treatment.

**REFERENCES**


Chapter 2

GLOBAL PREVALENCE OF MALOCCLUSION

Sanjida Haque¹, Shifat A Nowrin¹, Fazal Shahid¹ and Mohammad Khursheed Alam², PhD

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ABSTRACT

Most people have some degree of malocclusion. The mesio-buccal cusp of the maxillary first molar is aligned with the buccal groove of the mandibular first molar with normal overjet, overbite and the midline coincide is considered as ideal occlusion. An appreciable deviation from ideal occlusion is called malocclusion. A malocclusion is a misalignment of teeth and/or incorrect relation between the teeth of the upper and lower dental arches. Malocclusion is usually an inherited condition. This means that it can be passed down from one generation to the next. There are three major classes of malocclusion: Class I, Class II and Class III malocclusion. When normal molar relationships exist but there is a
presence of crowding, misalignment of the teeth, crossbite, etc. is defined as Class I malocclusion. Class II malocclusion subdivided into Class II Division 1 and Class II Division 2. When the mesiobuccal cusp of upper permanent first molar is placed mesial to the Class I relation then it called Class II malocclusion. Condition when Class II molar relationship is present with proclined upper central incisors is called Class II Division 1 and same molar relation with retroclined upper central incisors is called Class II Division 2 malocclusion. A malocclusion where the molar relationship shows the buccal groove of the mandibular first molar mesially positioned to the mesiobuccal cusp of the maxillary first molar when the teeth are in occlusion is called Class III malocclusion. Malocclusions have a strong hereditary component as etiologic factor, both in families and in ethnic and racial groups. This phenotype can be recognized at an early age and becomes progressively more evident with growth, appearing as one of the main factors that force patients to seek orthodontic treatment.

All over the world, occurrence of different kind of malocclusion varies between races and ethnic background. After ethnic background showed different prevalence rate in different malocclusions.

The purpose of this chapter is to elaborate the global prevalence of malocclusion. This chapter will give the readers an overview of malocclusion and the global variations of malocclusion. During treatment of different malocclusions the reading should be kept in consideration separately as it varies with the ethnic background.

**BACKGROUND**

Any abnormal relationships among the teeth considered as malocclusion which is common problem in oral cavity along with caries and gingivitis. The high prevalence of malocclusion is a public health problem which varies according to race, ethnicity, sex and malocclusion type. A knowledge of prevalence and severity of malocclusion helps the dentist especially orthodontist by giving information about the possibility of these problems and better serve the needs of those who suffer from malocclusion. Numerous studies have been carried out on prevalence of malocclusion worldwide. Majority of them, stated that the prevalence of malocclusion is from 20% to 80% and this wide range is due to differences in ethnic groups, age groups, and registration procedure. Moreover, the worldwide prevalence rate reported a low prevalence of Class III
malocclusion and a higher prevalence of Class I malocclusion, whereas prevalence rates of Class II malocclusion lie in the middle.

**Prevalence of Malocclusion in Asia**

Several studies have been conducted on prevalence of malocclusion in several countries of Asia and the results differ from one country to another. A study conducted in Korea with 8989 subjects found 61% had some degree of malocclusion. Among them, the prevalence of Class I, Class II, and Class III malocclusion was 45.7%, 7.6% and 7.9% respectively. They found class III is more frequent compared to class II malocclusion. Similar findings were also reported by Kang and Ryu in another study on Korean population. They found prevalence of Class I, Class II div. 1, Class II div. 2 and Class III was 61.6%, 11.3%, 1.9% and 16.7% respectively. Both studies did not get any sex predilection.

Rahman MM et al. surveyed 400 Bangladeshi subjects and found 61.53% had Class I, 30.76% had class II and 7.17% had Class III malocclusion which indicates class I malocclusion had the highest prevalent whereas class III had the least prevalence. There are several studies conducted on Indian population from different states. Most of the studies showed the same findings like Bangladeshi population, which means class I malocclusion are the most frequent and class III malocclusion are least frequent. On the other hand, Sakrani et al. evaluated the prevalence of malocclusion in Pakistani population and found highest 70% of the subjects had class II div I malocclusion and only 2% had class III malocclusion. A multi population study conducted among the Asian males including Malay, Indian and Chinese ethnic groups showed Malay and Chinese ethnic group having a higher prevalence of class III malocclusion whereas Indian male adults showed higher prevalence of class II div I malocclusion with increased overjet. In another study authors found Singaporean Chinese and Hong Kong Chinese were also more prone to class III malocclusion compare to the class II malocclusion. Komazaki Y et al. reported the same findings for the Japanese population.
Table 1. Prevalence of malocclusion in Asian population

<table>
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<tr>
<th>Author</th>
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<th>Population</th>
<th>Total sample</th>
<th>Prevalence of malocclusion</th>
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<td>2005</td>
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<td>339</td>
<td>Class I - 48.1%</td>
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<td>Class II Div 1 - 26.3%</td>
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<td>Class II Div 2 - 3.2%</td>
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<td>Class III - 22.4%</td>
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<td>Rahman MM et al.</td>
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<td>Bangladeshi</td>
<td>400</td>
<td>Class I - 61.53%</td>
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<td>Class II Div 1 - 22.56%</td>
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<td>Class II Div 2 - 8.2%</td>
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<td>Class II Div 1 -18.5%</td>
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<td>Class II Div 2 - 7.5%</td>
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<td>Class II Div 1 - 11.3%</td>
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<td>Class II Div 2 -1.9%</td>
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<td>Kharbanda OP et al.</td>
<td>1995</td>
<td>Indian</td>
<td>273</td>
<td>Class I - 27.7%</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Class II - 14.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class III - 3.4%</td>
</tr>
<tr>
<td>Mohanty et al.</td>
<td>2016</td>
<td>Indian</td>
<td>1207</td>
<td>Class I - 77.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 20.88%</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Class III - 1.82%</td>
</tr>
<tr>
<td>Tang EL</td>
<td>1994</td>
<td>Hong Kong Chinese</td>
<td>201</td>
<td>Class I - 63.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 16.4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class III - 19.9%</td>
</tr>
<tr>
<td>Sakrani et al.</td>
<td>2010</td>
<td>Pakistani</td>
<td>324</td>
<td>Class I - 22%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II Div 1 - 70%</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>Class II Div 2 - 6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class III - 2%</td>
</tr>
</tbody>
</table>
However, prevalence of class I, class II and class III malocclusion fluctuate from 44-48%, 30-32% and 4-16% respectively in Nepalese people. However, Chinese and Malaysian populations have higher prevalence of class III malocclusion whereas Indian populations have least prevalence compared to other Asian people. Table 1 shows prevalence of malocclusion in different countries of Asia.

**Prevalence of Malocclusion in Middle East**

In recent years, markedly increasing consciousness about aesthetics probably due to socioeconomic influences, cultural circumstances, and for improvement of self-esteem more patients are seeking orthodontic treatment in all over world. Therefore, health-care planners are required to survey and collect the epidemiological data of prevalence of different types of malocclusion in various population groups to help plan for proper treatment. A number of studies have been published on different countries of Middle East and the rate varies from group to group, state to state and country to country. Meer et al. and Albarakati and Taher evaluated the prevalence of malocclusion of male and female subjects of Saudi Arabia in two different research respectively and reported 62.3% and 73.9% of subjects had class I malocclusion which is the highest prevalence.

It is noted that Class I malocclusion is the most prevalent malocclusion in any population.
Table 2. Prevalence of malocclusion in Middle East

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Population</th>
<th>Total sample</th>
<th>Prevalence of malocclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sayin and Türkkahraman</td>
<td>2004</td>
<td>Turkish</td>
<td>1356</td>
<td>Class I - 64%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II Div 1 - 19%</td>
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<td></td>
<td>Class II Div 2 - 5%</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>Class III - 12%</td>
</tr>
<tr>
<td>Gelgör et al.</td>
<td>2007</td>
<td>Turkish</td>
<td>2329</td>
<td>Class I - 34.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II Div 1 - 40%</td>
</tr>
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<td></td>
<td>Class II Div 2 - 4.7%</td>
</tr>
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<td></td>
<td></td>
<td>Class III - 10.3%</td>
</tr>
<tr>
<td>Uslu et al.</td>
<td>2007</td>
<td>Turkish</td>
<td>900</td>
<td>Class I - 39.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II Div 1 - 36.1%</td>
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<td></td>
<td>Class II Div 2 - 5.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class III - 18.4%</td>
</tr>
<tr>
<td>Borzabadi-Farahani et al.</td>
<td>2009</td>
<td>Urban Iranian</td>
<td>502</td>
<td>Class I - 41.8%</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Class II Div 1 - 24.1%</td>
</tr>
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<td></td>
<td></td>
<td>Class II Div 2 - 3.4%</td>
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<td></td>
<td></td>
<td></td>
<td>Class III - 7.8%</td>
</tr>
<tr>
<td>Akbari et al.</td>
<td>2016</td>
<td>Iranian</td>
<td>28,693</td>
<td>Class I - 54.6%</td>
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<td></td>
<td></td>
<td>Class II - 24.7%</td>
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<td></td>
<td></td>
<td>Class III - 6.01%</td>
</tr>
<tr>
<td>Abu Alhaja et al.</td>
<td>2005</td>
<td>Jordanian</td>
<td>1003</td>
<td>Class II - 18.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class III - 1.4%</td>
</tr>
<tr>
<td>Krzyzov et al.</td>
<td>1974</td>
<td>Israel</td>
<td>538</td>
<td>Class I - 65.2%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II Div 1 - 21.4%</td>
</tr>
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<td></td>
<td></td>
<td>Class II Div 2 - 6.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class III - 2.6%</td>
</tr>
<tr>
<td>Meer et al.</td>
<td>2016</td>
<td>Saudi Arabian (Male)</td>
<td>3408</td>
<td>Class I - 62.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 28.4%</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Class III - 9.3%</td>
</tr>
<tr>
<td>Albarakati and Taher</td>
<td>2010</td>
<td>Saudi Arabian (Female)</td>
<td>330</td>
<td>Class I - 73.9%</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>Class II - 12.7%</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Class III - 13.3%</td>
</tr>
<tr>
<td>Saleh FK</td>
<td>1999</td>
<td>Lebanese</td>
<td>851</td>
<td>Class I - 35.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 19%</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>Class III - 5%</td>
</tr>
<tr>
<td>Elsayed et al.</td>
<td>2016</td>
<td>Egyptian</td>
<td>1936</td>
<td>Class I - 51.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 16.4%</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Class III - 5.9%</td>
</tr>
<tr>
<td>Behbehani et al.</td>
<td>2005</td>
<td>Kuwaitis</td>
<td>1299</td>
<td>Class I - 57.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 31.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class III - 11%</td>
</tr>
<tr>
<td>Atashi MHA</td>
<td>2006</td>
<td>Tabriz</td>
<td>398</td>
<td>Class I - 51%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 21.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class III - 17.1%</td>
</tr>
</tbody>
</table>
On the other hand, male (28.4%) Saudi patients showed high prevalent to class II malocclusion compared to the female (12.7%) patient. In contrast, both male and female showed less prevalent to the Class III malocclusion. In a study Celikoglu et al. reported Saudi population had less class III malocclusion compared to Turkish population. Gelgör IE et al. found in a study that class II division 1 is the most prevalent malocclusion in Turkish people. However, Sayin and Türkkahraman and Uslu O et al. found class I malocclusion is the most prevalent in Turkish population. A study done by Akbari et al. among Iranian children and the results revealed a high prevalence of malocclusion in girls compared to the boys. In another study, prevalence of class II malocclusion of Irani population was similar with white Americans and western Europeans but class III is higher than Caucasians. However, class III malocclusion was found the least prevalent among Israel, Jordan, Egypt and Tabriz people. Table 2 shows prevalence of malocclusion in different countries of Middle East.

**Prevalence of Malocclusion in Africa**

Dacosta surveyed Nigerian people and found a tendency of increasing class III malocclusion with age rather than that of class II malocclusion. The prevalence of malocclusion among Libyan people is 95.6 reported by Bugaighis and Karanth in 2013. 95.4% of malocclusion was also found among people of Morocco. In an epidemiological survey of 2550 subjects carried out to assess the prevalence of malocclusion in Sudan, it was seen that 30.2% subjects had class I malocclusion, 7.5% had Class II malocclusion and 4.3% subjects had Class III malocclusion. Kenyan exhibits high prevalent of class I malocclusion and least prevalent of class II malocclusion. Table 3 shows prevalence of malocclusion in different countries of Africa.
Table 3. Prevalence of malocclusion in Africa

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Population</th>
<th>Total sample</th>
<th>Prevalence of malocclusion</th>
</tr>
</thead>
</table>
| Diagne F et al.         | 1993 | Senegal    | 1708         | Class I - 73.3%  
                           |      |            |                                          | Class II - 12.7%  
                           |      |            |                                          | Class III - 4.4%  |
| Bourzgui et al.         | 2012 | Morocco    | 1000         | Class I - 61.4%  
                           |      |            |                                          | Class II - 24%    
                           |      |            |                                          | Class III - 10%   |
| Dacosta OO              | 1999 | Nigerian   | 1028         | Class I - 84%   
                           |      |            |                                          | Class II - 1.7%   
                           |      |            |                                          | Class III - 2%    |
| Onyeaso CO              | 2004 | Nigerian   | 636          | Class I - 50%   
                           |      |            |                                          | Class II - 14%    
                           |      |            |                                          | Class III - 12%   |
| Bugaighis and Karanth   | 2013 | Libyan     | 900          | Class I - 66.5%  
                           |      |            |                                          | Class II Div 1 - 21.9%  
                           |      |            |                                          | Class II Div 2 - 3.5%  
                           |      |            |                                          | Class III - 3.7%  |
| Omutimba et al.         | 2016 | Kenyan     | 40           | Class I - 70%   
                           |      |            |                                          | Class II Div 1 - 7.5%  
                           |      |            |                                          | Class II Div 2 - 5%  
                           |      |            |                                          | Class III - 5%    |
| Ali GAS                 | 2011 | Sudanese   | 2550         | Class I - 30.2%  
                           |      |            |                                          | Class II - 7.5%    
                           |      |            |                                          | Class III - 4.3%   |
| Ajayi EO                | 2008 | Benin      | 441          | Class I - 80.7%  
                           |      |            |                                          | Class II Div 1 - 1.1%  
                           |      |            |                                          | Class II Div 2 - 0.5%  
                           |      |            |                                          | Class III - 1.8%   |

PREVALENCE OF MALOCCLUSION IN EUROPEAN AND AMERICAN POPULATION

A number of studies have been piloted to determine the prevalence of malocclusion in different countries of Europe and America. In a study done by Ingerval B et al. the prevalence of malocclusion among Swedish was estimated that 80.4% subjects had class I malocclusion, 13.4% had Class II malocclusion and 6.2% subjects had Class III malocclusion.
Table 4. Prevalence of malocclusion in European and American population

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Population</th>
<th>Total sample</th>
<th>Prevalence of malocclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Šidlauskas et al.</td>
<td>2009</td>
<td>Lithuanian</td>
<td>1681</td>
<td>Class I - 68.4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 27.7%</td>
</tr>
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<td></td>
<td>Class III - 2.8%</td>
</tr>
<tr>
<td>Ingerval et al.</td>
<td>1978</td>
<td>Swedish</td>
<td>389</td>
<td>Class I - 80.4%</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Class II Div 1 - 8.1%</td>
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<td></td>
<td></td>
<td>Class II Div 2 - 5.3%</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Class III - 6.2%</td>
</tr>
<tr>
<td>Laganà et al.</td>
<td>2013</td>
<td>Tirana</td>
<td>2617</td>
<td>Class I - 40.4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 29.2%</td>
</tr>
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<td></td>
<td></td>
<td>Class III - 3.2%</td>
</tr>
<tr>
<td>Helm S</td>
<td>1968</td>
<td>Danish</td>
<td>1700</td>
<td>Class I - 58%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 24%</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>Class III - 4%</td>
</tr>
<tr>
<td>Gelmor et al.</td>
<td>2007</td>
<td>Anatolian</td>
<td>2329</td>
<td>Class I - 34.9%</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Class II Div 1 - 40%</td>
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<td></td>
<td>Class II Div 2 - 4.7%</td>
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<td></td>
<td></td>
<td></td>
<td>Class III - 10.3%</td>
</tr>
<tr>
<td>Lauc T</td>
<td>2003</td>
<td>Croatian</td>
<td>224</td>
<td>Class I - 47.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 45.1%</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>Class III - 5.4%</td>
</tr>
<tr>
<td>Silva and Kang</td>
<td>2001</td>
<td>Latino</td>
<td>507</td>
<td>Class I - 62.9%</td>
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<td></td>
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<td></td>
<td></td>
<td>Class II - 21.5%</td>
</tr>
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<td></td>
<td></td>
<td>Class III - 9.1%</td>
</tr>
<tr>
<td>Horowitz HS</td>
<td>1970</td>
<td>White American</td>
<td>718</td>
<td>Class I - 65.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 16.0%</td>
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<td></td>
<td></td>
<td>Class III - 5.5%</td>
</tr>
<tr>
<td>Garner and Butt</td>
<td>1985</td>
<td>Black American</td>
<td>445</td>
<td>Class I - 44.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 16.0%</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>Class III - 8.7%</td>
</tr>
<tr>
<td>Proffit et al.</td>
<td>1998</td>
<td>USA</td>
<td>----</td>
<td>Class I - 50-55%</td>
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<td></td>
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<td></td>
<td></td>
<td>Class II - 15%</td>
</tr>
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<td></td>
<td></td>
<td>Class III - &lt;1%</td>
</tr>
<tr>
<td>Emrich et al.</td>
<td>1964</td>
<td>Caucasian</td>
<td>1000</td>
<td>Class I - 42%</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>Class II - 4.3%</td>
</tr>
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<td></td>
<td></td>
<td>Class III - 2.4%</td>
</tr>
<tr>
<td>By Grando</td>
<td>2008</td>
<td>Brazilian</td>
<td>926</td>
<td>Class I - 55.4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 21.7%</td>
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<td></td>
<td></td>
<td>Class III - 11.3%</td>
</tr>
<tr>
<td>Bittencourt and Machado</td>
<td>2010</td>
<td>Brazilian</td>
<td>4776</td>
<td>Class I - 57.24%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class II - 21.73%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class III - 6.2%</td>
</tr>
</tbody>
</table>
In an epidemiological survey of 1681 subjects carried out to assess the prevalence of malocclusion in Lithuania, it was seen that 68.4% subjects had class I malocclusion, 27.7% had Class II malocclusion and 2.8% subjects had Class III malocclusion. The prevalence of malocclusion among Danish people is 72.8% as reported by Helm. Gelgör et al. surveyed among 2329 Anatolian subjects in 2007 and estimated the prevalence of Class I malocclusion was 34.9%, Class II div I was 40%, Class II div II was 4.7% and Class III was 10.3%. Croatian population exhibits high prevalence of class II malocclusion. Another epidemiological study was carried out among Latino and found 62.9% subjects had class I malocclusion, 21.5% had Class II malocclusion and 9.1% subjects had Class III malocclusion. Proffit et al. determined prevalence of malocclusion in USA and found <1% had class III malocclusion. Class III malocclusion was also least prevalent among Caucasians. Another study done by Bittencourt and Machado among Brazilian in 2010 and total prevalence of malocclusion was 85.17%. Table 4 shows prevalence of malocclusion in different countries of Europe and America.

REFERENCES


ETIOLOGY OF MALOCCLUSION

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¹Orthodontic Unit, School of Dental Science, Universiti Sains Malaysia, Kota Bharu, Kelantan, Malaysia
²Orthodontic Department, College of Dentistry, Al Jouf University, Sakaka, Kingdom of Saudi Arabia

ABSTRACT

A significant deviation from normal or ‘ideal occlusion’ is defined as malocclusion. Though malocclusion is not a life threatening problem, it influences an individual’s psychology as well as self-esteem. The World Health Organization (1987) classified malocclusion under the heading of a “Handicapping Dento Facial Anomaly.” And according to WHO, malocclusion is defined as “the disfigurement or functional defect” that “was likely to be an obstacle to the patient’s physical or emotional well-being.” Etiology of malocclusion is multifactorial in nature. Both genetic and environmental factors as well as local factors are thought to be responsible for this phenomenon. It is essential to understand completely the development and etiology of malocclusion for proper treatment planning and for a successful treatment outcome.

A number of classifications of etiology of malocclusion have been established for better understanding and effectively addressing the causes. This chapter will describe the etiology of malocclusion that will help to
generate better knowledge for treatment effectiveness of malocclusion and also will upgrade the standard of care for patients in daily orthodontics.

**Keywords**: Malocclusion, Causes, Dental anomalies, Genetic factors, Local factors

### INTRODUCTION

A significant deviation from normal or “ideal occlusion” is defined as malocclusion. The most important components that are comprised in the development of occlusion are:

**Skeletal Factors**

- The size of maxillae.
- The size of mandible (both ramus and body).
- The relationship between two skeletal bases (cranial base, environmental factor).
- The arch form.

**Dental Factors**

- The size and morphology of the teeth.
- The number of teeth present.

**Soft Tissues**

- The soft tissue morphology and behavior of lips, tongue and perioral musculature.
If any of these components alter from their normal state, it may lead to malocclusion. This alteration can occur due to a number of possible causes. The etiology of malocclusion is either by genetic factors or by environmental factors. A number of classifications of etiology of malocclusion have been established, which helps the clinician to make a proper treatment plan that effectively addresses the causes. The classifications that are established for etiology of malocclusion are:

- Moyer’s classification.
- White and Gardiner’s classification.
- Salzmann’s classification.
- Graber’s classification.

**CLASSIFICATIONS OF ETIOLOGY OF MALOCCLUSION**

**Table 1. Moyer’s Classification**

<table>
<thead>
<tr>
<th>1. Heredity</th>
<th>a) Neuromuscular system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b) Bone</td>
</tr>
<tr>
<td></td>
<td>c) Teeth</td>
</tr>
<tr>
<td></td>
<td>d) Soft parts</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Developmental defects of unknown origin</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>3. Trauma</th>
<th>a) Prenatal trauma and birth injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b) Postnatal trauma</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Physical agents</th>
<th>a) Premature extraction of primary teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b) Nature of food</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Habits</th>
<th>a) Thumb sucking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b) Tongue thrusting</td>
</tr>
<tr>
<td></td>
<td>c) Lip sucking and lip biting</td>
</tr>
<tr>
<td></td>
<td>d) Posture</td>
</tr>
<tr>
<td></td>
<td>e) Nail biting</td>
</tr>
<tr>
<td></td>
<td>f) Other habits</td>
</tr>
</tbody>
</table>
### Table 1. (Continued)

| 6. Diseases | a) Systemic disease  
| | b) Endocrine disease  
| | c) Local disease  
| | • Nasopharyngeal diseases and disturbed respiritory function  
| | • Gingival and periodontal disease  
| | • Tumors  
| | • Carries:  
| | o Premature loss of deciduous teeth.  
| | o Disturbance in sequence of eruption of permanent teeth.  
| | o Early loss of permanent teeth.  

| 7. Malnutrition |

### Table 2. White and Gardiner’s Classification

| 1) Dental base abnormalities | a) Anterior-posterior malrelationship  
| | b) Vertical malrelationship  
| | c) Lateral malrelationship  
| | d) Disproportion of size between teeth and basal bone  
| | e) Congenital abnormalities  

| 2) Pre-eruption abnormalities | a) Abnormalities in position of developing tooth germ  
| | b) Missing teeth  
| | c) Supernumerary teeth and teeth abnormal in form  
| | d) Prolonged retention of deciduous teeth  
| | e) Large labial frenum  
| | f) Traumatic injury  

| 3) Post-eruption abnormalities | a) Muscular  
| | • Active muscle force  
| | • Rest position of musculature  
| | • Sucking habits  
| | • Abnormalities in path of closure  
| | b) Premature loss of deciduous teeth  
| | c) Extraction of permanent teeth |
Table 3. Salzmann’s Classification

<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategory</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prenatal</td>
<td>Genetic</td>
<td></td>
</tr>
<tr>
<td>1)</td>
<td>Included malocclusions transmitted by genes, where the dentofacial anomalies may or may not be in evidence at birth.</td>
<td></td>
</tr>
<tr>
<td>2)</td>
<td>Differentiating Malocclusions that are inborn, engrafted in the body in the pre functional embryonic developmental stage. Can be subdivided into:</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>General - effect the body as a whole</td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>Local - effect the face, jaws and teeth only</td>
<td></td>
</tr>
<tr>
<td>3)</td>
<td>Congenital Can be hereditary or acquired but existing at birth. Can be subdivided as:</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>General or constitutional</td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>Local or dentofacial</td>
<td></td>
</tr>
<tr>
<td>Postnatal</td>
<td>Developmental</td>
<td></td>
</tr>
<tr>
<td>4)</td>
<td>a) General</td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>Birth injuries</td>
<td></td>
</tr>
<tr>
<td>ii.</td>
<td>Abnormalities of relative rate of growth in different body organs</td>
<td></td>
</tr>
<tr>
<td>iii.</td>
<td>Hypo- or hypertonicity of muscles which may eventually affect the dentofacial development and function</td>
<td></td>
</tr>
<tr>
<td>iv.</td>
<td>Endocrine disturbance which may modify the growth pattern and eventually affect dentofacial growth</td>
<td></td>
</tr>
<tr>
<td>v.</td>
<td>Nutritional disturbances</td>
<td></td>
</tr>
<tr>
<td>vi.</td>
<td>Childhood diseases that affect the growth pattern</td>
<td></td>
</tr>
<tr>
<td>vii.</td>
<td>Radiation</td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>Local</td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>Abnormalities of dentofacial complex:</td>
<td></td>
</tr>
<tr>
<td>•</td>
<td>Birth injuries of head, face and jaws</td>
<td></td>
</tr>
<tr>
<td>•</td>
<td>Micro- or macroglossia</td>
<td></td>
</tr>
<tr>
<td>•</td>
<td>Micro- or macroglossia</td>
<td></td>
</tr>
<tr>
<td>•</td>
<td>Abnormal frenal attachments</td>
<td></td>
</tr>
<tr>
<td>•</td>
<td>Facial hemiatrophy</td>
<td></td>
</tr>
<tr>
<td>ii.</td>
<td>Abnormalities of tooth development:</td>
<td></td>
</tr>
<tr>
<td>•</td>
<td>Delayed or premature eruption of deciduous and permanent teeth</td>
<td></td>
</tr>
<tr>
<td>•</td>
<td>Delayed or premature shedding of deciduous teeth</td>
<td></td>
</tr>
<tr>
<td>•</td>
<td>Ectopic eruption</td>
<td></td>
</tr>
<tr>
<td>•</td>
<td>Impacted teeth</td>
<td></td>
</tr>
<tr>
<td>•</td>
<td>Aplasia of teeth</td>
<td></td>
</tr>
<tr>
<td>5)</td>
<td>Functional</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>General</td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>Muscular hyper- or hypo tonicity</td>
<td></td>
</tr>
<tr>
<td>ii.</td>
<td>Endocrine disturbances</td>
<td></td>
</tr>
<tr>
<td>iii.</td>
<td>Neurotrophic disturbances</td>
<td></td>
</tr>
<tr>
<td>iv.</td>
<td>Nutritional deficiencies</td>
<td></td>
</tr>
<tr>
<td>v.</td>
<td>Postural defects</td>
<td></td>
</tr>
<tr>
<td>vi.</td>
<td>Respiratory disturbances (mouth breathing)</td>
<td></td>
</tr>
<tr>
<td>6)</td>
<td>Environmental or Acquired</td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>Local</td>
<td></td>
</tr>
<tr>
<td>vii.</td>
<td>Malfunction of forces exerted by inclined planes of cusps of the teeth</td>
<td></td>
</tr>
<tr>
<td>viii.</td>
<td>Loss of forces caused by failure of proximal contact between teeth</td>
<td></td>
</tr>
<tr>
<td>ix.</td>
<td>Temporomandibular articulation disturbances</td>
<td></td>
</tr>
<tr>
<td>x.</td>
<td>Masticatory and facial muscular hypo- or hyperactivity</td>
<td></td>
</tr>
<tr>
<td>xi.</td>
<td>Faculty masticatory functions, especially during the tooth eruption period</td>
<td></td>
</tr>
<tr>
<td>xii.</td>
<td>Trauma from occlusion</td>
<td></td>
</tr>
<tr>
<td>xiii.</td>
<td>Compromised periodontal condition</td>
<td></td>
</tr>
</tbody>
</table>
### Table 4. Graber’s Classification

<table>
<thead>
<tr>
<th>1) General factors</th>
<th>a) Heredity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b) Congenital</td>
</tr>
<tr>
<td></td>
<td>c) Environment:</td>
</tr>
<tr>
<td></td>
<td>i. Prenatal (trauma, maternal diet, German measles, material maternal metabolism, etc)</td>
</tr>
<tr>
<td></td>
<td>ii. Postnatal (birth injury, cerebral palsy, TMJ injury)</td>
</tr>
<tr>
<td></td>
<td>d) Predisposing metabolic climate and diseases:</td>
</tr>
<tr>
<td></td>
<td>iii. Endocrine imbalance</td>
</tr>
<tr>
<td></td>
<td>iv. Metabolic disturbances</td>
</tr>
<tr>
<td></td>
<td>v. Infectious diseases (poliomyelitis, etc.)</td>
</tr>
<tr>
<td></td>
<td>e) Dietary problem</td>
</tr>
<tr>
<td></td>
<td>f) Abnormal pressure habits and functional aberrations:</td>
</tr>
<tr>
<td></td>
<td>vi. Abnormal sucking</td>
</tr>
<tr>
<td></td>
<td>vii. Thumb and figure sucking</td>
</tr>
<tr>
<td></td>
<td>viii. Tongue thrust and tongue sucking</td>
</tr>
<tr>
<td></td>
<td>ix. Lip and nail biting</td>
</tr>
<tr>
<td></td>
<td>x. Abnormal swallowing habits (improper deglutition)</td>
</tr>
<tr>
<td></td>
<td>xi. Speech defects</td>
</tr>
<tr>
<td></td>
<td>xii. Respiratory abnormalities (mouth breathing, etc.)</td>
</tr>
<tr>
<td></td>
<td>xiii. Tonsils and adenoids</td>
</tr>
<tr>
<td></td>
<td>xiv. Psychogenetics and bruxism</td>
</tr>
<tr>
<td></td>
<td>g) Posture</td>
</tr>
<tr>
<td></td>
<td>h) Trauma and accidents</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2) Local factors</th>
<th>a) Anomalies of number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>i. Supernumerary teeth</td>
</tr>
<tr>
<td></td>
<td>ii. Missing teeth (congenital absence or loss due to accidents, caries, etc.)</td>
</tr>
<tr>
<td></td>
<td>b) Abnormalities of tooth size</td>
</tr>
<tr>
<td></td>
<td>c) Abnormalities of tooth shape</td>
</tr>
<tr>
<td></td>
<td>d) Abnormal labial frenum: mucosal barriers</td>
</tr>
<tr>
<td></td>
<td>e) Permanent loss</td>
</tr>
<tr>
<td></td>
<td>f) Prolonged retention</td>
</tr>
<tr>
<td></td>
<td>g) Delayed eruption of permanent teeth</td>
</tr>
<tr>
<td></td>
<td>h) Abnormal eruptive path</td>
</tr>
<tr>
<td></td>
<td>i) Ankylosis</td>
</tr>
<tr>
<td></td>
<td>j) Dental caries</td>
</tr>
<tr>
<td></td>
<td>i) Improper dental restorations</td>
</tr>
</tbody>
</table>
## Etiology of Malocclusion

### Table 5. Profitt’s Classification

| 1) Specific cause | a) Disturbances in embryologic development  
b) Skeletal growth disturbances   
   i. Fetal molding and birth injuries  
   ii. Birth trauma to the mandible  
   iii. Childhood fracture of the jaw  
c) Muscle dysfunction  
d) Acromegaly and hemi-mandibular hypertrophy  
e) Disturbance in dental development   
   i. Congenitally missing teeth  
   ii. Malformed teeth  
   iii. Supernumerary teeth  
   iv. Interference with eruption  
v. Ectopic eruption  
vi. Early loss of primary teeth  
vii. Traumatic displacement of teeth |
|-------------------|--------------------------------------------------------------------------------------------------|
| 2) Genetic influences | a) Equilibrium theory and the development of dental occlusion   
   i. Equilibrium effect on dentition  
   • Tooth contacts during mastication and swallowing  
   • Soft tissue pressure of lip, cheek and swallowing  
   • External pressure like habits and orthodontics  
   • Intrinsic pressures like PDL fibers and gingival fibers  
f) Equilibrium effects of jaw size and shape |
| 3) Environmental influences | a) Equilibrium theory and the development of dental occlusion   
   i. Equilibrium effect on dentition  
   • Tooth contacts during mastication and swallowing  
   • Soft tissue pressure of lip, cheek and swallowing  
   • External pressure like habits and orthodontics  
   • Intrinsic pressures like PDL fibers and gingival fibers  
f) Equilibrium effects of jaw size and shape |
|                     | b) Functional influences on dentofacial development   
   i. Masticatory function  
   • Function and dental arch size  
   • Biting force and eruption  
ii. Sucking and other habits  
iii. Tongue thrusting  
|                     | c) Respiratory pattern |
Orthodontic Equation

Causes → Act at Times → On Tissues → Producing Results

Primary Etiologic Site of Malocclusion

- Neuromuscular system.
- Facial bone.
- Tooth.
- Soft tissue.

LOCAL FACTORS

Abnormalities in the Size and Number of Teeth

Missing or Congenitally Absent Tooth

Congenital absence of a tooth is a common dental development abnormality. One or more teeth may be missing congenitally. This condition is known as hypodontia/oligodontia/anodontia.

- **Hypodontia**: when one or more teeth are missing (less than six teeth).
- **Oligodontia**: when six or more permanent teeth are missing.
- **Anodontia**: when all teeth are missing from the jaw.

The third molar are thought to be the most commonly missing tooth, followed by the maxillary lateral incisors, mandibular second premolars and mandibular incisors. Congenitally missing teeth are more common in the permanent rather than the deciduous dentition. If a deciduous tooth is missing, it will be obvious that there is no tooth germ for the permanent
tooth under the gum of the congenitally missing tooth. Congenitally missing teeth lead to different malocclusions, such as:

- Space between the teeth.
- Tilting/dislocation/axial inclination of adjacent tooth.
- Abnormal swallowing pattern.
- Difficulty in mastication and speech if multiple teeth are missing.

Teeth of Abnormal Size and Shape

Regarding abnormal tooth size, there are only two types of abnormalities;

- Macrodontia.
- Microdontia.

Macrodontia

In this condition, the teeth appear larger than their normal tooth size. Macrodontia can be localized and generalized. When all the teeth are larger than their normal size, it is called truly generalized macrodontia. In this situation, teeth are uniformly large in size. And when teeth are slightly larger and the jaw is smaller than normal, it is referred to as relatively generalized macrodontia. When a single tooth is involved, it is called localized macrodontia. Maxillary lateral incisors and the last molar teeth are commonly affected. In regards to a single tooth, the cause is still unknown, but the hormonal imbalance and pituitary gigantism are the cause of generalized macrodontia. Macrodontia can lead to malocclusion like crowding.

Microdontia

In this condition, the teeth appear smaller than normal tooth size. Microdontia can also be localized and generalized. When all the teeth are smaller than normal size, it is called truly generalized microdontia. In this situation, teeth are uniformly small in size. It is an uncommon condition. When teeth are slightly smaller and the jaw is larger than normal size, it is
referred to as relatively generalized microdontia. When a single tooth is involved, it is called localized microdontia. Permanent teeth are more affected than primary teeth. Microdontia is a common phenomenon in some congenital anomalies like Down syndrome and also several types of ectodermal dysplasia. The cause of microdontia may be due to:

- inherited, acquired or idiopathic;
- hypopituitarism;
- exposure to radiation or chemotherapy during dental development.

Microdontia can lead to:

- misalignment of teeth;
- spacing;
- difficulty in chewing;
- dental caries.

Abnormal size and shape of the teeth are usually interconnected with each other, which results in malocclusion. Some tooth shape anomalies that are commonly observed:

- Peg shaped tooth: Commonly seen in maxillary lateral incisors and leads to spacing and misalignment of adjacent tooth.
- Prominent cingulum on maxillary lateral incisors, which interrupts the normal overbite and overjet.
- True fusion of two adjacent tooth germ give a large single abnormal shaped tooth.
- Germinated tooth which also results in abnormal shaped tooth. When a single tooth germ form two incomplete teeth (twinning).
- Dilacerations, which is an abnormal deviation of the root of a tooth. The cause of dilaceration is probably by traumatic displacement during development of the root. This type of tooth fails to erupt normally, thus leading to malocclusion.
• Concrescence is the abnormal fusion of cementum of adjacent teeth, which also fails to erupt normally and leads to malocclusion.
• Congenital syphilis is often associated with abnormal shaped tooth, i.e., peg shaped laterals and mulberry molars; caused by direct invasion of tooth germs by Treponema organisms.
• Anomalies of shape can happen due to some other developmental defects like hypoplasia, dens in dente, screwdriver incisors, amelogenesis imperfecta and hypercementosis.

**Supernumerary Teeth**

Supernumerary is also hyperdontia. When one or more extra abnormal tooth is present in oral cavity it is termed as supernumerary. Supernumerary teeth do not morphologically appear as normal teeth. If any tooth morphologically appears as a normal tooth, that one called a supplementary tooth. Supernumerary teeth can be found in any region of the oral cavity, but are commonly found in the maxillary midline; they also appear in the premolar and molar region.

The cause of supernumerary teeth is unspecific. Many concepts have been elicited behind their presence in oral cavity. One theory suggests that abnormal division of the tooth causes supernumerary teeth, but another theory states that the hyperactivity of dental lamina is considered to be the cause of this abnormality. When the dental lamina shows hyperactivity then extra abnormal teeth are formed which are known as the supernumerary teeth. Hereditary etiology is also thought to be one of the main cause of supernumerary teeth. Supernumerary teeth is more common in permanent teeth compared to the deciduous teeth. The prevalence of supernumerary tooth is 0.03-0.6% in deciduous teeth and 1.0-3.5% in permanent teeth. 98% of supernumerary tooth form in maxillae and 75% of supernumerary tooth found in anterior region. The incidence of supernumerary teeth is almost equal in males and females in deciduous teeth but it is twice (2:1) in males as compared to the females in permanent teeth. It can be found both unilaterally or bilaterally. It can be also single or multiple. Generally it is single but in some cases like cleft lip and palate, cleidocranial dysplasia or Gardner’s syndrome, multiple supernumerary
teeth exist. The incidence of supernumerary teeth in cleft lip and palate cases is around 22%. While in cleidocranial dysplasia cases it is 22.2% in maxillary region and 5% in molar region.

Table 6. Classification of Supernumerary Teeth Based on its Location and Morphology

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conical Supernumerary Teeth</td>
<td>• Peg shaped; present between the maxillary central incisors; known as the Mesiodens.</td>
</tr>
<tr>
<td></td>
<td>• If remain unerupted cause median diastema.</td>
</tr>
<tr>
<td></td>
<td>• May cause rotation, displacement and uneruption of central incisors.</td>
</tr>
<tr>
<td>Tuberculate Supernumerary Teeth</td>
<td>• Barrel shaped; present palatally to the maxillary central incisors.</td>
</tr>
<tr>
<td></td>
<td>• Larger than conical supernumeraries.</td>
</tr>
<tr>
<td></td>
<td>• Have more than one cusp or tubercle.</td>
</tr>
<tr>
<td></td>
<td>• Often appears as paired and bilateral.</td>
</tr>
<tr>
<td></td>
<td>• Cause the delayed and uneruption of the central incisors.</td>
</tr>
<tr>
<td>Supplemental Supernumerary Teeth</td>
<td>• Replication of teeth in normal series.</td>
</tr>
<tr>
<td></td>
<td>• Common in lateral incisor, molar and premolar region.</td>
</tr>
<tr>
<td></td>
<td>• Common in deciduous teeth.</td>
</tr>
<tr>
<td>Odontoma</td>
<td>• Radio opaque lesions.</td>
</tr>
<tr>
<td></td>
<td>• Two types; complex and compound</td>
</tr>
<tr>
<td></td>
<td>• Complex odontoma is single, diffuse mass of dental tissue that is not organized.</td>
</tr>
<tr>
<td></td>
<td>• Compound odontoma is separate; resembles tooth like anatomical structures.</td>
</tr>
</tbody>
</table>

Supernumerary tooth can lead to:

- Displacement of the adjacent teeth.
- Misalignment of tooth.
- Noneruption of adjacent tooth.
- Delay eruption of adjacent tooth.
- Resorption of roots of adjacent tooth.
- Crowding.
- Unerupted mesiodens causes midline shifting.
- Unerupted supernumerary tooth leads a risk of cyst formation (dentigerous cyst).
Abnormal Labial Frenum

Labial frenum is the tight ligament that attaches the upper lip to the gums. It is a thin mucosal tissue involving the upper lip mucosa to the gingiva between the upper central incisors. The function of labial frenum is providing the stability of upper lip. Abnormal labial frenum may cause several problems including malocclusion.

Table 7. Problems that caused by abnormal labial frenum

1) Dental decay on maxillary incisors.
2) Median diastema.
3) Misalignment of maxillary incisors.
4) Periodontal problem.
5) Poor lip mobility or function. (especially during speaking and smiling)
6) Certain sounds, like ‘s’ cannot be pronounced properly

Premature Loss of Deciduous Tooth

Premature loss of deciduous teeth can be caused due to early resorption of deciduous root, trauma, caries and extraction. Usually premature resorption of root and trauma induced loss occurs on anterior region while loss of posterior teeth occurs mostly by caries and extraction. Early loss of deciduous tooth may cause severe malocclusion. Premature loss of canine is found less than the other tooth, as because the presence of this tooth relatively short than of others.

Table 8. Problems that caused by premature loss of deciduous teeth

1) Early loss of the roots of deciduous incisors and canines lead to crowding.
2) Early loss of deciduous molar lead to the migration of adjacent teeth and to shortage of space for permanent successors.
3) Due to early loss of deciduous tooth, successors may be damaged, abnormal shaped, hypocalcified and caries lesions also can be happened.
4) With the loss of second deciduous molars, the migration is usually limited to mesial displacement of the first permanent molars lead to malocclusion.
5) Loss of deciduous tooth by periapical infection or abscess, the greater possibility of malocclusion of successor.
Prolonged Retention of Deciduous Tooth

Prolonged retention of deciduous tooth is the condition in which the tooth fails to go through resorption. As a result, it will block the path of eruption of successors and lead to malocclusion. Absence of permanent tooth beneath the deciduous tooth is one of common reason of prolonged retention. Beside this, hypothyroidism, ankylosed and non-vital deciduous tooth is also responsible of prolonged retention of deciduous tooth.

Table 9. Problems that associated to prolong retention of deciduous teeth

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interrupts the normal eruption of permanent successor.</td>
</tr>
<tr>
<td>2</td>
<td>Prolonged eruption of anterior tooth resulting palatally or lingually eruption of permanent successor.</td>
</tr>
<tr>
<td>3</td>
<td>Prolonged eruption of buccal tooth resulting buccally or lingually eruption or impacted permanent successor.</td>
</tr>
<tr>
<td>4</td>
<td>Crowding.</td>
</tr>
<tr>
<td>5</td>
<td>Crossbite.</td>
</tr>
<tr>
<td>6</td>
<td>Bone resorption</td>
</tr>
<tr>
<td>7</td>
<td>Periapical pathology.</td>
</tr>
<tr>
<td>8</td>
<td>Gingival recession.</td>
</tr>
</tbody>
</table>

Delayed Eruption of Permanent Teeth

Normal eruption of permanent tooth is essential because it is the process by which a tooth take its ultimate position in the mouth and is also necessary for organization of the growth of face. Deviation from normal eruption of tooth is quite commonly seen by clinicians. It is a major anxiety among the children as well as parents. Delayed eruption of permanent tooth interrupts the developing of normal occlusion as well as causes disturbance in speech, chewing and mastication. After shedding of deciduous tooth, permanent tooth should start erupting within six months; should not exceed beyond twelve months.
Abnormal Eruptive Path

A tooth movement from the developmental site within alveolar process towards the functional position of oral cavity is the normal eruptive way. Sometimes a tooth deviates from its normal path and erupts in the oral cavity in a different way which results malocclusion. Maxillary canine is the most common tooth that erupts on abnormal path. There are several reason behind this phenomenon.

Table 10. Cause of delayed eruption of permanent tooth

| 1) | Absence of permanent tooth congenitally |
| 2) | Unfavorable tongue position. |
| 3) | Digit sucking habit or other teeth. |
| 4) | Tooth adjacent to the bone. |
| 5) | Mucosal barrier. |
| 6) | Early loss of deciduous tooth. |
| 7) | Hereditary. |
| 8) | Supernumerary tooth |
| 9) | Odontomas |
| 10) | Ankylosed deciduous tooth |
| 11) | Endocrine gland disturbances such as hypothyroidism, hypopituitarism, hypoparathyroidism, and pseudohypoparathyroidism. |
| 12) | Tumors |
| 13) | Injuries to deciduous tooth |
| 14) | Excess radiation |
| 15) | Cerebral palsy |
| 16) | Cleft lip and palate |

Table 11. Cause of abnormal eruptive path of tooth

| 1) | Impacted tooth. |
| 2) | Supernumerary tooth. |
| 3) | Arch length deficiency. |
| 4) | Retained root fragments. |
| 5) | Tooth bud that placed or displaced from its proper location. |
| 6) | Presence of tumor, cyst or odontomas. |
Ankylosis

Tooth ankylosis is an abnormality of tooth eruption. It is characterized by compact fixation of a tooth that form a fusion of the root or part of root with bone without any interference periodontal membrane. When ankylosis occurs the affected tooth stops erupting and gets stuck in the same place resulting in malocclusion. Some infectious diseases, endocrine disorder and congenital disorder like cleidocranial dysostosis are associated with the tooth ankylosis. Ankylosis of tooth can lead to:

- Displacement of tooth.
- Crowding.
- Impaction.
- Reduction of space for permanent successor.

Dental Caries

Dental caries is a common complication of malocclusion. It causes:

- Early loss of both deciduous and permanent tooth.
- Displacement of adjacent tooth.
- Reduction of arch length.
- Spacing.

GENERAL FACTORS

Heredity

A trait or character transferred from parents to offspring is known as heredity. Heredity and malocclusion are connected each other. It is not necessary all the malocclusion will appear on birth. Malocclusion may
present at any time of life and influence the neuromuscular system, tooth, bone and soft part of oral cavity.

**Neuromuscular System**

Certain anomalies that are related to the neuromuscular system like abnormal size, position, tonicity of tongue, oral and facial musculature are inherited. Microglossia, macroglossia, ankyloglossia may be acquired by inheritance. Microglossia is defined when tongue appears small in size and in this condition patient faces difficulty in speech and taking food. Larger size of tongue is termed as macroglossia which occurs due to muscular hypertrophy, neoplasm of the tongue, lymphatic obstruction, cretinism, acromegaly etc. Macroglossia leads to the displacement of tooth which finally leads to malocclusion. Ankyslossia also known as tongue tie. In this condition tongue fuses to the floor of the mouth. It can be partial and complete and occurs due to a short lingual frenum.

**Tooth**

A number of anomalies of tooth are found in oral cavity which are acquired hereditarily. Such as:

- Microdontia.
- Macrodontia.
- Hypodontia.
- Hyperdontia.
- Supernumerary tooth.
- Crowding
- Overjet and overbite.
- Germination.
- Fusion.
• Twining.
• Dilacerations.

Bone

Certain anomalies of skeletal structure of face (basal bone, craniofacial structures) are partially or completely inherited. Defects of jaw like micrognathia, macrognathia, facial hemi hypertrophy, facial hemi atrophy may be inherited. But the most common malocclusion that is strongly associated with familial inheritance is Class III malocclusion.

Soft Part of Oral Cavity

Soft tissue rather than neuromusculature like abnormal size and shape of the frenums, ankylossia, microstomia are sometimes seen in both parents and children.

CONGENITAL FACTORS

The malformations that are seen at the time of birth are called congenital defects. Several influences including genetic, chemical, infections, mechanical, radiologic, endocrine are associated with congenital defects that develops malocclusion later.

Table 12. Congenital factors that associated with malocclusion

<table>
<thead>
<tr>
<th>General Congenital Factors</th>
<th>Local Congenital Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Malnutrition.</td>
<td>1) Defects of jaw development.</td>
</tr>
<tr>
<td>2) Endocrinopathies.</td>
<td>2) Abnormal tongue development.</td>
</tr>
<tr>
<td>3) Metabolic disturbances.</td>
<td>3) Cleft lip and palate.</td>
</tr>
<tr>
<td>4) Infectious diseases.</td>
<td>4) Cerebral palsy.</td>
</tr>
<tr>
<td>5) Nutritional disturbances.</td>
<td>5) Cleidocranial dysostosis.</td>
</tr>
<tr>
<td>6) Accident during pregnancy and child birth.</td>
<td></td>
</tr>
</tbody>
</table>

Sanjida Haque and Mohammad Khursheed Alam
Defects of Jaw Development

Abnormalities of jaw developments is a phenomenon that extending from mild defects to severe defects resulting malocclusion. It can occur in one or both jaws.

Agnathia
In this condition jaw fails to develop completely. Complete absence of jaw is very rare condition while missing of a part of jaw such as condyle, premaxillae, ramus is common than total absence of jaw.

Micrognathia
In this condition, jaw develops smaller than normal size. It can be mandibular, maxillary or both. There are two types; true and pseudo micrognathia. True micrognathia can occurred due to some congenital causes like Congenital heart disease, Pierre-Robin syndrome, absence of premaxilla and also due to some acquired cause like ankylosis of Temporomandibular joint, symmetrical or asymmetrical etc. However, in case of pseudo micrognathia, jaw looks like smaller may be the opposite jaw is larger than normal in size.

Macrognathia
In this condition, jaw develops larger than normal size. It can be mandibular, maxillary or both. There are two types; true and pseudo macrognathia. True macrognathia can occur due to diseases like pituitary gigantism, Paget’s disease of bone, acromegaly etc. However, in case of pseudo macrognathia, jaw looks like larger may be the opposite jaw is smaller than normal in size.

Cleft Lip and Palate
Cleft lip and palate is one of the most common congenital anomalies present at birth. Cleft lip and palate is accompanied by a wide variety of
dental anomalies. The incidence of certain dental anomalies is strongly correlated with Cleft lip and palate.

Table 13. Dental anomalies associated with cleft lip and palate

<table>
<thead>
<tr>
<th>No.</th>
<th>Dental Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Multiple missing teeth/hypodontia/agenesis.</td>
</tr>
<tr>
<td>2</td>
<td>Ectopic teeth.</td>
</tr>
<tr>
<td>3</td>
<td>Impaction.</td>
</tr>
<tr>
<td>4</td>
<td>Supernumerary teeth.</td>
</tr>
<tr>
<td>5</td>
<td>Microdontia.</td>
</tr>
<tr>
<td>6</td>
<td>Maxillary canines and premolars transposition.</td>
</tr>
<tr>
<td>7</td>
<td>Delayed development.</td>
</tr>
<tr>
<td>8</td>
<td>Crown and root malformation.</td>
</tr>
<tr>
<td>9</td>
<td>Multiple decayed teeth.</td>
</tr>
<tr>
<td>10</td>
<td>Spacing.</td>
</tr>
<tr>
<td>11</td>
<td>Class III malocclusion.</td>
</tr>
</tbody>
</table>

Dental arch discrepancies

Cerebral Palsy

Cerebral palsy is also a common congenital deformity present at birth. Patient with Cerebral Palsy have a greater tendency than the general population to have oral hygiene conditions as well as dental anomalies.

Table 14. Dental anomalies associated with cerebral palsy

<table>
<thead>
<tr>
<th>No.</th>
<th>Dental Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tooth loss.</td>
</tr>
<tr>
<td>2</td>
<td>Overjet.</td>
</tr>
<tr>
<td>3</td>
<td>Anterior open bite.</td>
</tr>
<tr>
<td>4</td>
<td>Atypical facial type.</td>
</tr>
<tr>
<td>5</td>
<td>Mouth breathing.</td>
</tr>
<tr>
<td>6</td>
<td>Drooling.</td>
</tr>
<tr>
<td>7</td>
<td>Crowding.</td>
</tr>
<tr>
<td>8</td>
<td>Misalignment of tooth.</td>
</tr>
<tr>
<td>9</td>
<td>Difficulty in swallowing.</td>
</tr>
<tr>
<td>10</td>
<td>Lip incompetence.</td>
</tr>
<tr>
<td>11</td>
<td>Long face.</td>
</tr>
<tr>
<td>12</td>
<td>Periodontal disease.</td>
</tr>
<tr>
<td>13</td>
<td>Gingivitis.</td>
</tr>
</tbody>
</table>
Etiology of Malocclusion

Cleidocranial Dysostosis

Cleidocranial dysplasia is congenital deformity that is present at birth characterized by delayed closure of the cranial sutures, hypoplastic or aplastic clavicles, and multiple dental abnormalities. It affects the bone and teeth development.

Table 15. Dental anomalies associated with cleidocranial dysostosis

| 1) | Delayed retention of primary dentition. |
| 2) | Delayed eruption of permanent teeth. |
| 3) | Multiple supernumerary. |
| 4) | Peg shaped tooth. |
| 5) | Morphologic abnormalities of the maxilla and mandible. |
| 6) | Jaw discrepancies. |
| 7) | Misalignment of tooth. |

Endocrine Imbalance

Endocrinal disorder has reflective effect on the formation, eruption and growth of the teeth jaws, face and also cranium.

Metabolic Disturbances

In some cases, acute febrile disease affect to the growth and development. As a result, abnormal eruption and shedding of tooth happens which leads to malocclusion.

Nutritional Deficiencies

During growth period, nutritional deficiencies affects the normal development leading the malocclusion. Nutritional deficiency disease like
beriberi, scurvy, rickets, acute febrile condition have records of severe malocclusion. Usually this phenomenon are quite prevalent in developing countries rather than developed countries. Delayed eruption of tooth, gum bleeding, calcification of tooth, early loss of deciduous tooth, periodontal disease are common in protein and vitamin ABCDE deficiencies. Moreover in cleft lip and palate patients, vitamin B12, folic acid and insulin deficiencies are commonly observed.

**Table 16. Dental anomalies associated with hypothyroidism**

1) Delayed eruption.
2) Enamel hypoplasia in both dentitions, (being less intense in the permanent dentition)
3) Anterior open bite.
4) Macroglossia.
5) Micrognathia.
6) Thick lips.
7) Crowding.
8) Misalignment of tooth.
9) Abnormal root resoption
10) Dysgeusia.
11) Mouth breathing.

**Table 17. Dental anomalies associated with hyperthyroidism**

1) Accelerated dental eruption in both deciduous and permanent tooth.
2) Enlargement of extraglandular thyroid tissue (mainly in the lateral posterior tongue).
3) Increased susceptibility to caries.
4) Open bite.
5) Increase vertical facial height.
6) Root resorption of deciduous tooth.
7) Periodontal disease.
8) Maxillary or mandibular osteoporosis.
9) Burning mouth syndrome.
10) Development of connective-tissue diseases like Sjögren’s syndrome or systemic lupus erythematosus.
Table 18. Dental anomalies associated with hypoparathyroidism

1) Enamel hypoplasia in horizontal lines.
2) Poorly calcified dentin.
3) Widened pulp chambers.
4) Dental pulp calcifications.
5) Shortened roots.
6) Hypodontia.
7) Delay or cessation of dental development.
8) Mandibular tori.
9) Chronic candidiasis.
10) Paresthesia of the tongue or lips.
11) Alteration in facial muscles.

Table 19. Dental anomalies associated with hyperparathyroidism

1) Widened pulp chambers.
2) Development defects.
3) Alterations in dental eruption.
4) Weak teeth.
5) Malocclusions.
6) Brown tumor.
7) Loss of bone density.
8) Soft tissue calcification.
9) Paresthesia of the tongue or lips.
10) Alteration in facial muscles.

Infectious Diseases

Some infectious diseases that are congenitally transmitted from mothers to child and later on in life exhibit dental problems and malocclusion like dental decay, Hutchinson’s incisors, Mulberry molars and crossbite. Crowding, underdeveloped maxillae and smaller maxillary arch are seen in congenital syphilis. Similarly, severe caries, dental hypoplasia and delayed eruption of teeth are observed if a patient is congenitally transmitted with maternal rubella infection from birth.
**ABNORMAL PRESSURE HABITS**

**Table 20. Dental anomalies associated with abnormal pressure habits**

| Thumb and figure sucking | 1) Anterior open bite  
|                         | 2) Increased over jet  
|                         | 3) Decreased overbite  
|                         | 4) Class II canine and molar relationship  
|                         | 5) Median diastema.  
|                         | 6) Increased arch length  
|                         | 7) Posterior crossbite  
|                         | 8) Decreased the width of palate  
| Tongue thrust and tongue sucking | 1) Anterior openbite  
|                                  | 2) Reduced eruption of incisors  
|                                  | 3) Swallowing problem  
|                                  | 4) Proclination of upper anterior tooth  
|                                  | 5) Narrow and constricted maxillary arch  
|                                  | 6) Posterior crossbite  
| Lip and nail biting | 1) Increase overjet  
|                     | 2) Protrusion of maxillary incisors  
|                     | 3) Collapse of mandibular incisors  
|                     | 4) Median diastema  

| Mouth breathing | 1) Proclination of anterior tooth  
|                 | 2) Open bite  
|                 | 3) Distal relation mandible to maxillae  
|                 | 4) Gingivitis  
|                 | 5) Shorter upper lip  

| Bruxism | 1) Tooth mobility  
|         | 2) Soreness to biting stress  
|         | 3) Excessive abrasion of enamel  
|         | 4) Fracture of root and crown  

**REFERENCES**


CLASSIFICATION OF MALOCCLUSION

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ABSTRACT

Acquiring knowledge is easy if a vast group of identities is divided into groups and subgroups based on certain similarities. Different researchers classified malocclusion in different ways based on clinical relevance and their experiences. Knowing of these classifications is important for all the students of orthodontics as they would be repeatedly referred to during communications between consultants and sometimes, certain identities within a subgroup will require the same treatment protocols. The aim of this chapter is to discuss details about all types of classifications of malocclusion and their drawbacks. A classification system is a grouping of different clinical cases of similar appearance for easiness in treatment and discussion; it is a structure of diagnosis, method for determining prognosis, and a way of defining treatment.
INTRODUCTION

Individual tooth malposition, mal relationship of the dental or dentoalveolar segments and skeletal mal relationships can be present in a patient individually or in a combination with each other. These discrepancies are depending upon the presence of abnormality in the individual arch or the dentoalveolar segments or the underlying skeletal structure. For classifying malocclusion, commonly used classification and indices are- Angles’ classification, Simon’s system, and Ackerman-Proffit System. Among these methods of classifying malocclusions, only two are widely used now-a-days. The Angle system (Angle, 1907) is used most commonly, but the other, the Simon system (Simon, 1922) is used in its entirety by very few clinicians. However, certain important perceptions controlled in the Simon system have had a great influence.

Angle’s Classification

Edward Angle classified malocclusion in 1988 based on the anteroposterior or mesial-distal relation of the teeth, dental arches and jaws. Angle reflected maxillary first permanent molar in a fixed position in the jaw in his theory of classification. Therefore, he established his classification on the relationship of this tooth to other teeth in the mandibular jaw. Even after 100 years, Angle’s proposed classification is still using widely all over the world. Angle classified malocclusion into three comprehensive groups. It is presented in a form that is most accepted in the present times. The three groups are designated as “Classes” and are represented by Roman numerals- I, II and III.

Class I Malocclusion

Class I occlusion is a normal anteroposterior relationship between the both arch is dropping in this class. The mesiobuccal cusp of the maxillary
first permanent molar articulates in the buccal groove of the mandibular first permanent molar. The bony base supporting the mandibular dentition directly beneath that of the maxillary, and neither is too far anterior or posterior in relation to the cranium. Class I malocclusion occurs when maxillary and mandibular molars are in appropriate position but confined to mal position of the other teeth themselves which may be misaligned, mal placed on their boney bases (dentoalveolar protrusion) etc (Figure 1).

Figure 1. Class I malocclusion.

Class II Malocclusion

When there is a distal relationship of mandibular 1st molar compared to the maxillary molar it is considered as Class II malocclusion. Angle classification put emphasis on the “distal” positioning of the mandible to the maxilla in Class II malocclusion. However, many Class II malocclusion cases are observed where the maxilla is prognathic- quite a different craniofacial morphology but creating the same molar relationship and hence fall into the same classification. The mesial groove of the mandibular first permanent molar articulates posteriorly to the mesiobuccal cusp of the maxillary first permanent molar. While the word distal is usually used in this manner to describe Class II malocclusion is wrong. Distal denotes only to teeth surfaces or directions and the Class II malocclusion involves primarily the bony skeleton. The relationship of the mandible to the cranial base, for example, words such as posterior or dorsal are more appropriate. Class II malocclusion is divided as follows:
Division 1
Disto oclusion when the maxillary incisors are typically in extreme labio version (Figure 2).

Division 2
Disto oclusion when the maxillary central incisors are near normal anteroposteriorly or slightly in linguo version, whereas the maxillary lateral incisors have tipped labially and mesially (Figure 3).

Subdivisions
When the disto occlusion occurs on one side of the dental arch only, the unilaterality is referred to as a subdivision of its division (Figure 4).

Figure 2. Class II division 1.

Figure 3. Class II division 2.
The malocclusions in which there is a mesial relationship of mandible to maxilla make up Class III malocclusion. The mesial groove of the mandibular first permanent molar articulates anteriorly to the mesiobuccal cusp of the maxillary first permanent molar (Figure 5).

Though, Angle’s classification is being used all over the world due to its simplicity, there are some controversies also. Successive cephalometric researches have not validated the Angle’s hypothesis. Highlighting on the relationship of the first permanent molars caused orthodontists to overlook the facial skeleton itself and to think only in terms of the teeth position. Consequently, faulty bone growth and muscles malfunction are often unnoticed. Even today, there is a tendency to center too much attention on this one tooth relationship. The molar relationship alters during the different stages of development of the dentition. A better correlation between Angle's concepts and treatment is obtained if one uses the Angle groups to classify skeletal relationships.
Simon’s Classification

In 1930, Simon divided the cranium in three planes to relate the dental arches to the face and classified malocclusion based on those three planes i.e.

- Frankfort horizontal (vertically);
- Orbital plane (anteroposteriorly);
- Raphe or median sagittal plane (transverse).

These planes are commonly used in cephalometric analyses. However, the only part of this system in routine current usage is some of the terminology.

**Frankfort Horizontal (Vertically)**

Frankfort horizontal plane (FH Plane) is drawn by a straight line from eye to ear. Line which go through the margins of the bony orbit directly under the pupil of the eye to the upper margins of the external auditory meatus (the notch above the tragus of the ear) (Figure 6).

This plane classified malocclusions in the vertical plane. Vertical deviations with respect to the plane are:
Attraction
When the dental arch, or part of it, is nearer to the Frankfurt plane than the normal position, it is said to be in attraction.

Abstraction
When the dental arch, or part of it, is farther away from the Frankfurt plane than the normal position, it is said to be in abstraction.

Orbital Plane (Anteroposteriorly)
Orbital plane is perpendicular to the Frankfort horizontal plane. This plane goes through the margin of the bony orbit directly under the pupil of the eye. According to Simon’s classification, the orbital plane passes through the distal axial aspect of the maxillary canine (Figure 7). Malocclusions labelled based on the distance from the orbital plane in anterior-posterior direction. The planes are:

Protrusion
When the dental arch, or part of it, is more anteriorly placed than normal with respect to the orbital plane, it is said to be in protraction.

Retraction
When the arch, or part of it, is more posteriorly placed than normal with respect to the orbital plane, it is said to be retraction.

Raphe or Median Sagittal Plane (Transverse)
The raphe or median sagittal plane is drawn by points roughly 1.5 cm apart on the median raphe of the palate. The raphe median plane passes through these two points at right angles to the Frankfort horizontal plane (Figure 8). Malocclusions classified according to transverse deviations from the median sagittal plane are:

Contraction
When the dental arch, or part of it, is nearer to the midsagittal plane than the normal position, it is said to be in contraction.
Distraction

When the arch, or part of it, is farther away from the midsagittal plane than the normal position, it is said to be in distraction.

Figure 7. Orbital plane.

Figure 8. Raphe or median sagittal plane.

Only protraction, retraction, and contraction terms are commonly used. For example, an Angle Class II malocclusion case may appear due to maxillary protraction, mandibular retraction, or both. Likewise, a constricted dental arch is called to be contracted. The major influence of
the Simon’s classification system is its emphasis on the co-ordination of the dental arches to the facial skeleton. In addition to this, it separates carefully, by means of its terminology, problems in mal-position of teeth from those of osseous dysplasia; for example, maxillary dental protraction is distinguished from total maxillary protraction. In earlier, only the teeth are anteriorly placed, whereas, in the later, the entire maxilla and its teeth are protracted. This system perhaps is adept of more precision than the Angle system, and it is three-dimensional. Conversely, in truth, it is clumsy, confusing at times (e.g., attraction is intrusion of the maxillary teeth and extrusion of mandibular teeth), and very minimum use in practice. Simon's classification concepts, however, have had a great influence on orthodontic thinking and even have changed the fashion in which the Angle system is used.

**Ackerman-Proffit System**

Due to the popularity of traditional Angle’s classification and its use, Ackerman and Proffit proposed a scheme of malocclusion which focused on the neglected factors of Angle’s classification. This Ackerman- Proffit system symbolizes the Angle’s classification with five characteristics of malocclusion within a Venn diagram (Ackerman & Proffit, 1969) (Figure 9).

The characteristics are as follows:

**Alignments**

Alignment and symmetry in the intra arch are assessed as when seen in the occlusal view. A dental arch is classified as ideal/ crowded/ spaced.

**Profiles**

The profile can be convex/ concave/ straight. This also embraces the valuation of facial divergence, i.e., anterior or posterior divergence.
Transverse Relationships

Skeletal and dental relationships are included in transverse relationships. Buccal and palatal crossbites are observed. Unilateral or bilateral crossbites are sub classified additionally. Difference is made between dental and skeletal crossbites.

Class

Here the sagittal relationship of the teeth is evaluated using the Angle classification as Class I, Class II and Class III. A division is made between skeletal and dental malocclusions.

Overbite

Malocclusions are measured in the vertical plane. They are described as anterior open bite/ posterior open bite/ anterior deep bite/ posterior collapsed bite. Here again a distinction is made as to whether the malocclusion is skeletal or dental.

Though the degree of alignment of the teeth in the arches is common to all dentitions, it is represented as the universe (group 1). Their profile is embodied as a major set (group 2) within the universe. Lateral, anteroposterior, and vertical are depicted as deviations from the normal with their interrelationships as interlocking subsets (groups 3 through 9) within the profile set. In this system, any malocclusion can thus be described by five or fewer characteristics.

When one is classifying using this method, the alignment and symmetry of the teeth in the dental arches are analyzed, the patient’s profile is viewed, the dental arches are studied with regard to the lateral dimensions, and the buccolinguual relationships to the posterior teeth are noted. The patients and the dental arches are viewed in the sagittal plane using the Angle system whether the deviation is skeletal, dento-alveolar or
a combination. Moreover, the patients and dentition are observed with respect to the vertical dimension. Apparently Group 9, which pools elements of all of the interlocking sets, represents the most complex malocclusions. The system has some advantages mostly for the student or beginner in orthodontics as it teaches a perspective about the difficulties of malocclusion. All three planes of space and the influence of the dentition on the profile are reflected. The discrepancy between skeletal and dental problems is made at the suitable level, and arch length problems with or without an inspiration on the profile are documented. Besides, this classifying scheme leads one realistically to the diagnosis and to differential treatment planning since homologous malocclusions probably would require similar treatment plans. Whereas analogous malocclusions may require different treatment plans. Though this system has not been widely adopted for clinical use, it will increase an integrated outlook of classification in practice.

Figure 9. Venn diagram (Adapted from web).
Malposition of Individual Teeth

Individual teeth may have following position:

Tilted or Inclined

The crown of the tooth may be tilted or inclined with its apex placed normally in the arch. Tilted teeth are described according to their direct of tilting.

- Labioversion - Labially tilted.
- Linguo version - Lingually tilted.
- Mesioversion - towards midline.
- Distoversion - away from midline.
- Bucco version - Buccaly inclined.

Displacement

They are also described according to their directing of displacement. Thus there may be:

- Medial displacement.
- Distal displacement.
- Lingual or palatal displacement.
- Labial or buccal displacement.

Rotation

A tooth may be rotated around its long axis. There may be:

- Mesiolabial or mesiobuccal rotation.
- Distolabial or Distobuccal rotation.
- Lingual or mesioplatal rotation.
- Distolingual or Distopalatal rotation.
Classification of Malocclusion

**Supra Occlusion/Supraversion**
When the tooth has over erupted passing the occlusal level.

**Infra Occlusion/Infraversion**
When the tooth has not reached the occlusion it is termed infra occlusion.

**Transposition or Transeversion**
When two teeth have reversed their position. e.g., upper canine in the position of 1st premolar & 1st premolar in the position of canine

**Imbrication**
Overlapping of adjacent teeth due to crowding commonly found in anterior segment.

**Transiversion**
Is twisted tooth, where the tooth is rotated on its long axis.

**Axioversion**
Mal-relationship of dental arch in different planes.

**Variation of Occlusion Relation May Take Place in 3 Planes**

- Anterior-posterior plane
- Lateral plane
- Vertical plane

**Anterior-Posterior Plane**
Relationship between upper & lower arch may be:

**Normal or Neutron Occlusion**
When the lower arch is normally related to the upper arch produce a normal over jet 2-3 mm.
Post Normal Occlusion
When the lower arch occlude distally in relation to the upper arch & thus increasing the over jet.

Prenormal Occlusion
When the lower arch occlude mesially or anteriorly in relations to the upper arch and there will be reduced over jet, edge to edge on even reverse over jet then it is called prenormal or mesio occlusion.

Molar Relationship
It is the relationship of the upper the permanent molar to lower permanent molars. It can be:

- Class I: Normoocclusion.
- Class II: Distoocclusion.
- Class II: subdivision: Class II on one side and Class I on the other side.
- Class III: mesio occlusion
- Class III Sub division: Class III on one side and Class I on the other side.
- Class IV: Class II on one side and Class III on the other side.

Canine Relationship

- Class I: Mesial inclination of the upper canine overlaps the distal inclination of the lower canine.
- Class II: upper canine is placed forward. i.e., distal incline of upper canine contacts the mesial incline of lower canine.
- Class III: The lower canine is placed forward to the upper canine and there is no overlapping.

**Incisor Relationship**

It is based on the British standard classification of incisor relationship. We have:

- Class I
- Class II division 1
- Class II division 2
- Class III

**Lateral Plane**

Relationship between upper and lower may be:

**Normal**

The lower arch is covered by the upper arch. So that the maxillary teeth occlude half a cusp buccal to the mandibular molars & the upper & lower midline considered.

**Abnormal**

When fails to achieve normal relationship. These may be:

- Crossbite: When the maxillary posterior teeth occlude in the central fossa of the mandibular teeth that is the upper buccal teeth are in lingual occlusion. It may be:
  - Unilateral crossbite
  - Bilateral crossbite
- Reverse crossbite: when the maxillary posterior teeth are placed completely inside or outside the mandibular teeth.
- Mid line shifting.
Vertical Plane

Complete Overbite

When the lower incisor occlude on the palatal surfaces of upper incisors or on the palatal mucosa, is called complete overbite.

Incomplete Overbite

When the lower incisors do not contact either the palatal surface of upper incisors or the palatal mucosa is incomplete.

Increased or Excessive Overbite

When overlapping of lower incisors by the upper incisor is more than normal. It may be complete or incomplete.

Reduced Overbite

When overlapping of lower incisors by the upper incisors is less than normal, it may also be complete or incomplete.

Open Bite

When the upper incisor fails to overlap lower incisor or upper posterior. Teeth fail to overlap lower posterior teeth. There is a vertical gap between them. It may be:

- Anterior
- Posterior

REFERENCES


Chapter 5

CLASS I MALOCCLUSION

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ABSTRACT

Most people have some degree of malocclusion. Class I malocclusion shows the highest prevalence compared to other malocclusions in any population worldwide. When the molars are in Angle’s class I position but other teeth in mal-relation it is referred as Class I malocclusion. This malocclusion said to occur when there is a harmonious relationship of the underlying skeletal structures and the malocclusion element is limited to the dental structures only. The aim of this chapter is to describe the etiology, features, diagnosis and treatment of class I malocclusion.
INTRODUCTION

Mandibular dental arch is in normal mesiodistal relation to the maxillary arch, with the mesiobuccal cusp of the maxillary first molar occluding in the buccal groove of the mandibular first permanent molar and the mesiolingual cusp of the maxillary first permanent molar occludes with the occlusal fossa of the mandibular first permanent molar when the jaws are at rest and the teeth approximated in centric occlusion [1]. Class I malocclusion is where the antero-posterior occlusal relationship is normal and there is a discrepancy either within the arches and/or in the transverse or vertical relationship between the arches.

FEATURES OF CLASS I MALOCCLUSION [2, 3]

Extraoral Features

- Facial profile straight.
- Competent/incompetent lips.

Intraoral Features

- **Skeletal pattern**: Usually Class I skeletal pattern. Mild Class II or Class III skeletal pattern may found in the rare case.
- **Incisor relationship**: Class I incisor relationship.
- **Molar relationship**: Angle Class I molar relationship.
- **Soft tissue morphology and behaviour**: Soft tissue environment is favourable. The major exception is bimaxillary proclination.
- **Upper and Lower incisor angle**: Normal axial angle.
- **F.M. plane angle**: Usually average
- **Dento-alveolar**: Most frequent abnormalities are crowding, rotation and displacement also may present in the incisor and canine region. Median diastema and spacing may also be present.
Class I Malocclusion

- **Overjet**: Usually normal in range but an individual tooth may be proclined showing increased overjet or retroclined and locked the bite.
- **Overbite**: Usually normal and complete. But may be “incomplete overbite” or even an “openbite.”
- **Crossbite**: May be present.

**AETIOLOGY**

**Local Factors [2, 3]**

Local factors include displaced or impacted teeth, and anomalies in the size, number and form of the teeth. However, it is interesting to know that these factors can also be found in Class II or Class III malocclusion.

- Proclination of the anterior teeth.
- Medial, distal, buccal or lingual (palatal) tilts or inclinations.
- Medial, distal, buccal or lingual (palatal) tilts or displacements.
- Supra-occlusion and infra-occlusion.
- Localized spacing and diastema.
- Rotations.

**Dento-Alveolar Disproportion [2, 3]**

- Crowding-Outstanding, instanding, imbrications, rotation etc.
- Spacing, diastema.

**Malrelationship of Arch in Lateral Plane [2, 3]**

- Crossbite.
- Central-line shift.
Malrelationship of Arch in Vertical Plane [2, 3]

- Excessive overbite.
- Open bite: Anterior, posterior.

TREATMENT OPTION OF CLASS I MALOCCLUSION

Treatment options are influenced primarily by the dento-alveolar features of the malocclusion, as the skeletal pattern is generally Class I.

Crowding [2, 4, 5]

Crowding occurs where if there is a discrepancy between the size of the teeth and the size of the arches. Around 60% of Caucasian young kids exhibits crowding to some degree. In a crowded arch lack of a permanent or deciduous tooth will result in the other teeth tilting or migrating into the space produced. This trend is greatest when the adjacent teeth are erupting. Crowding can either be accepted or relieved. Prior to evaluating between each of these alternatives the following should be taken into considered:

- The position, presence, and prognosis of rest of the permanent teeth.
- The degree of crowding which is frequently measured in millimeters per arch or quadrant.
- The patient's malocclusion as well as orthodontic treatment planning, including anchorage criteria.
- The patient's age and the chance of the crowding increasing or decreasing along with development.
- The patient's profile

In a Class I case by having mild crowding (<4 mm per arch) acceptance, or maybe extraction of second molars, should be taken into
consideration until a significant increase in crowding is anticipated. In cases by having moderate crowding (4- mm per arch) extraction of premolars is frequently indicated. While the crowding is severe (more than 8 mm per arch) space maintenance is unquestionably indicated just before the extraction of the first premolars most likely. In the maxillary arch, additional space could be made by the distal movement of the molars. In the maxillary arch, this could be accomplished by the headgear. Sometimes the extraction of a pair of teeth from each quadrant is indicated, however, this severity of crowding is the province of the specialist.

After the relief of crowding a degree of natural spontaneous movement will take place. In general, this is greater under the following conditions:

- In a growing child.
- If the extractions are carried out just before eruption of the adjacent teeth.
- Where the adjacent teeth are auspiciously aligned to upright if space is created (for an example, substantial improvement will often appear in a crowded lower labial segment providing the mandibular canines are mesially inclined).
- There are no occlusal interferences with the anticipated tooth movement.

Most spontaneous development appears in the initial 6 months after the extractions. If alignment is not complete immediately after 1 year, in that case further improvement needs a dynamic impulsive tooth movement with appliances.

**Spacing [2, 4]**

Treatment of mild spacing move the incisors together as well as gathering the space distal to the lateral incisors. In the generalized case, the incisors and canines can be moved towards in the direction of the midline and space gathered distal to the canines. To prevent relapse some type of
prosthesis will essential for aesthetics. The space adjacent to a crowded area should automatically correct either there is no occlusal interference.

**Median Diastema [4, 5]**

Median diastema appears in 98% of 6-year-olds, 49% of 11-year-olds, and 7% of 12 to 18-year-olds [6].

Aetiology, which has been considered to result in a median diastema include the following:

- Physiological.
- Small teeth in large jaws.
- Missing teeth.
- Midline supernumerary tooth/teeth.
- Proclination of the upper labial segment.
- Prominent fraenum.

A median diastema is frequently present between the maxillary permanent central incisors when they first erupt. As the lateral incisors and then the canines arise the diastema usually closes. Therefore, a midline diastema is a normal characteristic of the developing dentition; however, whether it remains after the eruption of the canines, it is unlikely that it will close spontaneously [4].

In the deciduous dentition, the upper midline fraenum runs between the central incisors and attaches straight into the incisive papilla area. However, as the central incisors move together with the eruption of the lateral incisors. It tends to migrate round into the labial aspect. In a spaced maxillary arch, or where the maxillary lateral incisors are missing this recession of the fraenum attachment is more unlikely to occur and in such cases, it is definitely not appropriate to attribute the resistance of a diastema to the fraenum itself. However, in a small proportion of cases, the upper midline fraenum can lead the way to the resistance of a diastema. Factors that might indicate that this is the case include the following.
Class I Malocclusion

- When the fraenum is placed under tension there is blanching of the incisive papilla.
- Radiographically, a notch can be seen at the crest of the interdental bone between the maxillary central incisors.
- The anterior teeth might be crowded.

Management

It is highly recommended to take a periapical radiograph to exclude the presence of a midline supernumerary tooth just before treatment planning for a midline diastema.

In the developing dentition, a diastema of less than 3 mm rarely warrants intervention: in particular, extraction of the deciduous canines should be avoided because this will tend to make the diastema worse. However, if the diastema more than 3 mm and the lateral incisors are present, it may be needed to consider appliance treatment to approximate the central incisors to provide space for the laterals and canines to erupt. However, care should be taken to ensure that the roots of the teeth being moved are not pressed against any unerupted crowns as this can lead to root resorption. If the crowns of the teeth are tilted distally, an upper removable appliance (URA) can be used to approximate the teeth, but fixed appliances can be an option for bodily movement. Closure of a diastema has a remarkable tendency to relapse [6]. Therefore, a long time retention is required. This is most quickly accomplished by placement of a bonded retainer.

Central Line Shift [4]

Central line shift in the mandibular arch usually does not require any treatment. In the maxillary arch slight move (up to 2 mm) in well-aligned arch should accept. However, gross move (more than 2 mm) will need treatment. Multiband appliances are usually used. When there a few teeth
have distal tipping movement, a removable appliance can be used to correct the shift. Moreover, if the shift associated with mandibular deviation due to premature contact or unilateral crossbite should correct itself after premature contact relief or crossbite corrected. Therefore, the shift associated with the pathology of facial skeleton is better to accept the shift.

**Open Bite [4, 5]**

**Anterior Open Bite**
Elimination of relevant habits like thumb sucking or tongue thrusting can be corrected with habit braking appliance. In mixed dentition period, if skeletal open bite diagnosed, the Frankel IV or under chin cap with high pull headgear can be the treatment of choice. Fixed appliances with box elastics can be considered as a treatment of mild open bite cases. After completion of growth skeletal open bite can be treated by surgical intervention. If the open bite due to supra-eruption of posteriors, posterior segmental osteotomy should be done to reposition the segment.

**Posterior Open Bite**
A posterior open bite can occur due to tongue thrust habit, it can be corrected by removable or fixed habit breaking appliances. A mild to moderate posterior open bite sometimes left alone or treated with Frankle appliances. In terms of severe case vertical subigmoid on sagittal bone, splitting give the maximum outcome. Bony osteotomy can be performed in condition when occlusion permit.

**Crossbite [4, 5]**

**Anterior Crossbite**
If maxillary incisors erupt too far lingually, they may be trapped into a crossbite malocclusion. In mixed dentition period when an anterior
crossbite is identified, clinicians are concerned that the malocclusion may adversely affect forward maxillary alveolar growth and further complication associated with the crowding of the maxillary anterior teeth in patients with arch length deficiency problems.

**Factors That Can Influence the Correction of Anterior Crossbite**

*Overbite*

The overbite influence the treatment and retention of the teeth associated with crossbite. When anterior crossbite occurs with a deep anterior overbite, a posterior bite plane is required to procline maxillary incisors without occlusal interferences from the lower incisors. When it associated with a little overbite a posterior bite plane is not recommended for correction of crossbite. After correction of crossbite, retention stability depends on the presence of overbite. The most challenging crossbite to treat and retention, when the incisor crossbite associated with little or no overbite. This condition can be treated with fixed appliances that can extrude incisors and develop sufficient overbite to retain the teeth in their corrected position.

*Anterior Arch Length*

A maxillary incisor in palatal crossbite must have sufficient space in the arch. When the insufficient arch length is available, first create the space to move the incisors out of the crossbite. Open coil springs are usually used to create sufficient arch length to move the tooth into its position.

*Torque of Maxillary Incisor Roots*

In palatal crossbite incisors roots are may introduce lingually while their crowns are moved anteriorly out of crossbite. The long axis of the tooth is in a greater labial inclination than normal. After the crown has been moved out of the crossbite, the fixed appliance with torque can torque
the root labially. A bracket with built-in torque is bonded to accomplish this kind of movement. Rectangular arch wire is used for torqueing procedure and it takes 8 to 12 weeks for completion.

**Alignment of Mandibular Teeth**

The alignment of mandibular anterior teeth should be delayed until the maxillary anterior teeth have been moved out of crossbite.

**Retention**

Retention stability is important after orthodontic treatment. Stability can be tested by removing the appliance or archwire from a fixed appliance for a period of two to three weeks after completing the treatment. If maxillary tooth remains stable no retainer is required. Further treatment may be needed if the tooth moves lingually and a maxillary retainer should be placed to hold the tooth out of crossbite.

**Posterior Crossbite**

Posterior crossbite generally involves with the displacement of a maxillary tooth and the buccal displacement of an occluding mandibular tooth. The buccal displacement of a maxillary tooth and lingual displacement of an occluding mandibular tooth creates a rare posterior crossbite called a scissors bite. Typically scissor bites occur in the first premolars of patients with Class II Division 1 malocclusion.

**Factors That Can Influence the Correction of Posterior Crossbite**

**Buccolingual Inclination of Teeth**

The buccolingual inclination of the maxillary and mandibular posterior teeth associated with crossbite. When the maxillary molar involves with crossbite and unusually inclined lingually, the correction of crossbite by tipping the molar buccally which improves the inclination. Opposed to this,
Class I Malocclusion

when the maxillary posterior crossbite unusually inclined buccally (etiology- may results of a narrowness of the maxillary arch in relation to the width of the mandibular arch), the correction of crossbite by widening of the maxillary arch with rapid maxillary expander appliance, rather than tipping of the upper molars buccally.

Estimate of Expansion Needed

An estimate of expansion needed when Class I malocclusion with bilateral or unilateral posterior crossbites with functional shifts associated with the permanent first molar and other posterior teeth. The estimation can be obtained by (1) deducting the width between the buccal grooves of the mandibular first molars from the width between the mesiobuccal cusp tips of the maxillary first molars, (2) adding to this difference 2 or 3 mm for overcorrection as a protection against the return of the crossbite after treatment.

When the estimated needed expansion of the maxillary arch is $\leq 4$mm with labially inclined maxillary molars, both fixed and removable appliances (quad helix, W-spring fixed or removable appliances, transpalatal arch) can be the choice of option. Fixed appliances (maxillary midpalatal expanders) is the best option when the expansion of the maxillary arch between 5mm to 12mm. When a patient needing expansion greater than 12 mm may require a combination of jackscrew and surgical orthodontic treatment.

Age of the Patient

Child and young adolescent age is the best period for correction of bilateral and unilateral posterior crossbite with a lateral shift. Correction of posterior crossbite can be done in adolescents with good success. But older adolescent and adults are often resistant to standard jackscrew expansion since the ossified midpalatal suture of adults is more difficult to separate. Moreover, the soft tissues lead the tendency for relapse. Surgical approach with jackscrew expansion is often applied in the treatment of posterior crossbite in adults.
Displaced Teeth [5]

Management of tooth displacement of teeth depends upon the degree of displacement. When it is mild, extraction of the associated primary tooth with space maintenance may result in an improvement in position. Alternatively, exposure and the application of orthodontic traction may be used to bring the mildly displaced tooth into the arch. If the displacement is severe, extraction is usually necessary.

Bimaxillary Proclination [4, 5]

When bimaxillary proclination occurs in a Class I malocclusion the overjet is increased due to the angulation of the incisors. Management is difficult because to reduce overjet both upper and lower incisor need to be retroclined. A high chance of relapse after removal of appliances due to retroclination of the lower labial segment will encroach on tongue space. If the lips are incompetent but have a good muscle tone and are likely to achieve a lip-to-lip seal if the incisors are retracted the chances of a stable are increased. However, the patient should still be warned that the prognosis for stability is guarded. Where bimaxillary proclination is associated with competent lips or with glossy incompetent lips which are unlikely to retain the corrected incisor position, it may be wiser not to proceed. However, if treatment is decided upon, permanent retention is advisable.

CLASS I MALOCCLUSION CLINICAL CASE

Case 1 [7]

History and Diagnosis
A Hispanic girl, age 12 years 9 months came with the complaint of anterior open bite with a convex profile. She has no relevant medical
history and quite happy to wear braces. The patient has a history of thumb sucking and tongue-thrust habit during swallowing and conversation.

Pre-treatment facial photographs showed that the patient had a convex soft tissue profile, the face was slightly asymmetric and chin deviated slightly toward the left. Upon smiling, she had inadequate gingival exposure. Intraorally, slight Class II molar tendency bilaterally. A 5mm anterior open bite was observed with 2 levels of occlusal planes, anterior and posterior. The maxillary arch was relatively narrow compared with the mandibular arch. Moderate anterior crowding in the maxillary arch and mild anterior crowding in the mandibular arch were observed. The panoramic radiographs show no caries and all the third molars are congenitally missing. The cephalometric analysis demonstrated a Class I (ANB: 2.2°; Wits appraisal: -2.2mm) skeletal pattern with a hyperdivergent growth pattern tendency. The angle between the maxillary incisors and the sella-nasion plane was 107.4°, the mandibular incisor to mandibular plane angle was 99°, and the interincisal angle was 114.8°.

Based on the findings, the patient was diagnosed as skeletal Class I with a dental openbite. The etiology of the openbite malocclusion appeared to be a combination of hereditary and habitual factors.

**Treatment Objectives**

The following treatment objectives were established:

- Close the patient's open bite and create ideal overjet and overbite.
- Relieve the crowding.
- Correct the constricted maxilla
- Eliminate the tongue thrust
- Correct the midline deviation
- Obtain a stable occlusal relationship.
- Ultimately improve her dental aesthetics by establishing an aesthetic smile.
Treatment Options

Both non-extraction and extraction treatment were possible for this patient:

- Non-extraction with maxillary expansion to correct the posterior crossbite and gain space to correct crowding and also use a tongue crib or spurs to modify the tongue-thrust behaviour during the treatment followed by a set of retainers with a tongue reminder.
- Extraction of 4 premolars to gain space for the correction of crowding and in consideration of the open-bite tendency for hyperdivergent growth.

The patient and her parents declined orthodontic treatment with extraction for that reason the plan include a non-extraction approach with rapid expansion and a tongue appliance to correct the openbite malocclusion. While the orthodontic treatment was in progress, the patient learned new tongue positions at rest and during swallowing.

A fixed retainer was attached to the lingual surface of the mandibular anterior teeth. Hawley retainers were fabricated and delivered to secure the stability of both arches. A tongue crib was incorporated in the maxillary Hawley retainer to prevent relapse of the tongue-thrust habit. Total treatment time for this patient was 24 months.

Case 2 [8]

History and Diagnosis

A 13 year old female came with the complaint of crowding associated with her teeth. There was no relevant medical history and she was quite happy to wear braces.

The pre-treatment facial photographs showed straight soft tissue profile with a symmetrical face. Her lip was competent. Upper incisor shows at rest 4mm and at smiling 9mm. She had mild skeletal Class II extraorally. All permeant teeth were present in the oral cavity except the
third molars. Her oral hygiene was poor with gingival hyperplasia. In the mandibular arch, mild anterior crowding and normal incisor inclination were observed. In the upper arch, moderate anterior crowding was present, normal incisor inclination and both the canines were buccally placed. Incisor relationship was Class I. Molar relation was ¼ unit Class II bilaterally. The panoramic radiographs showed all third molar tooth germs were present. The cephalometric analysis demonstrates Class I skeletal pattern.

In summary, a 13-year female presented with a Class I malocclusion on a mild skeletal Class II pattern with average vertical dimension complicated by moderate upper arch crowding and a localized crossbite.

**Treatment Plan**

The following treatment plan was established:

- Occipital pull extra-oral traction to reinforce anchorage.
- Upper and lower pre-adjusted edgewise appliances.
- Long-term retention.

**Treatment Progress**

Headgear compliance was poor. It was therefore decided to the extraction of both maxillary second premolars to recreate space for maxillary arch alignment.

**REFERENCES**


Chapter 6

INDIVIDUAL TOOTH/TEETH MALOCCLUSION

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ABSTRACT

This chapter outlines the types of malocclusion affecting the single tooth. The definition, classification, etiology, diagnosis and orthodontic management of discrepancies between the arch length and tooth material such as crowding and spacing, malocclusion in vertical planes such as open bite and deep bite, median diastema and transverse plane malocclusions such as crowding are described. Ectopic eruption of the different teeth, the impact of missing or unerupted teeth, the importance of midline and its deviation in orthodontics are also discussed in details with the management of such complications.
INDIVIDUAL TOOTH MALOCCLUSION

These occur when an individual tooth is positioned abnormally in relation to the adjacent teeth within the same dental arch. They are also known as intra-arch malocclusions.

A tooth may be misaligned with its crown abnormally inclined while its root apex is normally positioned or the whole body of the tooth may be abnormally displaced in the same direction. The tooth may either be rotated along its long axis or may be positioned either inferior or superiorly in relation to the adjacent teeth. These various anomalies of tooth position can be described according to the following nature and the direction of the malposition [1]:

Tipping

Tipping occurs when the crown of the tooth is abnormally positioned but the root remains in the normal position. Tipping of the tooth may occur mesially or distally and linguually or buccally.

Mesial Tipping

The crown of the tooth is inclined abnormally towards the midline of the dental arch than the root.

Distal Tipping

The tooth is inclined abnormally so that its crown is positioned away from the midline of the dental arch than the root.

Lingual/Palatal Tipping

The tooth is tipped abnormally towards the tongue or the palate. Retroclination is the term that is frequently used to describe the lingual inclination of the anterior teeth.
Individual Tooth/Teeth Malocclusion

Labial/Buccal Tipping
The crown of the tooth is abnormally positioned towards the lips in case of anterior teeth or the cheeks in case of posterior teeth. For anterior teeth, proclination is the term that is frequently used.

Displacement
When the whole body of a tooth (including both crown and root) is abnormally positioned in relation to the adjacent teeth is termed as displacement. Tooth displacement may also occur either mesially or distally and lingually or buccally.

Mesial Displacement
The tooth is bodily displaced towards the midline of the dental arch.

Distal Displacement
The tooth is bodily displaced away from the midline of the dental arch.

Lingual Displacement
The tooth is bodily displaced towards the tongue.

Labial/Buccal Displacement
The tooth is bodily displaced towards an outward direction.

Infra-Occlusion
This term is used for the tooth which has not erupted sufficiently so that its occlusal surface or the incisal edge is at the lower level than the adjacent teeth in the arch.

Supra-Occlusion
This is the exact opposite of the infra-occlusion which mainly occurs due to the over-eruption of an individual tooth.
**Rotation**

Rotation is the movement of a tooth around its long axis. Rotation of a tooth can be of two types: mesiolingual and distolingual.

*Mesiolingual Rotation*

The tooth is rotated around its long axis so that its mesial aspect is turned towards the tongue. It can also be said as distolabial rotation because the distal aspect of the tooth is also turned labially at the same time.

*Distolingual Rotation*

This is the opposite of the mesiolingual rotation as the distal aspect of the tooth is rotated towards the tongue instead of the mesial aspect and as the mesial aspect of the tooth is rotated labially this may also be termed as mesiolabial rotation.

**Transposition**

Transposition is a condition which appears when two teeth exchange their position within the same dental arch during the development of occlusion. Transposition between the upper canine and the upper first premolar or the lateral incisor on the same side of the arch are commonly observed.

**CROWDING**

Crowding occurs when the size of the dentition is greater than the available space in the dental arch for the accommodation of the teeth in perfect alignment.

Crowding is very common as approximately 60 percent of the Caucasian children have some degree of crowding. Crowding may involve any teeth: the incisors and the canines are involved if the arch is narrow or
short, the molars when the arch is short and the premolars and canines due to the drifting followed by the early loss of deciduous molars [2].

Etiology

The causes of crowding may be:

- The discrepancy between the arch length and the tooth material due to reduced arch length or increased tooth material.
- Prolong retention of deciduous teeth.
- Early loss of deciduous teeth particularly deciduous second molars, as a result of which the first permanent molar drifts into and occupy the place of the second premolar, so the second premolar erupts into an abnormal space and causes crowding.
- Presence of supernumerary teeth.

Assessment

Assessment of crowding can be made by measuring the mesiodistal widths of any teeth misaligned in relation to the available space in the dental arch. The amount of crowding can be classified as [5]:

- Mild (less than 4 mm)
- Moderate (4-8 mm)
- Severe (more than 8 mm)

Management

A certain degree of crowding is acceptable and can be left untreated. However, the following factors should be considered before making the treatment plan:
• The position, presence and the prognosis of the remaining permanent teeth.
• The degree of crowding (mild, moderate or severe)
• The pattern of malocclusion and planned orthodontic treatment with anchorage requirements.
• Patient’s age with the likelihood of increasing or decreasing crowding with growth.
• Patient’s profile.

Mild Crowding

• Extraction is rarely indicated unless there is severe incisor protrusion or severe vertical discrepancy.
• Mild crowding may also be managed without arch expansion by slightly reducing the width of the selected teeth with coordination in the amount of reduction in both upper and lower arch.
• Cases requiring tipping movement of the teeth can be treated with removable appliances such as a spring retainer.
• Fixed appliances can also be used for maximum control of movement to align the teeth. An edgewise appliance with the bands placed on the upper and lower first molars and the brackets bonded to the upper and lower anterior teeth, flexible nitinol wires can be used for initial leveling followed by the rectangular stainless-steel wire for finishing details [17].

Moderate Crowding

• Treatment with either extraction or non-extraction is possible depending on the hard and soft tissue characteristics of the patient and on how the final position of the incisors will be controlled [17].
• Extraction of premolars is usually indicated.
• Non-extraction treatment requires increasing the arch length by the transverse expansion across the molars and premolars with the distal movement of the posterior teeth.
• Fixed appliances can be used for initial leveling and the alignment of the dental arches.
• Retainer wear is indicated to prevent relapse.

Severe Crowding

• Extraction is almost always compulsory. The choice of extraction is four first premolars.
• Space maintenance is indicated prior to the extraction.
• Additional space can be gained in the upper arch by the distal movement of the molars.

SPACING

Although spacing is considered as normal and of positive prognostic value in deciduous dentition, in permanent dentition space between the teeth is abnormal. The spacing between the teeth can be seen either at the localized area of the arch or the entire arch.

Etiology

• Generalized spacing is very rare and is usually caused by disproportion in the size of tooth material relative to the arch length. Conditions like hypodontia and microdontia can predispose to generalized spacing [16].
• Abnormal tooth forms such as peg-shaped lateral incisors can lead to spacing.
• Harmful oral habits like thumb sucking or tongue thrusting cause spacing in the anterior region.
• Unerupted supernumerary teeth or bony cystic lesion between the teeth can cause spacing.
• Premature loss of permanent teeth due to trauma, pathology, displacement or morphology.
• Congenital absence or impaction of the permanent dentition.

Diagnosis

• Model analysis to determine the arch length-tooth material discrepancy.
• Radiographic examination to determine underlying bony pathology, unerupted or missing tooth.

Management

Orthodontic management of the generalized spacing is often difficult as there is a greater tendency for relapse unless permanently retained.

• For mild spacing, acceptance is usually the best option. Alternatively, composite laminations or porcelain veneers may be given to increase the mesiodistal widths of the labial segment of the teeth [17].
• In more severe spacing, orthodontic treatment (e.g., fixed appliance with elastic chains or elastic thread) is done to concentrate the space at specific sites prior to the placement of a prosthesis or implant [17].
• Habit breakers may be employed to intercept the oral habits, any bony pathology or cystic lesion if present should be removed [17].
OPEN BITE

Open bite is a malocclusion that occurs due to lack of vertical overlap between the maxillary and mandibular dentition [16]. An open bite can occur in both the anterior and the posterior region and are called the anterior and the posterior open bite respectively.

Anterior Open Bite

It is the condition when the incisors do not overlap vertically when the posterior teeth are in occlusion.

Etiology

Skeletal Pattern

Increased lower facial height and high FMPA resulting in an increased distance between the upper and the lower incisors [8]. The inter-occlusal distance is not possible to compensate by the eruption of the incisors which results in an anterior open bite. The condition is worsened if the vertical, downward and backward pattern of the mandibular growth continues as the anterior open bite will become more prominent.

Soft Tissue Pattern

Patients with the anterior open bite due to digit-sucking habit has the tendency to push the tongue forward between the anterior teeth to achieve anterior oral seal during swallowing.

Habits

Persistent digit-sucking habit continuing into the mixed and permanent dentition period restricts the development of the incisors, often producing an asymmetric anterior open bite. This is often associated with the
posterior crossbite due to constriction of the upper arch by the cheek muscles and a lowered tongue position during digit-sucking.

Localized Failure of Development

Anterior open bite is rarely seen in a patient with a cleft of the lip and alveolus for unknown reasons.

Management

Apart from the anterior open bite entirely caused by the digit-sucking habit, the management is challenging for the orthodontists.

In the mixed dentition, the anterior open bite due to digit-sucking should be managed by gentle discouragement of the habit and a removable appliance should be fitted as a reminder if the child is keen to stop this habit. However, if a habit-breaker is indicated then a simple plate with a long labial bow for anterior retention can be given [5]. After fitting the appliance, the acrylic behind the upper incisors should be trimmed to allow any spontaneous alignment by the retraction of the incisors once the habit is stopped.

For anterior open bite other than the ones caused by the digit-sucking habit, a period observation may be useful because in some cases the anterior open bite may reduce spontaneously probably due to maturity of the soft tissues, improved lip competence or favorable growth. Although the management of anterior open bite can be approached in three ways:

Acceptance of the Condition

The treatment is mainly aimed at correction of any crowding or alignment of arches. Acceptance should be considered in the following situations [5]:

- Mild Cases.
- Lips are markedly incompetent or endogenous tongue thrust is suspected.
Marked malocclusion where the patient cannot be motivated to surgery.

Orthodontic Correction

Orthodontic management is possible if the growth and the soft tissue conditions are favorable.

Treatment should be aimed at intruding the molars as the extrusion of the incisors result in relapse once the appliance is removed. The intrusion of the molars can be done by the high-pull headgear in case of milder malocclusion. For more severe anterior open bite with Class II skeletal pattern, a combined treatment with removable appliance incorporated with buccal blocks and high-pull headgear may be used to control vertical maxillary growth [5]. For effective growth modification, intrusive force should be applied to the maxilla for 14-16 hours per day during a pubertal growth spurt and should be continued until the growth rate slows down.

Functional appliances such as van-Beek appliance or twin-block appliance with high-pull headgear can also be used for class II malocclusion with anterior open bite. At the end of functional therapy fixed appliances are applied for arch alignment together with extraction if needed.

Orthognathic Surgery

In the adult patient in whom growth is complete but the anterior open bite is severe or is of skeletal etiology where an aesthetic or stable result cannot be achieved only by the orthodontic therapy. In some patients, correction of anterior open bite with a gummy smile requires a combination of orthodontic and surgical approach [5].

Posterior Open Bite

Posterior open bite occurs when there is no contact between the posterior teeth of the upper and lower arch while the rest of the teeth are in occlusion.
The posterior open bite is very rare and the exact etiology is not clearly known. The possible causes may be:

- Failure of eruption of molar teeth due to unknown etiology.
- The arrest of the eruption of molar teeth. The affected tooth seems to erupt normally but the cessation of occlusal development as the rest of the dentition and the alveolar process continues to develop. The etiology is not understood yet.
- Rarely in unilateral condylar hyperplasia.
- Early extraction of first permanent molars with the resulting lateral tongue spread.

In both cases of either failure of eruption or arrest of the eruption of molar tooth extraction of the affected tooth/teeth is the only alternative treatment. For unilateral condylar hyperplasia, condylectomy is indicated if there is excessive growth [5].

CROSSBITE

A crossbite is an abnormal buccolingual relationship between the upper and lower dentition in the transverse plane. Crossbites may be anterior or posterior, buccal or lingual, unilateral or bilateral or may be associated with mandibular displacement on closing.

Etiology

Local Factors

- Crowding is the most common cause. For example, due to lack of space between upper central incisor and the deciduous canine, the upper lateral incisor erupts palatally and crossbites with the opposing tooth in the lower arch.
- Early loss of deciduous second molars in a crowded arch causing forward movement of the first permanent molar and therefore due to lack of space the second premolar erupts palatally and crossbite results in the posterior jaw segment.
- Retention of the deciduous predecessor may also contribute to crowding by occupying the space for permanent successors.

**Skeletal Factors**

- Posterior crossbite mainly occurs due to the discrepancy in the relative width between the upper and lower arches or due to an anterior-posterior skeletal discrepancy.
- Anterior crossbites are mainly associated with the Class III skeletal pattern.
- Growth restriction of the maxilla after cleft repair or of the mandible secondary to condylar trauma can lead to posterior crossbite.

**Soft Tissue Factors**

In individuals with digit-sucking habit, the position of the tongue is lowered and a negative pressure is created intra-orally which displaces the upper posterior teeth palatally causing crossbite.

**Types of Crossbite**

**Buccal Crossbite**

When buccal cusps of the lower dentition occlude buccal to the buccal cusp of the upper dentition.

**Lingual Crossbite**

When the buccal cusps of the lower dentition occlude lingual to the lingual cusps of the upper dentition. The condition is also known as Scissor’s bite.
Mandibular Displacement

During the closure of the mandible from the resting position into maximum interdigitation the occlusal contact is deflected laterally and/or anteriorly. This is often associated with the central line shift.

Anterior Crossbite

When one or more of the upper incisors are lingually occluded to the lower arch. Reverse overjet can be found and are frequently associated with the mandibular displacement on closure.

Posterior Crossbite

Crossbite at the premolar and molar region involving one or two teeth or the entire posterior segment of the dental arch. Posterior crossbites can be of following types:

Unilateral Buccal Crossbite with Mandibular Displacement

Crossbite involving one or two teeth or the entire posterior segment of a single jaw quadrant. A single tooth is involved when one tooth is displaced buccally or lingually from the opposing tooth leading to deflecting contact on closure into crossbite [4]. The whole posterior segment may be affected when the maxillary arch is of similar width to the mandibular arch and on closure, the upper and lower posterior teeth on the affected side meet cusp to cusp. As a result, in order to achieve maximal intercusption, the mandible is displaced to one side and an asymmetrical malocclusion appears which may be associated with a central line shift in the lower arch in the direction of the mandibular displacement.

Unilateral Buccal Crossbite without Displacement

It is less common and occurs mainly due to the true asymmetry of one arch due to underlying skeletal asymmetry. Occasionally, may be produced by some pathological factors like unilateral cleft lip causing maxillary asymmetry, unilateral condylar hyperplasia causing mandibular asymmetry.
Bilateral Posterior Crossbite
This is mainly of skeletal origin particularly when the maxilla is narrow relative to the mandible. For this reason, they are often associated with Class III malocclusion.

Unilateral Lingual Crossbite
This mostly occurs due to the displacement of a single tooth due to the retention of a deciduous predecessor.

Bilateral Lingual Crossbite
This is mainly associated with the underlying skeletal malformation. For example, in a skeletal Class II malocclusion where the upper arch is abnormally placed in a further forward position relative to the lower arch the posterior teeth of the lower arch has to occlude with the wider segment of the lower arch. This condition is known as Scissor’s bite.

Management
Crossbite associated with mandibular displacement requires functional indication for orthodontic treatment because the displacing contacts may predispose to temporomandibular joint dysfunction syndrome [4]. Bilateral crossbite without displacement should be treated with caution because due to a partial relapse it may turn into unilateral crossbite with displacement. Compromised periodontal support seen in anterior crossbites due to traumatic displacement of the anterior occlusion forcing the lower incisors to move labially through the labial supporting tissues requires early treatment [8].

Treatment of Anterior Crossbite

Anterior Crossbite with One or Two Incisors
This is often associated with the mandibular displacement and if the treatment is to be done during the early mixed dentition period, make sure
that there exists sufficient overbite and space in the dental arch in order to allow and maintain the teeth alignment [8]. Space can be created by the extraction if indicated. If correction is possible by simple tipping movement of the tooth, an upper removable appliance incorporated with buccal capping to free the occlusion and Z-spring for the proclination may be used [8]. The appliance should also contain good anterior retention to counteract the displacing effect of spring. Alternatively, a screw appliance may overcome this problem. Otherwise, it is advisable to wait until the permanent dentition period and then treat with comprehensive fixed orthodontic appliance.

If sufficient overbite cannot be anticipated at the end of treatment to retain the corrected incisors then the treatment should be aimed at moving the lower incisors lingually without damaging the periodontal tissues to increase the overbite. In a crowded upper arch where there is severe bodily displaced lateral incisor palatally, extraction of the displaced tooth can be done to relieve crowding.

**Treatment of Posterior Crossbite**

It is important to determine the etiology first before the treatment. Crossbite due to displacement of a single tooth can be treated simply by aligning the tooth itself or by the reciprocal movement of the opposing teeth. But crossbite due to underlying skeletal etiology requires expansion of the upper arch to create additional space. Crossbite due to skeletal asymmetry requires thorough investigation to determine the undermined etiology including the influence of both maxilla and the mandible to the presenting features. A combined treatment approach is required in this case including orthognathic surgery [8].

**Unilateral Buccal Crossbite**

Crossbite due to the displacement of a single tooth (for example, palatally displaced upper premolar) can be treated by an upper removable
Individual Tooth/Teeth Malocclusion

Appliance incorporated with T-spring or screw section for alignment of the tooth into the arch. In cases requiring reciprocal movement of the opposing tooth in the opposite direction, fixed appliances with the cross-elastics attached to the brackets and bands bonded to the teeth involved are given. Crossbite due to the severe displacement of a tooth requires extraction of that affected tooth to relieve crowding.

Unilateral buccal crossbite associated with mandibular displacement due to narrowing of the maxillary arch due to digit-sucking habit requires upper arch expansion either by using upper removable appliance with midline expansion screw and buccal capping to disengage the occlusion if the teeth are not tilted buccally already or more commonly by quad-helix appliance if treatment with the fixed appliance is indicated [4]. The quad helix appliance consists of a 1mm stainless steel wire with four coils in the shape of a ‘W’ and it is attached to the bands on the molar tooth on each side of the arch. A slight over expansion of the arch is advisable because there may be a degree of relapse after the treatment [4].

**Bilateral Buccal Crossbite**

Bilateral buccal crossbites are generally accepted unless the teeth at upper buccal segment are tilted palatally to a significant degree. The rapid expansion of the mid-palatal suture may be attempted only by the specialists because some degree of relapse is anticipated in the buccopalatal tooth position with the risk of developing unilateral crossbite with displacement. This is usually done by turning a midline screw which is connected to the bands on the molars and premolars twice daily for 2 weeks to achieve an expansion of 0.2-0.5 mm/day. The expansion should be carried out no later than the growth period. Surgically assisted rapid maxillary expansion can also be considered [4].

In patients with the repaired cleft palate, bilateral buccal crossbite is more common and usually treated by the expansion of the upper arch by stretching the scar tissue using a quad-helix appliance.
**Lingual Crossbite**

A single tooth may be displaced into crossbite due to crowding. After relieving the crowding, crossbite should be corrected by the palatal movement of the affected upper tooth by the fixed appliance. In more severe cases with skeletal involvement requires buccal movement of the affected lower teeth and the palatal movement of the upper teeth with fixed appliances. Surgery may be indicated for complete bilateral lingual crossbite or unilateral lingual crossbite with no displacement [4].

**Deep Bite**

Deep Bite is a condition characterized by the excessive overlapping of the mandibular incisors over maxillary incisors in the vertical plane which is beyond the normally reported coverage of 30%-40%. According to Graber, Deep bite is a condition of excessive overbite where the vertical measurement between the maxillary and mandibular incisal margin is excessive when the mandible is brought into centric occlusion. Although many may refer to the overbite in millimeters the percentage computation is more reliable because the difference in the crown height of the mandibular incisors, the degree of inclination of both maxillary and mandibular incisors influence the amount of overbite [12]. The ideal overbite in normal occlusion ranges from 2 to 4mm which means more appropriately 5%-25% overlapping of mandibular incisors by the maxillary incisors [12]. Deep bite may coexist with different malocclusion (Class I, Class II and Class III) but the most severe form is associated with Class II, Division 2 malocclusion which is also known as ‘overbite’ characterized by the complete covering of the mandibular crown due to excessive overbite and the retroclination of maxillary incisors [3]. In a very severe form of deep bites, mandibular incisors impinge on the palatal mucosa which in addition to the functional problem this may cause loss of maxillary incisors. Another severe form of the deep bite is known as
'closed bite' which is mostly seen in adults due to early loss of posterior teeth [3].

**Etiology**

Deep bite occurs due to heredity or environmental factors or both are responsible in combination. In a skeletal deep bite, the horizontal growth pattern of the jaw is seen with reduced lower anterior facial height mainly due to growth discrepancy between the upper and lower arch, hypo divergent jaw bases and reduced mandibular ramus height. The dental deep bite is characterized by the undereruption of the molars, overeruption of the incisors or both [12]. Deep bite of environmental origin is also known as ‘acquired deep bite’ which may occur due to disruption in the dynamic equilibrium and the harmony of the soft tissue structures (tongue, facial muscles) surrounding the teeth leading to malocclusion such as [3]:

- A lateral tongue thrust causing infra-occlusion of the posterior teeth.
- Tooth abrasion or wearing of the occlusal surface.
- Mesial drifting of the posterior tooth to the site of extraction.
- Prolong thumb sucking.

**Diagnosis**

The common diagnostic tools are clinical examination, study model analysis, and lateral cephalograms. Lateral cephalometric analysis revealing short lower anterior facial height with a flat mandibular plane angle, acuter gonial angle, parallel upper and lower occlusal planes and a deep curve of Spee in the mandibular arch suggests skeletal deep bite. Infraoccluded molars and over-eruption of the incisors can be observed clinically [3].
Factors to be Considered before Correcting Deep Bites

**Growth**

Treatment of deep bite is easier and stable in growing patients. During the period of active development of mandible, tooth eruption can be stimulated in the posterior segment and inhibited in the anterior segment as the dentoalveolar growth is facilitated by the condylar growth.

**Vertical Dimension**

It occurs either by extrusion of the molars or by intrusion of the incisors. However, the influence on the vertical facial height should be carefully monitored. In no cases, these eruptive mechanisms should disrupt the ‘free-way space’ which is about 2-4 mm when the mandible is in physiological resting condition.

**Soft Tissues**

Position of the maxillary incisors in relation to the upper lip is very important. The decision has to be made whether to maintain, extrude or intrude the upper incisors relative to the upper lip for aesthetic smile designing. Correction of the deep bite should be done by maintaining a suitable incisal exposure: in relaxed lip position while smiling and during the speech. According to Maulik and Nanda, in a relaxed lip position the incisors should have 2-4 mm of exposure including the incisal edges and during smiling the average incisor exposure is almost about two-thirds of the upper incisors. If the lip position is correct but deep bite exists then treatment should be done either by the extrusion of the posteriors or by the intrusion of the lower incisors.

The interlabial gap is another important thing to consider during treatment. Posterior extrusion is contraindicated in a patient with large interlabial gap because it may further increase the gap and worsen the aesthetics and causing functional problems.
Individual Tooth/Teeth Malocclusion

Treatment

There are three options for correction of deep bite malocclusion:

- Intrusion of the upper/lower incisors.
- Extrusion of the upper/lower posterior teeth.
- A combination of intrusion/extrusion.

**Intrusion of the Upper/Lower Incisors**

This mode of treatment is indicated in a patient with a vertical maxillary excess, large inter-labial gap, a long lower facial height or a steep mandibular plane. The choice of fixed appliances are Intrusion arch, utility arch or three-piece intrusion arch.

**Extrusion of Upper/Lower Posterior Teeth**

This can be done by using bite planes or functional appliances.

**Bite Planes**

Bite planes are the most popular appliances for deep bite correction. They block the occlusion of the incisors while exerting an intrusive effect but leave the posterior free to erupt for leveling the curve of Spee primarily by the posterior extrusion. Two types of bite planes can be used; removable or fixed. Fixed bite planes are more advantageous because of their integration with the fixed appliance mechanotherapy, no patient compliance, and less bulkiness.

**Functional Appliances**

Functional appliances can also be used to achieve posterior extrusion particularly in low-angle Class II malocclusions. They disocclude the posterior teeth by bringing the lower jaw forward to an edge-to-edge relationship. The posterior teeth then erupt freely. The eruption can be aided by using elastics during fixed appliance therapy. For successful treatment, the functional appliance should be worn full-time [12].
Combination of Intrusion and Extrusion

The simultaneous intrusion of anterior teeth and extrusion of posterior teeth can be achieved by positioning the anterior brackets incisally and posterior brackets gingivally or by using reverse-curve archwires. But such therapy may have certain drawbacks like a change in axial inclination of posterior teeth, proclination of the incisors and a reverse “curve of Spee” due to the discrepancy between the intrusion and extrusion [3].

Implants for Deep Bite Correction

Mini implants are indicated for anchorage control; especially if huge bite opening needs to be achieved by the genuine massive intrusion of all six anterior teeth.

ECTOPIC ERUPTION

When a permanent tooth bud is malposed and therefore erupts in an abnormal space, the condition is called ectopic eruption [7]. Ectopic eruption causes the resorption of primary tooth other than its normal predecessor or resorption of the adjacent permanent dentition. It is most likely to occur in eruption of the maxillary first molars [8].

Ectopic Eruption of Maxillary First Molars

This is usually painless and often remains unrecognized unless identified by the routine bitewing radiographs. Sometimes the eruption pathway may be drifted too far mesially at an early stage that the permanent molar is unable to erupt and damages the root of the deciduous molar. When only small amount of resorption is seen (<1 to1.5mm), careful observation is required because self-correction occurs in two-thirds of the cases. Treatment is indicated if the eruption is blocked for 6 months.
and the resorption continues. Lack of timely intervention will result in early loss of the primary molar with space loss.

The treatment should be aimed at moving the ectopically erupting tooth distally from the resorbing primary molar. If little movement is required but the permanent molar is little or not visible clinically, 20 or 22 mil brass wire can be looped and tightened around the contact between the primary second molar and the ectopically erupted permanent molar [7]. It is sometimes necessary to anesthetize the soft tissues before placing the wire because it may be difficult to direct the wiring sub gingivally, sometimes depending on the tooth position and the depth of contact between the teeth. The brass wire should be tightened at every two weeks interval so that it does not move in relation to the tooth. Another alternative is to place a steel spring clip separator if there is only a small amount of resorption. If the resorption is more severe and more distal movement of the molar is required, simple fixed appliance should be fabricated to move the molar distally providing access for the occlusal surface of an ectopically erupted molar.

If the primary molar is severely damaged then it should be extracted to allow permanent molar to move mesially and shorten the arch length. If the second premolar is not missing and the arch length is purposefully reduced or considerable mesial movement of the molar is not tolerable and later premolar extraction is not planned a ‘distal shoe’ should be placed as a space maintainer that will guide the erupting molar after extracting the damaged deciduous tooth. After the full eruption, the molar will have to be repositioned distally using headgear or any other space regaining appliance.

**Ectopic Eruption of Lateral Incisors**

Ectopic eruption of the lateral incisors results in loss of one or both primary canines due to excessive resorption. The underlying reasons may be lack space in the arch for the permanent incisors or may be due to abnormal eruption path of the lateral incisor [7].
The choice of treatment, whether space maintenance, space regaining or more complex type is required should be determined by the space analysis with anterior-posterior incisor position and the facial profile [7].

When one primary canine is lost treatment should be done either by extracting the contralateral primary canine to prevent midline shift or by maintaining the position of the erupting lateral incisor on the site of canine loss by using lingual arch with a spur if space is adequate and there will be no midline shift.

If both primary canines are lost, the permanent incisors may tip lingually. Thereby reducing the arch circumference and increasing the crowding. To prevent this lingual tipping and for space maintenance, a passive lingual arch can be given. If there is shifting of the midline with or without adequate space, it could be resolved before the eruption of the permanent canine [7].

**Ectopic Eruption of Maxillary Canines**

Ectopic eruption of the maxillary canines may lead to either impaction of the erupting permanent canine or resorption of the lateral incisor roots or both. This may be genetic in origin and may also be related to either small or missing maxillary lateral incisor and missing second premolars. Field-of-view (FOV) CBCT (cone beam computed tomography) is indicated for identifying the position of the impacted canines and evaluating root resorption of other teeth than full field CBCT to reduce radiation exposure [7]. In addition, conventional cephalometric digital image and digital panoramic radiograph should be taken assisting the diagnosis and management [7].

Early diagnosis and management are of paramount importance to prevent or limit the root resorption. Extraction of the primary canine is indicated when the permanent canine is ectopically positioned mesially and threatening the resorption of the incisor roots.

Ericson and Kurol stated that, if the permanent canine overlaps less than half of the lateral incisor roots then there is 91% chance of
normalization of the path of eruption [8]. When more than half of the lateral incisor root is overlapped, then early extraction results in 64% recovery in the normal pathway of the eruption with improvement in the canine position even it is not corrected totally.

**IMPACTED OR UNERUPTED TEETH**

Impaction of a tooth mainly occurs due to an arch length discrepancy, the presence of a barrier (e.g., odontomes, supernumerary teeth) that interferes with its eruption. Maxillary canine or canines are most frequently impacted. Although the management of impacted incisors, canines and premolars are all the same but other than maxillary canines it is less necessary to bring other impacted teeth into the alignment of the dental arch. Impacted lower second molar poses a different type of problems and should be managed uniquely [9].

Management of an unerupted tooth should be done in the following three steps: i) Surgical exposure, ii) Attachment to the tooth, iii) Orthodontic tooth movement to bring the tooth in proper occlusion [9].

**Surgical Exposure**

Before surgery, it is necessary to locate the unerupted tooth precisely. Nowadays, CBCT (cone beam computed tomography) with a small field-of-view is the most preferred diagnostic tool because the combination of panoramic and occlusal radiograph or multiple periapical radiographs are basically two-dimensional that provide much less information with similar radiation exposure [9]. During planning the exposure of an unerupted tooth it is important that the tooth erupts through the attached gingiva, not alveolar mucosa. The crown of a canine can be exposed by laser if it is labially positioned and is not covered with any attached tissue. Flap reflection can be done preferably from the crest of the alveolus in cases where the unerupted tooth is placed more apically in the mandibular arch.
or labially in the maxillary alveolar process and sutured so that the attached gingiva is transferred to the site of crown exposure. Without doing this if attempts are made to bring the unerupted tooth through the alveolar mucosa, the soft tissue will strip away from the crown which will ultimately result in an unsightly and periodontally compromised gingival margin. A tunnel method can be a good alternative to flap reflection for high canine positioned labially. Flap reflection for open exposure is less critical if the unerupted tooth is positioned palatally [9]. A tooth erupt willingly into its correct position after the obstruction (e.g., odontomes, supernumerary tooth) is removed surgically for exposure.

**Method of Attachment**

The best method is to directly bond, preferably a button or a hook to the exposed area of the crown. Then before repositioning the flap, a fine gold chain should be tied to the attachment and positioned so that it extends into the mouth after the flap is repositioned and sutured. The chain is easier to tie and safer to use than a wire ligature which is destructive to the periodontal tissues and bone surrounding the unerupted tooth [9].

**Mechanical Approaches for Aligning Unerupted Teeth**

Immediately after the surgical exposure, the impacted teeth should be pulled preferably away from the roots of other permanent teeth and brought into the occlusion by using orthodontic traction. Active orthodontic tooth movement should be started no more than two or three weeks after the surgery. Enough space should be created pre-surgically for the alignment of other teeth so that a heavy stabilizing arch wire can be in positioned at the time of surgery to start orthodontic tooth movement immediately afterwards [9].

In order to correct the asymmetric alignment problem which is often associated with an unerupted tooth, an auxiliary NiTi wire can be
incorporated on the stabilizing arch that brings the impacted tooth into position in a most effective manner [9].

Use of magnetic force can be an option to initiate unerupted tooth movement, particularly in a maxillary arch with other tooth missing. Because here mechanical attachment is not required. This is usually done by attaching a small magnet to the unerupted tooth and by placing a larger magnet in attraction within a palate covering-removable appliance [9].

Ankylosis is a potential problem for an unerupted tooth. A tooth may become ankylosed due to a small area of fusion to the surrounding bone. This can be managed by anesthetizing the area followed by gentle luxation of the ankylosed tooth to break the area of ankylosis and facilitate tooth movement. It is important to apply orthodontic forces immediately after the treatment as there is a high chance of re-ankylosis [9].

**Unerupted/Impacted Lower Second Molars**

Unlike impaction of other teeth, lower second molars are usually impacted during orthodontic treatment when the mesial marginal ridge of the lower second molar is locked against the distal surface of a lower first molar or against the edge of a lower molar band. As a result, instead of erupting, the lower second continues to tip mesially. Moreover, distal movement of the first molar during the mixed dentition period will add to the impaction of the second molar.

Treatment requires uprighting and tipping movement of the impacted second molar posteriorly. Usually, if the mesial marginal ridge can be unlocked, the tooth erupts on its own. If the second molar is not severely tipped then correction can be done simply by placing a separator between the teeth. In more severe cases, an attachment is bonded to the impacted second molar. An auxiliary spring may be useful. Another easy way is placing a segment of NiTi wire from the auxiliary tube on the first molar to the tube on the second molar. This provides a light force to align the second molars while a heavier and more rigid wire remains in place anteriorly, which is much better than attaching light round wire for the
entire arch just to align the second molars [9]. Surgical uprighting of the impacted second molar can be done in adolescents by utilizing the space after extracting the third molar.

**Midline Deviation**

Midline deviations are the most commonly faced problems in orthodontics. They may be either skeletal or dental in origin. A dental midline is a midsagittal line of the maxillary and mandibular dental arches possessing teeth of ideal size, shape, and position when situated in maximum intercuspation [10]. The facial midline is defined by an individual’s soft tissue symmetry such as the base of the nose, nasal apex, the center of the philtrum and central point of the chin [15].

Maxillary midline position relative to the facial midline possesses an important diagnostic feature in orthodontic treatment planning. The upper dental midline is usually evaluated by locating the tip of the gingival papilla between the central incisors which should be located below the center of the philtrum of the upper lip [10]. Sarver classified facial symmetry under following reference planes: Nasal tip to the mid sagittal plane, maxillary dental midline to mid sagittal plane, maxillary dental midline to the mandibular dental midline, mandibular dental midline to mid symphysis and the mid symphysis to the mid sagittal plane [15]. Often found in orthodontic patients that the maxillary and mandibular midlines deviate either with each other or relative to the midline facial structures during diagnosis. However, the subtle asymmetry between the dental and facial midlines are acceptable to certain limits but significant discrepancy altering the dental and facial aesthetics requires intervention [11].

**Classification**

According to the structures involved, midline deviations can be classified as [15]-
Individual Tooth/Teeth Malocclusion

Dental
Asymmetry between the maxillary and mandibular midlines.

Skeletal
It may either involve one bone such as maxilla or mandible or may involve a number of skeletal and muscular structures on one side of the face such as- hemifacial macrosomia.

Muscular
Abnormal muscle activity or muscular asymmetry also may result in midline deviation such as- hemifacial atrophy or cerebral palsy.

Functional
At the time of closure to achieve maximum intercuspation in centric relation, the mandible may be deflected laterally or antero-poteriorly due to narrow maxillary arch or occlusal interference such as a malposed tooth. Temporomandibular joint dysfunction associated with anteriorly displaced disc without reduction may result in midline shift during opening due to interference in mandibular translation on the affected side.

Etiology
According to Lundstrom, the midline deviation may be genetic or non-genetic in origin and is usually a combination of both. In general, there are three main causes of midline deviation: true skeletal asymmetry of the facial structures including the maxilla and mandible, dental asymmetries in one or both arches and deviation of the mandible during opening and closure [15].

Genetic Factors
- Neurofibromatosis.
- Hemifacial Microsomia
- Cleft lip and palate.
Undermined Pathology

- Osteochondroma of the mandibular condyle.
- Untreated fractures of the mandible.
- Ankylosis of the mandibular condyle to the temporal bone due to trauma and infection.
- Nerve damage resulting in loss of muscle function and tone.

Dental Asymmetry

- Early loss of deciduous teeth.
- Congenitally missing tooth or teeth.
- Habits such as thumb sucking.
- Asymmetry in the tooth size and shape.
- Asymmetry in the shape of dental arches.

Diagnostic Tools

- A detailed intra-oral and extra-oral clinical examination.
- Intra-oral and extra-oral photographs.
- Radiographic examination:
  - Lateral cephalogram
  - Postero-anterior cephalogram
  - Panoramic radiograph

Treatment

Correction of Dental Midline Deviation

True dental midline deviation due to congenital missing of the permanent tooth is treated orthodontically. The available treatment options
are asymmetric extraction sequences and asymmetric mechanics such as class III elastics on one side and class II elastics on the other side with oblique elastics anteriorly. If the deviation is pronounced then composite build-ups or fixed prosthodontic restorations may be considered [10].

**Correction of Skeletal Midline Deviation**

In growing patients, abnormal skeletal growth can be controlled by the orthopedic appliances in association with orthodontic treatment. Severe skeletal deformity requires a combination of surgery and orthodontic treatment [15].

**Correction of Functional Midline Deviation**

Mild deviations are corrected with minor occlusal adjustments, severe deviation requires orthodontic treatment. Occlusal splints can be given to break down the habitual posturing. Functional midline deviation due to skeletal asymmetry is treated by the combination of rapid maxillary expansion, orthognathic surgery and orthodontic treatment [10].

**Correction of Soft Tissue Asymmetries**

Midline deviations due to soft tissue asymmetries are treated either by the augmentation or reduction surgery to recontour desired areas of the face.

**Bimaxillary Protrusion**

Bimaxillary protrusion is a condition where both upper and lower incisors are proclined with increased procumbency of the lips. The patient has a convex facial profile. It is most commonly seen in African-American and Asian population but can be found in any ethnicity [11]. There may be various degrees of lip incompetence with strain on the mentalis, gummy smile and anterior open bite. The etiology of bimaxillary protrusion is multifactorial including genetics, abnormal tongue and lip habits, mouth breathing and tongue volume [13].
The essential diagnostic tools are study model analysis, lateral cephalogram, panoramic radiographs.

The aim of the treatment is to effectively retract and retrocline both maxillary and mandibular incisors with a significant decrease in the soft tissue procumbency and convexity [11]. The most common choice of treatment is the extraction of four first permanent premolars followed by the retraction of anterior teeth with maximum anchorage mechanics [11]. However, retroclination of the lower incisor will reduce the tongue space which may increase the possibility of relapse after the treatment. If the lips are incompetent but there is good muscle tone and greater possibility to achieve lip to lip seal, chances of stability is more after incisor retraction. But where the bimaxillary protrusion is associated with competent lips or severely incompetent lips, it is advisable not to proceed the treatment as there is a high chance of relapse [13].

**MEDIAN DIASTEMA**

Spacing between the two maxillary central incisors is termed as a median diastema. This gap is usual of normal growth pattern during the primary and mixed dentition period and is closed by the time of the permanent maxillary canine eruption. However, in some cases, the spacing may not close physiologically, particularly after the completion of the permanent canine eruption. Median diastema occurs 98% of deciduous dentitions, 49% of early mixed dentition and only 7% of the late mixed dentition periods [14].

**Etiology**

Factors considered to be responsible for the median diastema are:

- Physiological during normal dental development.
- The discrepancy between arch length and tooth material.
Individual Tooth/Teeth Malocclusion

- Missing teeth (e.g., Lateral Incisors).
- The supernumerary tooth in the midline.
- Abnormal tooth size and shape (e.g., Peg laterals)
- Proclination of the upper anterior segment.
- Prominent frenum.
- Pernicious habits. (such as- digit sucking, lower lip biting)
- Endocrine Imbalance (such as- acromegaly)
- Other pathologies in the midline (such as-cysts, fibromas).

**Diagnosis**

*Thorough Medical and Dental History*

For medical problems such as hormonal imbalance and dental problems such as oral habits, previous dental treatments, family history of diastemas etc are required to be noted.

*Clinical Examination*

For oral habits, soft tissue imbalances (e.g., macroglossia), excessive overbite/overjet, missing teeth or any other dental anomalies. Blanching tests are useful to detect abnormal frenal attachments. If the fraenum is in tension there will be blanching of the incisive papilla.

*Panoramic and Periapical Radiographs*

Used to detect dental age, physical obstruction, abnormal suture morphology, missing teeth, abnormal eruption pathway or other dental anomalies.

**Treatment**

The success of diastema treatment requires the accurate diagnosis of the specific etiology and the management specific to the etiology. Intervention is usually not required in diastemas less than 3 mm. Treatment
should be delayed until the eruption of the permanent maxillary canines is completed [14].

In a patient where closure of the diastema is limited to the central incisors with good posterior occlusion, diastema can be treated simply with a removable appliance. A Hawley appliance with finger springs is commonly used for the mesial tipping of the incisors. But with removable appliances, there is a greater tendency of relapse. On the other hand, fixed appliances provide better control of dental alignment. The Simple fixed appliances are often used for tipping movement and full banded/bracketed arch appliances are applied for the bodily movement of the incisors [14].

In midline diastemas caused by the missing teeth, the spaces can be closed orthodontically and then reconstructed with a fixed prosthesis after redistribution of the space by the orthodontic treatment. In some cases, the spaces can be closed by tooth recontouring with composite resin.

Median diastemas due to abnormal maxillary frenal attached should be treated by frenectomy and circumferential supra-crestal fibrostomy in conjunction with the orthodontic treatment to prevent the relapse [14].

Permanent retention is required because even the best treated median diastema has a tendency to relapse. A lingually bonded fixed retainer is recommended.

REFERENCES

Individual Tooth/Teeth Malocclusion


Chapter 7

CLASS II MALOCCLUSION

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ABSTRACT

Class II malocclusion is an unfortunate overview which assemblages’ together morphologies of extensive extending varieties often with one common trait, their abnormal molar relationship. Only Angle’s classification is considered as a standard method for identifying and classifying the types of Class II malocclusion. However, Angle’s classification has innate flaws, as it does not comment upon the etiology or the underlying skeletal structures. Class II malocclusion is the most common and the toughest to treat as compared to other malocclusions, due to its wide ranging varieties and relationship of various types of etiological factors.

It is very important for every orthodontist to have acceptable knowledge and precise understanding of the various types of Class II

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malocclusions before starting a treatment plan. There is no collective method of dealing with the condition. It is important to have an adequate knowledge of normal growth pattern and various cephalometric analysis for proper diagnosis and treatment planning. The aim of this chapter is to describe details about Class II malocclusion, etiology, types and different treatment options.

**INTRODUCTION**

Most people have some degree of malocclusion. A malocclusion is a misalignment of teeth and/or incorrect relation between the teeth of the upper and lower dental arches [6, 15, 17]. Malocclusion is usually an inherited condition. This means it can be passed down from one generation to the next. According to Angle’s classification, when mesiobuccal cusp of the upper first permanent molar occludes with the mesiobuccal groove of the lower permanent first molar is known as Class I or ideal occlusion. There are three major classes of malocclusion: Class I, Class II and Class III malocclusion. Class II malocclusion subdivided into Class II Division 1 and Class II Division 2. When the mesiobuccal cusp of upper permanent first molar is placed mesial to the Class I relation then it called Class II malocclusion. Condition when Class II molar relationship is present with proclined upper central incisors is called Class II Division 1 and same molar relation with retroclined upper central incisors is called Class II Division 2 malocclusion [3, 5, 6, 12, 15, 16, 17]. Class II malocclusions have a strong hereditary component as etiological factors, both in families and in ethnic and racial groups [9]. This phenotype can be recognized at an early age and becomes progressively more evident with growth, appearing as one of the main factors that force patients to seek orthodontic and surgical treatment. Patients having severely proclined upper anterior teeth with narrow maxilla may affect in terms of speech that may affect self-confidence of the individual. This may also affect in career capability. The primary concern of most of the orthodontic patients is to improve their dentofacial aesthetics and the secondary concern is to have oral health benefits [1].
Class II malocclusion can be treated by several means, depends on various factors, such as anterior posterior discrepancy, according to the characteristics associated with the problem, age and patient compliance [2]. Methods include extra oral appliance, functional appliance and fixed appliance associated with Class II intermaxillary elastics [14].

Now-a-days fixed appliances are recommended for treating all kind of malocclusions. The duration of orthodontic treatment with fixed braces is 2 to 3 years on average [8]. However, the patient does not expect more than 1.5 years [18]. Prolonged treatment duration is also detrimental to the productivity of a national health care system and private practices too [19].

**CLASS II MALOCCLUSION**

Angle assumed in his classification of malocclusion that the first permanent molars are constant in relation to jaws, which is associated to the relative sagittal position of mandible and maxilla. When maxillary first permanent molar is more mesially positioned than the mandibular first permanent molar, it is called Class II malocclusion [4]. In contrast, British Orthodontic Society (1992) announced a classification for malocclusions that was based on the incisal relationships. In which mandibular incisor edges are positioned backward to the cingulum plateau of maxillary incisors [21].

Still, Angle’s classification is regularly used due to its simplicity. However, many authors criticized and pointed out due to the vertical and transverse considerations [7, 20]. According to Angle’s classification of malocclusion, Class II malocclusion embraces different dental and skeletal mechanisms that may vary from the perception of the normality. Such skeletal disparity is a consequence from growth resentment between maxilla and mandible creates a convex facial profile. Class II malocclusion is of great concern for a fact that many patients having this malocclusion are treated routinely for orthodontic reasons [14]. The concern of development in Class II subjects has become important because of the
increasing awareness in enhancing treatment timing and planning in dentofacial orthopedics.

CLASSIFICATION OF CLASS II MALOCCLUSION

Class II Malocclusion has two divisions to describe the position of the anterior teeth.

- Class II Division 1: When the maxillary anterior teeth are proclined and a large overjet is present is termed as Class II Division 1 (Figure 1).
- Class II Division 2: Where the maxillary anterior teeth are retroclined and a deep overbite exists is termed as Class II Division 2 [10] (Figure 2). Additional Van der Linden has classified the Class II Division 2 into three types reliant on the severity:
  - Type A: When the upper central and lateral incisors are retroclined. It is less severe in nature (Figure 3).
  - Type B: When the central incisors are retroclined and are overlapped by the lateral incisors (Figure 4).
  - Type C: When the central and lateral incisors are retroclined and are overlapped by the canines (Figure 5).

Figure 1. Class II division 1 malocclusion.
Figure 2. Class II Division 2 malocclusion.

Figure 3. Class II Division 2 malocclusion type A (Adapted from web).

Figure 4. Class II Division 2 malocclusion type B.
**Etiology of Class II Malocclusion**

**Skeletal Pattern**

A Class II division 1 incisor relationship is generally related with a Class II skeletal pattern, mainly due to a retrognathic mandible (Figure 6). Nevertheless, Class II division 2 malocclusion is generally associated with a mild Class II skeletal pattern, but may also follow in association with a Class I or even a Class III dental base relationship. Proclination of the upper incisors and/or retroclination of the lower incisors by a habit or the soft tissues can result in an increased overjet on a Class I, or even a Class III skeletal pattern.
Various kind of skeletal patterns are found to be associated with incisor relationship in Class II malocclusion. Management of those patients with significantly increased or significantly reduced vertical proportions is usually difficult and is the province of the specialist.

**Soft Tissue Pattern**

The impact of the soft tissues on a Class II malocclusion is mostly mediated by the skeletal pattern, both vertically and anteroposteriorly. Though, the functional activity and resting position of the soft tissues also plays an important part. Usually, the lips are incompetent in a Class II division 1 malocclusion owing to the prominence of the upper incisors and/or the underlying skeletal pattern. If the lips are incompetent, the patient will try to attain an anterior oral seal in one of the following ways:

- circumoral muscular activity to achieve a lip seal (Figure 7);
- move the mandible forwards to allow the lips to meet at rest;
- the lower lip is drawn up behind the upper incisors;
- the tongue is placed forwards between the incisors to contact the lower lip, often contributing to the development of an incomplete overbite;
- a combination of these.

Where a patient can attain lip seal by circumoral muscle activity or positioning the mandible forwards, the soft tissues often effect the underlying skeletal pattern by dento-alveolar compensation. More frequently the lower lip functions by being drawn up behind the upper incisors, which leads to retroclination of the lower labial segment and/or proclination of the upper incisors with the result that the incisor relationship is more severe than the underlying skeletal pattern.

Nevertheless, if the tongue consistently comes forward to interact with the lower lip, proclination of the lower incisors may occur, helping to recompense the underlying skeletal pattern. This type of soft tissue actions
is often related with increased vertical skeletal proportions and/or grossly incompetent lips, or a habit which has caused in an increase in overjet and an anterior open bite. In practice, it is often tough to determine the degree to which this is adaptive tongue behavior or whether a rarer endogenous tongue thrust exists.

Occasionally, a Class II division 1 incisor relationship happens owing to retroclination of the lower incisors by a very active lower lip.

On the other hand, the effect of the soft tissues on Class II division 2 malocclusions is usually facilitated by the skeletal pattern. The lower lip line seems higher compared to the crown of the upper incisors when the lower facial height is reduced (more than the normal one-third coverage). A high lower lip line usually has a tendency to retrocline the upper incisors. Upper lateral incisors with shorter crown length will escape the action of the lower lip, so they often lie at an average inclination while the central incisors are retroclined.

Dental Pattern

Presence of crowding, spacing or tooth size discrepancies may cause Class II division 1 incisor relationship. Lack of space due to the crowded
arch may result in the upper incisors being crowded out of the arch labially and thus cause exacerbation of the overjet. Inversely, lower arch crowding in the labial segment may benefit to compensate for an increased overjet in the same manner.

As with other malocclusions, crowding is regularly seen in combination with a Class II division 2 incisor relationship. Moreover, any previous crowding is aggravated because of the retroclined upper central incisors results in them being positioned in an arc of smaller circumference. Lack of space due to the retroclined central incisors, upper lateral incisors are usually crowded and are typically rotated mesiolabially out of the arch.

**Genetic Factor**

The relative influence of genes and the environment to the etiology of malocclusion has been a matter of dispute throughout the twentieth century. Genetic contrivances are undoubtedly playing an important role during embryonic craniofacial morphogenesis; however, environmental factors are also believed to influence dentofacial morphology postnatally, mostly in facial growth. Both genetic and environmental influences play major role in the development of Class II malocclusion. Different studies proved that patients with Class II relationship have shown that this condition is heritable and is consistent with a polygenic mode of inheritance [13]. However, only one study found by Gutierrez et al., in which genetic analysis were carried out in four Colombian families with Class II malocclusion and found that homozygous rare allele in SNP on the Nog (Noggin) gene [11].

**Habits**

An orthodontic force can be generated upon the teeth by a persistent digit-sucking habit if indulged for more than a few hours per day. The
severity of the effects will depend upon the duration and the intensity, but the following are commonly associated with a determined habit (Figure 8):

- Proclination of the upper incisors
- Retroclination of the lower labial segment
- An incomplete overbite or a localized anterior open bite;
- Narrowing of the upper arch thought to be mediated by the tongue taking up a lower position in the mouth and the negative pressure generated during sucking of the digit.
- The first two effects will contribute to an increase in overjet.

For Class II division 2 malocclusion following features are found:

- Retroclination of the upper central incisors
- Average angulation or are proclination of the lateral incisors
- Retroclination of the upper lateral incisors where the lower lip line is very high
- Patients with severe Class II skeletal pattern the overbite may be complete onto the palatal mucosa
- Severe Class II skeletal pattern can causes lingual crossbite of the first and occasionally the second premolars (Figure 9)

Figure 8. Effects of digit sucking habits (Adapted from web).
TREATMENT OF CLASS II MALOCCLUSION

Most of the patients with Class II malocclusion are treated with fixed orthodontic. Orthodontics can be relied upon to achieve a good outcome for the most patients with mild Class II skeletal bases. Managements of Class II malocclusion depends on three important factors:

1. Age of the patient
2. The nature and severity of the problem
3. The underlying etiologic factors from the clinical and functional examination.

Therefore, management of Class II malocclusion can have three approaches:

1. Anticipate preventing the malocclusion from developing
2. Interceptive treatment of the developing malocclusion
3. Management of an already developed malocclusion.

The standard treatment of severe Class II malocclusion in the adolescent stage is orthognathic surgery [22]. Orthodontic camouflage treatment can also be attempted in some cases. However, in younger ages...
before the puberty the orthopedic treatment is the treatment of choice especially in early mixed dentition years [1].

**Camouflage Treatment**

Orthodontic camouflage of moderate Class II malocclusion can be done without surgery only by retracting the maxillary teeth and proclining the mandibular teeth. Moreover, application of skeletal anchorage now makes it possible to move the entire maxillary dentition distally. However, due to deficient amount of supporting bone will may show negative result for the dentition. A patient who might be a candidate for Class II camouflage treatment would have increased overbite and overjet due to protrusive maxillary incisors and retrusive mandibular incisors, with more mandibular deficiency than maxillary prognathism, as well as long anterior face height (Figure 10 & 11).

Figure 10. Camouflage treatment of Class II Division 1 malocclusion (Adapted from web).

Figure 11. Camouflage treatment of Class II Division 2 malocclusion (Adapted from web).
Following three patterns of tooth movement can be used to correct Class II malocclusion:

**Non-Extraction**

*Class II Division I Malocclusion:*

Treatment with Class II elastics is usually the treatment of choice in these type of cases. A combination of retraction of upper teeth and proclination of lower teeth is effected without doing extraction (Figure 12). After treatment, lip pressure moves lower incisors lingually leading to:

- Lower incisors crowding
- Return of overjet
- Return of overbite

*Class II Division 1 Malocclusion*

Dental camouflage without extraction is rare in case of skeletal Class II malocclusion

- Mild skeletal Class II cases
- Mild excessive overjet
- Adequate space available
- Maxillary molar distalization

**Retraction of Maxillary Incisors into a Premolar Extraction Space**

Extraction of maxillary first pre-molar, leading to retraction of incisors in premolar space without lower extraction:

- Class II molar relation
- Class I canine relation
- Normal overjet
Extraction of maxillary 1st premolars and mandibula 2nd premolars, with the use of Class II elastics, bring lower molars forward and retract upper incisors:

- Class I molar relation
- Class I canine relation
- Normal overjet

**Distal Movement of Upper Teeth**

- Rotation of maxillary 1st molars mesiolingually, correcting rotation moves buccal cusps posteriorly and provides at least a small space mesial to the molar.
- Extraction of 2nd molar creates a space for distal movement of maxillary 1st molar, then with the help of combination distalization-expansion appliance (PENDEX) distal tipping of molars is done which opens about 2/3rd of space between premolar and molar, which provides molar no more than molar half cusp correction (Figure 11).
- Bone anchors are placed bilaterally in the vicinity of base of zygomatic arch or in palate and a nickel titanium spring generates the force needed for distalization (Figure 12).
Orthognathic Surgery

Usually, the surgery done in case of Class II malocclusion is to move the maxilla backwards by maxillary segmental setback osteotomy in case of proclination of maxilla caused the malocclusion (Figure 13). However, patients with mandibular deficiency need sagittal split osteotomy mandibular advancement to correct the malocclusion (Figure 14). Sometimes, bilateral sagittal split osteotomy mandibular advancement
followed by sliding Genioplasty is also performing to make the chin protruded (Figure 15). However, if the Class II malocclusion caused by due to both maxillary and mandibular arch then bimaxillary orthognathic surgery is perform to correct malocclusion in proper manner (Figure 16).

The main advantage of surgical intervention is it to provide a rapid treatment option with limited need for patient cooperation. Moreover, it can correct the facial patterns with direct access for bony correction, without any opposed dental tipping that is often accompanied with conventional orthodontic treatment [76]. On the other hand, the orthognathic surgery has many disadvantages. It is invasive, expensive and should be done after growth cessation so that patients suffer from the deformity for a long time before treatment and a certain degree of relapse is also still present [76].

Figure 13. Maxillary segmental setback osteotomy (Adapted from web).

Figure 14. Sagittal split osteotomy mandibular advancement (Adapted from web).
Orthopedic Treatment

The goal of growth modification by orthopedic treatment is to enhance the unacceptable skeletal relationship by modifying remaining facial growth pattern of the jaws. Optimum timing is Pre-pubertal growth spurt (active growth period).

Two types of orthopedic appliances used in skeletal Class II malocclusion:
Headgear

Growth modification by attempting control of maxillary growth, by encouraging mandibular growth, or using the combination of the two. Headgear is considered useful to try and restrain growth of the maxilla horizontally and/or vertically, depending upon the direction of force relative to the maxilla (Figure 17). Functional appliances seem to produce partial restraint of maxillary growth while encouraging mandibular growth. Nevertheless, many recent studies have revealed that the actual amount of growth modification achieved is inadequate; and success is dependent upon favourable growth and an enthusiastic patient.

![Figure 17. Head gear (Adapted from web).](image)

Functional Appliances

Class II functional appliances are designed to position the mandible in downward and forward position to enhance its mandibular growth patterns in case of mandibular deficiency.

Removable functional appliances are:

- Activator
- Bionator
- Twin block
- Frankyl II
Moreover, fixed functional appliances are:

- Herbst
- Jasper jumper

**REFERENCES**


Chapter 8

CLASS III MALOCCLUSION

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ABSTRACT

Class III malocclusion has been the subject of interest in many researches, due to the challenges in its class treatment. Researchers concluded that diverse combinations of skeletal and dental rudiments are drawn in to produce Class III malocclusion. It may due to maxillary deficiency, overgrowth of mandible or a complexion of both. Whatever the reason, to find out the exact etiology and treat the Class III malocclusion is a big challenge in orthodontics. It is essential to know the exact etiology and all predisposing factors to treat Class III malocclusion. The aim of this chapter is to describe details about Class III malocclusion, etiology, types, prevalence in different populations and different
treatment options. Retention appliances are mandatory to be worn until growth cessation. Patients’ compliance is necessary in case of extending treatment protocols to achieve successful and stable treatment results. Surgical intervention may still be needed in a few cases. More advanced treatment procedures will offer hope for patients so that psychological setbacks are avoided and decreased during the formative years of life.

**Keywords:** Class III malocclusion, classification, prevalence, treatment

**INTRODUCTION**

Angle assumed in his classification of malocclusion that the first permanent molars are constant in relation to the jaws, which is associated to the relative sagittal position of mandible and maxilla. When a mandibular first permanent molar is more mesially positioned than the maxillary first permanent molar, it is called a Class III malocclusion (Angle, 1907) (Figure 1). In contrast, British Orthodontic Society (1992) announced a classification for malocclusions that are based on the incisal relationships, in which mandibular incisor edges are positioned forward to the cingulum plateau of maxillary incisors (Williams and Stephens, 1992) (Figure 2).

Still, Angle’s classification is regularly used due to its simplicity. However, many authors criticized and pointed out the vertical and transverse considerations (Case, 1921; Van Loon, 1915). According to Angle’s classification of malocclusion, Class III malocclusion embraces different dental and skeletal mechanisms that may vary from the perception of normality; this phenomenon may occur either due to retrusion of maxilla, protrusion of mandible or a blend of both (Graber et al., 2016). Sanborn stated in his study that Class III malocclusion observed that 33%, 45.2% and 9.5% of the subjects were perceived due to maxillary retrusion, mandibular protrusion and a combination of both skeletal patterns, respectively (Sanborn, 1955). Such skeletal disparity is consequent of the growth resentment between maxilla and mandible; this creates a concave facial profile. Class III malocclusion is of great concern
due to the fact that many patients have this malocclusion and are treated routinely for orthodontic reasons (Cruz et al., 2008).

Figure 1. Angle’s Class III malocclusion.

Figure 2. Incisor relationships of Class III malocclusion.
CLASSIFICATION OF CLASS III MALOCCLUSION

Mostly, Class III malocclusion is classified into three types - dental, skeletal and pseudo type (Graber et al., 2011).

Dental Features of Class III Malocclusion

Patient with dental Class III malocclusion usually showing molar relation in Class III but incisor relation might display edge-to-edge relationship or anterior crossbite. The maxillary arch is narrower and crowded while the mandibular arch is often spaced (Iyyer et al., 2012).

Skeletal Features of Class III Malocclusion

Generally, Class III malocclusion is associated with underlying skeletal mal-relationship. Commonly seen skeletal features are:

- A short or retrognathic maxilla
- A long or prognathic mandible
- A combination of both (Graber et al., 2011)

Pseudo Type Class III Malocclusion

Pseudo type Class III malocclusion is categorized by presence of premature occlusal contact that causes a habitual forward positioning of the mandible. These patients may exhibit a forward path of closure (Iyyer et al., 2012). Different authors also modified the classification of Class III in different ways (Park and Baik, 2001; Tweed, 1966). Park and Baik, (2001) classified Angle’s Class III malocclusion into three categories based on abnormalities on maxillae.
• Type A: true mandibular prognathism, where the mandible is overgrown but the maxilla is normal
• Type B: characteristics of the overgrown mandible and maxilla along with anterior crossbite
• Type C: indicates a hypoplastic maxilla with anterior crossbite (Park and Baik, 2001)

Moreover, Tweed, (1966) classified Class III malocclusion into two categories,

• Category A: Pseudo Class III malocclusion with conventional shaped mandible
• Category B: Skeletal Class III malocclusion with large mandible or underdeveloped maxilla (Tweed, 1966)

**Prevalence of Class III Malocclusion**

The prevalence of Class III malocclusion has been described between 1% (Emrich et al., 1964; Hill et al., 1959) to over 10% (El-Mangoury and Mostafa, 1990), depending on ethnic backgrounds (Emrich et al., 1964), gender (Baccetti et al., 2005; El-Mangoury and Mostafa, 1990) and age (Thilander et al., 2001). It has been reported that approximately 75% of Class III malocclusion cases in male Caucasians have a skeletal origin and were a result of mandibular prognathism or macrognathia (Staudt and Kiliaridis, 2009). The prevalence of Class III malocclusion among Caucasian people ranges from 0.48% to 4% (Emrich et al., 1964). However, compared to Caucasian people the prevalence of Class III malocclusion is higher in the Japanese population, reaching up to 10% (Nakasima et al., 1986).

Several studies have documented the prevalence of Angle’s Class III malocclusion. However, different populations have different proportions (El-Mangoury and Mostafa, 1990; Hill et al., 1959; Staudt and Kiliaridis,
Multiple studies have stated that Asian ethnic groups have a higher prevalence of Angle’s Class III malocclusion than other ethnic groups (Emrich et al., 1964; Lew et al., 1993; Onyeaso, 2004; Soh et al., 2005; Tang, 1994a; Tang, 1994b; Woon et al., 1989). In other populations, the prevalence of Class III malocclusion was found between 1-5%, whereas in Chinese and Korean population it increased 9.4 to 19% (Chan, 1974).

Table 1 shows the prevalence of Class III malocclusion in different studies among different ethnic groups.

**Caucasian People**

Emrich et al., (1964) observed 10,133 Caucasian children that were 6-8 years old and 13,475 children that were 12-14 years old and found that 1% of both groups had Class III malocclusion (Emrich et al., 1964).

**Black People**

Altemus, (1959) reviewed 3,289 black people between the ages of 12 and 16 years and reported that Class III malocclusion was present in 5% of them (Altemus, 1959). Emrich et al., (1964) also found that 3% of the black people surveyed at the age of 12 to 14 years and 2% of the black people surveyed at the age of 6-8 years had Class III malocclusion (Emrich et al., 1964). Dacosta, (1998) also found that 2% of 1,028 school children in Northern Nigeria had Class III malocclusion (Dacosta, 1998). The prevalence of malocclusion was investigated in 245 children from a pastoral community in Kenya and it was found that 5% of them had Class III malocclusion (Ng'Ang'A et al., 1993). Similarly 1,601 school going children including 16 different primary schools in Tanzania, aged 12 to 16 years were observed and among them only 2% of children were found having Class III malocclusion (Mtaya et al., 2009). In contrast, in another study among Tanzanian’s 289 randomly selected primary school children
were taken to observe the prevalence of malocclusion and 11% had documented for Class III malocclusion (Rwakatema and Nganga, 2006).

**Europeans**

Perillo et al., (2010) collected 703 samples of 12 years old school children from southern part of Italy to check the prevalence of malocclusion (Perillo et al., 2015). That study showed 4.3% prevalence of Class III malocclusion. Another article documented that 4% of 137 Swedish subjects at 21 years of age, had Class III malocclusions (Thilander et al., 2001). The prevalence of malocclusion was surveyed among 7–15 years old Lithuanian school children and 2.8% had Class III malocclusion (Šidlauskas and Lopatienė, 2009).

**Asian People**

**Chinese People**

Lew et al., (1993) surveyed 1,050 Chinese school children of age between 12 to 14 years to assess certain occlusal features, both qualitatively and quantitatively (Lew et al., 1993). The population was found to have a high incidence of Class III malocclusions (12.6%) compared with Caucasians (5.5%). In addition, 19.9% among 201 Chinese adult showed prevalence of Class III malocclusion (Tang, 1994b). They also checked the prevalence of malocclusion among 108 young Chinese individuals and concluded that 14.8% had Class III malocclusion (Tang, 1994a).

**Indian People**

One Indian study showed that among 3,164 samples (age 6-15 years) only 1.3% had Class III malocclusion (Guaba et al., 1998).
Malaysian People

Woon et al., (1989) surveyed the occlusal relation between three ethnic groups Chinese, Malay and Indian in Malaysia (Woon et al., 1989). He found significantly higher prevalence of Class III occlusion among the Chinese and Malay ethnic groups compared to the Indian ethnic group in Malaysia. In addition, Soh et al., (2005) also studied Chinese, Indian and Malay ethnic groups and documented the prevalence rate of Class III malocclusion were 22.9%, 4.8% and 26.7% respectively (Soh et al., 2005).

Table 1. Prevalence of Class III malocclusion in different ethnic group

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Ethnic group</th>
<th>Number of samples</th>
<th>Prevalence</th>
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<td>1965</td>
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<td>Altemas LA</td>
<td>1959</td>
<td>African-American</td>
<td>3,289</td>
<td>5%</td>
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<tr>
<td>Emrich et al.</td>
<td>1965</td>
<td>African-American</td>
<td>##</td>
<td>3%</td>
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<tr>
<td>Dacosta OO</td>
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<td>Nigeria</td>
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<td>2%</td>
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<tr>
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<td>1993</td>
<td>Kenya</td>
<td>245</td>
<td>5%</td>
</tr>
<tr>
<td>Mtaya et al.</td>
<td>2009</td>
<td>Tanzania</td>
<td>1,601</td>
<td>1.81%</td>
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<td>Rwakatema et al.</td>
<td>2006</td>
<td>Tanzania</td>
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<td>19.72%</td>
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<td>Perillo et al.</td>
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<td>703</td>
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<td>Sweden</td>
<td>137</td>
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<tr>
<td>Šidlauskas &amp; Lopatienė</td>
<td>2009</td>
<td>Lithuania</td>
<td>1681</td>
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<td>Lew et al</td>
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<td>Chinese</td>
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<td>Woon et al.</td>
<td>1989</td>
<td>Chinese, Indian, Malay</td>
<td>154, 42, 151</td>
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<td>Guaba K</td>
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<td>India</td>
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<td>Soh</td>
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<td>Chinese, Indian, Malay</td>
<td>258, 21, 60</td>
<td>22.87%, 4.76%, 26.67%</td>
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<td>Tang E</td>
<td>1994</td>
<td>Chinese</td>
<td>201</td>
<td>19.90%</td>
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##, Not mentioned in literature; %, percentage.
AETIOLOGY OF CLASS III MALOCCLUSION

Class III malocclusion is a multifactorial disease mainly with skeletal involvement. Whereas risk factors such as environment and genetics can manifest on progression of the disease.

Skeletal Intervention

The location of the temporomandibular articulation and to some extent displacement of the lower jaw equally disturbs the vertical and sagittal relationships of jaw and teeth of maxilla and mandible (Björk, 1950; Hopkin et al., 1968; Kerr and Tenhave, 1988; Williams and Aarhus, 1986). Size and relative positions of the cranial base, position of the spinal column, foramen magnum (Houston, 1988) and habitual head position (Jacobson, 1989) might also effect the subsequent facial pattern.

Environmental Factors

Extensive varieties of environmental factors have been suggested as contributing to the development of Class III malocclusion. Hormonal disturbances (Pascoe et al., 1960), trauma and disease, a habit of protruding the mandible, posture, pituitary glandular dysfunction, premature loss of the first molar (Gold, 1949), congenital anatomic defects (Monteleone and Duvigneaud, 1963), enlarged tonsil, difficulty in nasal breathing (Angle, 1907), irregular eruption of permanent incisors or loss of deciduous incisors (Rubbrecht, 1939) are considered main environmental factors contributing to Class III malocclusion.

Genetic Factors

Class III malocclusion is considered as a developmental problem. Moreover, hereditary or genetic factors play an important role in
craniofacial development (Graber et al., 2011). It has already been acknowledged that genes are involved in the guidelines of growth of skeleton (Le Roith and Butler, 1999). The role of genetics in the pathogenesis of Class III malocclusion is unravelling gradually. There are around 15 genes suggested to attain polymorphism and they have been related to Class III malocclusion (Frazier-Bowers et al., 2009; Jang et al., 2010; Nikopensius et al., 2013; Perillo et al., 2015; Xue et al., 2010; Yamaguchi et al., 2005; Zhou et al., 2005). To yield proper immune response, the hormonal and cellular components of immune system should essentially co-ordinate (Gudmundsson and Agerberth, 1999). Any genetic flaw and/or functional impairment results in a tendency to Class III malocclusion (PA and D ORTH, 1999).

**TREATMENT OF CLASS III MALOCCLUSION**

The standard treatment of moderate or severe Class III malocclusion patients in the adolescent stage is orthognathic surgery (Yen, 2011). Orthodontic camouflage treatment can also be attempted in some cases. However, in younger ages, before the puberty the orthopedic treatment is the treatment of choice especially in early mixed dentition years (Feng et al., 2012; Williams et al., 1997).

**Camouflage Treatment**

Orthodontic camouflage of moderate Class III malocclusion can be done without surgery only by proclining of the maxillary teeth and retracting of the mandibular teeth. Moreover, application of skeletal anchorage now makes it possible to move the entire mandibular dentition distally (Proffit et al., 1989). However, due to prominent chin and deficient amount of supporting bone may show negative result for the dentition
especially when the patient has a large and prominent mandible (Steinberg et al., 1999).

A patient who might be a candidate for Class III camouflage treatment would have reverse overbite and reverse overjet largely due to protrusive mandibular incisors and retrusive maxillary incisors, with more maxillary deficiency than mandibular prognathism, as well as short anterior face height. The downward–backward rotation of the mandible can be done during orthodontic treatment would improve vertical facial proportion. Class III malocclusion is rare in patient of European descent but occurs more frequently in Asians according to prevalence, so camouflage treatment in Class III malocclusion is likely to be more useful in patients of Asian descent (Proffit et al., 2013) (Figure 3).

Figure 3. Camouflage treatment done in Class III malocclusion case (Adopted from web).
Orthognathic Surgery

Usually, the surgery conduct in case of Class III malocclusion is to advance the maxilla by Le Fort 1 (Figure 4) in case the retruded maxilla caused the malocclusion. However, patients with severe mid face deficiency may require Le Fort 2 or 3 (Figure 5 & 6). In case of prognathic mandible, bilateral sagittal split osteotomy surgical procedure is done to correct the occlusion (Figure 7). Sometimes, bilateral sagittal split osteotomy followed by Genioplasty is also performed in cases of protruded chin (Figure 8). However, if the Class III malocclusion is caused due to both maxillary and mandibular arch then bi-maxillary orthognathic surgery is performed to correct malocclusion in proper manner (Figure 9).

The main advantage of surgical intervention is it provides a rapid treatment option with limited need for patient cooperation. Moreover, it can correct the reverse cross-bite, facial patterns with the direct access for bony correction, without any opposed dental tipping that is often accompanied with conventional orthodontic treatment (Yen, 2011). On the other hand, the orthognathic surgery has many disadvantages. It is invasive, expensive and should be done after growth cessation so that patients suffer from the deformity for a long time before treatment and a certain degree of relapse is also still present (Yen, 2011).
Figure 5. Pattern of Le Fort 2 surgery (Adopted from web).

Figure 6. Pattern of Le Fort 3 surgery (Adopted from web).
Figure 7. Bilateral sagittal split osteotomy surgical procedure for mandibular setback (Adopted from web).

Figure 8. Genioplasty for protruded chin (Adopted from web).
Orthopaedic Treatment

The concept of orthopedic treatment includes the application of protraction forces on the maxilla or retraction forces in mandible depends on skeletal patterns. The therapeutic managements designed to influence the facial morphology during growth. Growth can be modified using functional intraoral appliances or extra oral traction (Merwin et al., 1997).

Functional Intraoral Appliances

There are few alternatives in Class III treatment with intraoral appliances that can cause skeletal changes through neuromuscular modifications. These include the Fränkel III (Fränkel, 1970), Reverse twin block (Clark, 1982), Tandem appliance (Klempner, 2011), the removable mandibular retractor (Tollaro et al., 1995) and the 2-piece corrector (Eganhouse, 1997).
The Frankel III (FR-III) appliance has been extensively used as a functional intra oral appliance in correction of Class III malocclusion (Baik et al., 2004; Levin et al., 2008) (Figure 10 & 11). These studies reported that FR-III appliance encourages backward and downward movement of the mandible with slight forward maxillary movement, where as the dentoalveolar effect is mainly due to retroclination of the mandibular incisor. The limited effect of FR-III appliance on the maxilla is mainly due to its design, the FR-III appliance restrict the force of the soft tissue on the maxilla and transmit it to the mandible through the upper lip pad. This consider as major weakness in the FR-III appliance on the treatment of Class III malocclusion cases that is associated with maxillary retrusion and makes its effect more suitable for cases with mandibular protrusion only.

Figure 10. Frankel III appliance (Adopted from web).
The Twin block appliance developed by Clark, (1995) which consist of upper and lower removable inclined plate for treatment of Class II malocclusion (Clark, 1982). The first clinical report for using the reverse twin block appliance is done by Kidner et al., (2003) and he found that the reverse twin block appliance can decrease the SNB angle, increase the anterior vertical dimension and retroclination of mandibular incisor and proclination of maxillary incisor (Kidner et al., 2003) (Figure 12 & 13).

Figure 11. Clinical application of Frankel III appliance (Adopted from web).

Figure 12. Reverse twin block appliance (Adopted from web).
Figure 13. Clinical application of Reverse twin block appliance (Adopted from web).

Figure 14. Tandem appliance (Adopted from web).

Tandem appliance was introduced by Klempner in 2011 as an attempt for early treatment of Class III open bite malocclusion without increasing
the vertical dimension (Klempner, 2011). Tandem appliance has an upper fixed maxillary expander with soldered buccal arms for elastics attachments and lower removable component with bite blocks to control the vertical dimension and face-bow tubes in first molar region. Tandem appliance can treat Class III open bite in children without unfavorable increase in the lower vertical dimension (Figure 14).

The double-plate appliance (DPA) was designed by Planas (1983) as intra-orally opposed angulated acrylic blocks. The aim of the blocks is to alter the vertical components of the masticatory forces to the sagittal components. The system was supplied by Class III elastics that were accepted to be effective in Class III treatment (Üçem et al., 2004) (Figure 15).

Generally, reduced mandibular protrusion and more favorable sagittal growth of the maxilla were reported with these appliances. But it’s skeletal effects in relation to extra-oral traction appliances using facemasks is limited (Tollaro et al., 1995).

**Extra-Oral Appliances**

Facemask appliance is one of the main management approaches for orthopedic treatment of Class III malocclusion. The facemask has three

Figure 15. The double-plate appliance (DPA) (Adopted from web).
components: facemask, a bonded maxillary splint and elastic. The facemask is the extra-oral part and composed of a forehead and chin pads that linked by steel rod. The intraoral part consists of a banded or bonded maxillary splint with vestibular hooks and elastics that connected to the facemask in a downward and forward direction exerting a heavy orthopedic force of a level ranged from 500-2000 gm (Kapust et al., 1998). The maxillary intraoral splint usually have a mid-palatal expansion screws that can widen the narrow maxilla and also facilitate the process of maxillary protraction done by the face mask by aid in the luxation of the circummaxillary suture prior to maxillary protraction (Franchi et al., 2004; Yavuz et al., 2009) (Figure 16).

Figure 16. Facemask appliance (Adopted from web).

Delayer’s demonstration in 1970 stated that a facemask attached to maxillary splint could move the maxilla forward by inducing growth at the maxillary suture. The face mask is considered the most effective orthopedic treatment to Class III malocclusion that is associated with
retrusive maxilla (Kim et al., 1999), however beside its big size and unfavorable appearance it has several limitations.

Firstly, it has relatively strict age limit and its optimal age is younger than 10 years old preferable at the early mixed dentition or even in primary dentition period (Kim et al., 1999). In addition to that face mask wear is usually limited to 14 hours per day at best (De Clerck et al., 2010).

Secondly, maxillary deficiency combined with long face type is a great challenge for it due to downward decent of the posterior part of the maxilla during protraction leading to clockwise rotation of the mandible and an increase in the lower vertical dimension of the face (Yoshida et al., 2007).

Patient with normal maxilla and prognathic mandible is usually treated with chin cup. Chin cup is one of the ideal orthopedic appliances for Class III malocclusion in case of growing children. The theory of using chin cup is that it provides the direct orthopedic forces to improve mandibular shape in Class III malocclusion (Ritucci and Nanda, 1986). For using chin cup, 4 to 14 years of age is recommended (Barrett et al., 2010). Habitually, females mature formerly than males, so patients’ gender also influences the use of chin cup. Level of force should increase progressively. Force at the center of chin with the chin cup is recommended 150g up to 1200g (Abdelnaby and Nassar, 2010; Barrett et al., 2010). Moreover, 8 to 18 hours per day is the suggested hours for wearing this orthopedic appliance (Barrett et al., 2010; Gökalp and Kurt, 2005). Chin up usually two types:

**Occipital Pull Chin Cup**

This appliance derives the anchorage from the occipital bone. Used in Class III malocclusion associated with mild to moderate mandibular prognathism. Also indicated patients with slightly protrusive lower incisors as they invariably produce lingual tipping of the lower incisors (Figure 17).

**Vertical Pull Chin Cup**

This appliance derives anchorage from the parietal region of the head. Indicated in patients with steep mandibular plane angle and excessive anterior facial height. These patients usually exhibit an anterior open bite.
(Figure 17). Patients were asked to wear these appliances for 12-14 hours a day to achieve the desire results.

![Figure 17. Chin cup appliance (Adopted from web).](image)

In conclusion, based on the analysis of malocclusion, different intra oral and extra oral appliances in both removable and fixed orthodontic treatment have a remarkable effect on Class III malocclusion. Moreover, it is important to choose the best treatment option amongst all treatment modalities to correct this type of malocclusion. The long-term treatment with an aggressive protocol will significantly improve the growth of mandible and maxilla in Class III malocclusion cases.

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ORTHODONTIC APPLIANCES FOR MALOCCLUSION

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ABSTRACT

Orthodontic appliances are the base of orthodontic therapy. To understand and plan the treatment, detailed knowledge should be obtained. Removable appliances are a major part of orthodontic appliances. These are used separately or in conjunction with other types of appliances.
ORTHODONTIC APPLIANCES

The main goal of orthodontic treatment is to establish functional efficiency, structural balance and aesthetic harmony. During orthodontic treatment, a required amount of force is applied on the tooth/teeth, jaw bone and surrounding musculature to attain this goal. This force is applied by means of orthodontic appliances, which are the crucial part of orthodontic therapy. Orthodontic appliances can be defined as tools, by which meticulous force can be applied or transmitted to an individual tooth or a group of teeth and/or the surrounding structures to bring about necessary changes in the dento-facial structures to attain functional efficiency, structural balance and aesthetic stability [1, 2, 3, 4].

CLASSIFICATION OF ORTHODONTIC APPLIANCES

Orthodontic appliances can be classified in many ways but generally, there are four types that are used individually or in combination to treat malocclusions:

- Removable orthodontic appliances;
- Fixed orthodontic appliances;
- Functional orthodontic appliances;
- Orthopedic orthodontic appliances.

IDEAL REQUIREMENTS OF AN ORTHODONTIC APPLIANCE

All orthodontic appliances should consider the following requirements. Although it is not possible for a single appliance to attain all the requirements, during designing an appliance these are the points that should be kept in mind [1, 2, 3]:

- Removable orthodontic appliances;
- Fixed orthodontic appliances;
- Functional orthodontic appliances;
- Orthopedic orthodontic appliances.
Orthodontic Appliances for Malocclusion

- Biologic requirements;
- Mechanical requirements;
- Aesthetic requirements.

**Biologic Requirements**

- The appliance should be able to produce required tooth movement efficiently.
- It should be biocompatible, non-allergic and non-toxic.
- It should be tasteless, odorless and inert to the oral fluid.
- It should not do any harm to the teeth and surrounding tissues during tooth movement.
- The appliance should not abuse the normal growth.
- It should not interfere with normal physiological functions, i.e., speech, mastication, deglutition.
- The appliance should be easy to clean and should not interfere with oral hygiene maintenance.
- It should be comfortable and acceptable to the patient.

**Mechanical Requirements**

- The appliance should produce or transmit desired force in a controlled manner.
- It should not produce any undesired tooth movement.
- It should be easy to fabricate and repair.
- The appliance should be easy to activate.
- It should not be bulky or heavy.
- The appliance should have adequate retention.
AESTHETIC REQUIREMENTS

- The appliance should be esthetically acceptable to the patient.
- It should not embarrass the patient and should be as inconspicuous as possible.
- During treatment planning the orthodontist should select the appliance according to the specific treatment needs, type and etiology of malocclusion and patient compliance.

REFERENCES


Chapter 10

REMOVABLE APPLIANCES FOR MALOCCLUSION

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ABSTRACT

The components of removable appliances are particularly designed for different treatment effects. The proper use of its components can bring tremendous change. The major drawback of removable appliance therapy is that the success of the treatment solely depends on patient compliance. Therefore, proper instruction and education should be given to the patient prior to treatment.
REMOVABLE ORTHODONTIC APPLIANCES

Definition

The removable appliances can be defined as orthodontic appliances which can be removed from the mouth by the patient for cleaning and by the orthodontist for adjustment [1, 3, 4].

Tooth Movements by Removable Appliances

Following tooth movements can be achieved by removable appliances on a single tooth or a group of teeth [4, 5].

- Tipping.
- Extrusion.
- Intrusion.

Indication [3, 4, 6, 7, 8]

- Simple malocclusions where only tipping movement is required.
- Reducing overjet and/or overbite in Class II malocclusion.
- Correction of open bite.
- As a phase one treatment before starting fixed orthodontic treatment.
- As a retainer to maintain the teeth position.

Advantages [1, 2, 6, 7, 8]

- Most of the cases those require simple tipping movement can be treated by removable appliances.
- Removable appliances can be used as retainers, bite planes, habit breakers and for muscle exercise.
- This type of appliance is more acceptable to the patients due to less conspicuous design and easy to wear and remove.
- Oral hygiene maintenance is easier with removable appliances.
- If there is any breakage or discomfort the patient can remove the appliance immediately.
- Less chair side time is needed. So, the clinician can attend more patients.
- Removable appliances are less complex and less expensive than other types of orthodontic appliances.

**Disadvantages** [1, 2, 6, 7]

- Only limited cases requiring tipping movement can be treated with removable appliances.
- Cooperation of the patient is very important in the success of treatment as the duration of appliance wear, cleaning and sometimes a small part of activation depends upon the patient.
- Multiple movements are difficult with removable appliances.
- Greater risk of loss or breakage of the appliance.
- Treatment scope in lower arch is very limited.

**Components of Removable Appliance**

Removable appliance is composed of the following three parts [4, 5, 6, 7, 8, 9]:

- Active components.
- Retentive components.
- Base plate.
Active Components

Active components are responsible for creating the desired tooth movement by applying forces to the teeth. Active components are classified as springs, screws, bows and auxiliary elastics.

Springs [6, 7, 8]

Various types of springs are used in removable appliance depending upon the treatment need. But, there are some basic mechanical principles which need to be considered [1, 3, 5].

- The force should be delivered at the right angles to the long axis of the tooth.
- The tooth will move perpendicular to the contact point of active arm of the spring.
- The coil of the spring should be placed opposite to the direction of tooth movement. It should unwind as the tooth movement takes place.
- The point of application of force should be close to the center of resistance to prevent rotation.
- The force \( (F) \) applied by the spring is related to the length \( (L) \) of the wire, diameter \( (D) \) of the wire and the deflexion \( (d) \).

\[ F = dD^4/L^3 \]

Palatal Finger Spring

- Wire used for fabrication- 0.5 or 0.6 mm round stainless steel wire.
- Description- It contains active arm, helix and retentive arm. Active arm is the free end, 12-15 mm in length. The helix is about 3 mm in diameter and rests at the long axis of the tooth to be moved.
Retentive arm is about 4-5 mm in length and ends with a retentive tag.

- **Movement**- Mesial or distal movement.
- **Activation**- By opening the helix and moving the active arm about 3 mm towards the tooth to be moved.
- **Indication**- Closure of midline diastema and closure of minor anterior spacing.

**Buccal Canine Retractor**

- Wire used for fabrication- 0.7 mm round stainless steel wire.
- **Description**- It may be buccal or palatal, with a helix or with a loop, and push type or pull type. It consists of active arm, a loop or helix and retentive arm.
- **Movement**- Distal movement.
- **Activation**- For helical retractors by opening the helix for 1-2 mm. For looped retractors by compressing the loop.
- **Indication**- For retraction of buccally or palatally placed canine.

**Z-Spring/Double Cantilever Spring**

- Wire used for fabrication- 0.5 or 0.6 mm round stainless steel wire.
- **Description**- This spring is ‘Z’ shaped with two helices and is known as double cantilever spring. The active arm is very short, about 4-5 mm in length and retentive arm is long, about 12 mm in length. It is palatally positioned perpendicular to the tooth/teeth to be moved.
- **Movement**- Labial movement.
- **Activation**- Depends upon the indication. For minor rotations, only one helix is opened. Both helices are opened for about 2-3 mm where more force is required.
Indication - Correction of minor rotation, labial movement of incisors, and correction of single or segmental anterior crossbite.

**T-Spring**

- Wire used for fabrication- 0.5 or 0.6 mm round stainless steel wire.
- Description- This spring has ‘T’ shaped active arm with loops and retentive arm. It is positioned palatally perpendicular to the tooth to be moved.
- Movement- Buccal movement.
- Activation- By pulling the free end away from the baseplate towards the desired direction of tooth movement.
- Indication- To place premolars and canines buccally.

**Coffin Spring**

- Wire used for fabrication- 1.25 mm round stainless steel wire.
- Description- It is an omega ‘Ω’ shaped spring used instead of a screw for slow expansion. A good retention of the appliance is required.
- Movement- Expansion.
- Activation- By gently pulling away from the two arms of the loop or by flattening the loop at its curvature. The activation should be 1mm/side.
- Indication- Slow dentoalveolar expansion of maxillary arch.

**Mattress Spring**

- Wire used for fabrication- 0.6 mm round stainless steel wire.
- Description- This mattress shaped spring consists of ‘U’ loops up to the retentive arm. The free end contacts the gingival margin of the palatal surface of the tooth to be moved.
Removable Appliances for Malocclusion

- **Movement**- Labial movement.
- **Activation**- By expanding the loops.
- **Indication**- Correction of anterior crossbite in the maxillary arch where there is sufficient space.

**Helical Coil Spring**

- **Wire used for fabrication**- 0.6 mm round stainless steel wire.
- **Description**- This free ended spring contains two helices on different arms. The free ends act as two active arms and the arm between the two helices is the retentive arm.
- **Movement**- Two arms move in opposite direction, one in mesial and other in distal direction.
- **Activation**- By opening the helices. Two helices can be opened in different degrees according to the requirement.
- **Indication**- To regain the space lost after extraction.

**Screws [3, 5, 6, 7, 9]**

- **Description**- Screws are active components of the removable appliance embedded in a base plate. It is made of a rod with two (right and left) hand threads at both end and a nut in the center. This nut is turned for activation using a key. An intermittent force is applied by the screw. Patient skill and cooperation is the vital part of using a screw as it needs to be activated by the patient or parent.
- **Movement**- labial/buccal and mesial/distal movement.
- **Activation**- The key is turned towards the direction of the arrow for activation. One-quarter turn per week is indicated for adults and for children it is one-quarter turn per three days.
- Indication- Arch expansion, correction of posterior crossbite and distal movement of the buccal segments.

**Elastics [3, 5, 6, 7]**

Elastics with removable appliances produce light intermittent forces. They can be placed intra- or inter-arch attached to a hook from labial bow. It is used for retraction of anterior segment along with some intrusive movements. Good retention is required for the stability of the appliance. Patient skill and cooperation is also needed as it needs to be reactivated regularly by the patient.

**Bows [6, 7, 8, 9]**

Different types of labial bows are used as an active component of removable appliances. They are mainly used for reduction of overjet, space closure and for stability of the anterior segment [5]. Some commonly used labial bows are as follows-

- Short labial bow.
- Long labial bow.
- Split labial bow.
- Reverse labial bow.
- Robert’s retractor.
- Mill’s retractor.
- High labial bow with apron springs.
- Fitted labial bow.
Short Labial Bow

- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Description- It extends from right canine to left canine consisting of a bow, two ‘U’ loops and two retentive arms. The bow should be leveled at the center of the labial surface of anterior teeth. The loops will be on canines and the retentive arms will be from the distal margin of the canines to the palatal/lingual area.
- Activation- Reduction of the base plate palatal/lingual to the anterior teeth and by compressing the ‘U’ loops 1-2 mm.
- Indication- Minor overjet (3.5mm) correction, anterior space closure and for retention purpose.

Long Labial Bow

- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Description- It extends from the right first premolar to the left first premolar consisting of a bow, two ‘U’ loops and two retentive arms. The bow should be leveled at the center of the labial surface of the anterior teeth. The loops will be on the first premolars and the retentive arms will be from the distal margin of the first premolars to the palatal/lingual area.
- Activation- Reduction of the base plate palatal/lingual to the anterior teeth and by compressing the ‘U’ loops 1-2 mm.
- Indication- Minor overjet correction, closure of space distal to canine, guiding the canine during canine retraction and for retention purpose.

Split Labial Bow

- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Description- It extends from the right canine to the left canine with a split bow into two buccal arms, two ‘U’ loops and two retentive
arms. The bow should be leveled at the center of the labial surface of the anterior teeth. The loops will be on the canines and the retentive arms will be from the distal margin of the canines to the palatal/lingual area.

- **Activation** - Reduction of the base plate palatal/lingual to the anterior teeth and by compressing the ‘U’ loops 1-2 mm.
- **Indication** - Retraction of the anterior segment and closure of the midline diastema. For closure of the midline diastema, the two buccal arms extend to the opposite central incisors and engage to the distal surface.

**Reverse Labial Bow**

- **Wire used for fabrication** - 0.7 mm round stainless steel wire.
- **Description** - It extends from the right canine to the left canine with a bow, two ‘U’ loops and two retentive arms. The loops are distal to the canines and the bow is formed by bending the distal arms at right angles. The retentive arms run through the distal margin of the canines to the palatal/lingual area.
- **Activation** - Activation of reverse labial bow is different from the conventional ones. It is activated by opening the ‘U’ loops instead of compressing.
- **Indication** - Reduction of overjet (5-7 mm).

**Robert’s Retractor**

- **Wire used for fabrication** - 0.5 mm round stainless steel wire.
- **Description** - It extends from the right canine to the left canine consisting of a bow, two ‘U’ loops with helices of 3 mm diameter and two retentive arms. The bow should be leveled at the center of the labial surface of the anterior teeth. The helical loops will be on
the canines and the retentive arms will be from the distal margin of the canines to the palatal/lingual area.

- **Activation** - Reduction of the base plate palatal/lingual to the anterior teeth and by closing the both helices.
- **Indication** - Reduction of large overjet (7-9 mm).

**Mill’s Retractor**

- **Wire used for fabrication** - 0.7 mm round stainless steel wire.
- **Description** - It extends from the right canine to the left canine consisting of a complexly designed labial bow to increase the flexibility. It is not widely used due to difficulty in fabrication and poor patient compliance.
- **Activation** - Reduction of the base plate palatal/lingual to the anterior teeth and by compressing the looping.
- **Indication** - Reduction of large overjet (more than 9mm).

**High Labial Bow with Apron Springs**

- **Wire used for fabrication** - 0.9 mm round stainless steel wire for the labial bow and 0.4 mm wire is used for the apron springs.
- **Description** - It extends high in the labial vestibule. Due to its flexibility and ability to generate light force, it can be used in adult patients. However, it is not widely used due to the complex design, risk of soft tissue injury and poor patient compliance.
- **Activation** - By bending the apron springs towards the teeth, up to 3 mm at a time.
- **Indication** - For correction of proclined incisors.
Fitted Labial Bow

- Wire used for fabrication- 0.7 or 0.9 mm round stainless steel wire.
- Description- It is so called because of the adaptation of the bow to the contours of the labial surface of the anterior teeth.
- Indication- For retention purpose after finishing the fixed orthodontic therapy.

Retentive Components

Retentive components are responsible for holding the appliance inside the oral cavity and resisting any displacement during application of forces. The success of the removable appliance therapy largely depends upon a good retention. An appliance without adequate retentive components may lead to many problems such as loss of anchorage, ill-fitting, damage to the surrounding tissues, breakage of an appliance, and failure to attain the treatment goal. Clasps are the retentive components of the removable appliances which are wire components act by engaging into the undercuts on the teeth.

Clasps [1]

Clasps of various designs are used to retain the appliance according to the treatment needs. They are responsible for the retention of the appliance along with the stability.

Properties of an Ideal Clasp

- It should provide adequate retention.
- It should not be able to produce any active force.
• It should be designed such so that it can be used in both partially and fully erupted teeth.
• It should not contain any sharp part which can irritate or traumatize the soft tissue.
• It should be easy to fabricate.
• It should not create any discomfort to the patient.

Types of Clasps Used As Retentive Component

• Circumferential clasp/‘C’ clasp.
• Jackson’s clasp/Full clasp.
• Adams clasp.
• Southend clasp.
• Triangular clasp.
• Ball-end clasp.
• Schwarz clasp.
• Crozat clasp.
• Duyzing clasp.
• Eyelet clasp.
• Delta clasp.
• Plint Clasp.

Circumferential Clasp

• Synonym- Three-quarter clasp, ‘C’ clasp.
• Wire used for fabrication- 0.7 mm round stainless steel wire.
• Parts- Squash loop, circumferential arm, interdental arm, retentive arm, and retentive tag.
• Engage- On bucco-cervical undercut of the premolars and molars.
• Advantages:
  – It is simple in design.
It is easy to fabricate.

Disadvantage- Not suitable for deciduous or partially erupted teeth.

**Jackson’s Clasp**

- Synonym- Full clasp.
- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Parts- One circumferential arm, two interdental arms and two retentive arms with retentive tags.
- Engage- On bucco-cervical undercut of the premolars and molars.
- Advantages
  - It has a simple design.
  - It is easy to fabricate.
  - It provides adequate retention.
- Disadvantage- Not suitable for deciduous or partially erupted teeth.

**Adams Clasp [3]**

- Synonym- Liverpool clasp, Universal clasp, Modified arrowhead clasp.
- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Parts- Two arrowheads with a connecting bridge and two retentive arms with two retentive tags. The bridge should be placed at the level of the middle third of the crown and at 45° to the long axis of the tooth.
- Engage- The arrowheads connected by the bridge should be engaged at mesio-buccal and disto-buccal proximal undercuts of the premolars and molars.
- Advantages
  - It provides excellent retention.
- It can be used in partially and fully erupted deciduous/permanent teeth.
- It can be used in the molars, premolars, and incisors also.
- Varieties of modifications are available according to the clinical need.
- It can be repaired by soldering.
- Disadvantage- Fabrication is not as easy as the previous clasps.
- Modifications
  - *Adams with single arrowhead*: It is indicated in partially erupted tooth positioned last in the arch. The single arrowhead is positioned in the mesial undercut and the other end is adapted distally similar to the circumferential clasp.
  - *Adams with additional arrowhead*: It is used for additional retention purpose. The additional arrowhead engages the proximal undercut on the adjacent tooth and is attached to the bridge of the main Adams clasp by soldering.
  - *Adams clasp with distal extension*: The distal extension is extended from the distal arrowhead and is used for engaging elastics and for additional retention purpose also.
  - *Adams clasp with J-hook*: A J-hook is soldered on the bridge of the Adams clasp and is used for engaging elastics.
  - *Adams clasp with helix*: This type of modification has a helix incorporated into the bridge of the Adams Clasp and is used to engage elastics.
  - *Adams clasp with soldered buccal tube*: A buccal tube is soldered on the bridge of the Adams clasp to allow extra-oral attachments.
  - *Adams clasp on incisors and premolars*: The bridge is fabricated along the span of the tooth/teeth and the arrowheads are engaged in the disto-buccal undercuts.
Southend Clasp [3]

- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Parts- Two circumferential arms with two retentive arms.
- Engage- Cervical margin of the maxillary central incisors.
- Advantages
  - It is simple in design.
  - It is easy to fabricate.
  - Appearance is aesthetic.
  - It can be used in incisors with limited undercuts.
- Disadvantage- It cannot be used in proclined incisors.

Triangular Clasp

- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Parts- Base and apex of the triangle with one retentive arm.
- Engage- On the proximal undercuts between the two posterior teeth.
- Advantages
  - It is easy to fabricate.
  - It has no occlusal interference.
  - It can be used for additional retention.
- Disadvantage- It does not provide adequate retention if used alone.

Ball-End Clasp

- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Parts- One end having ball-like structure soldered on and the other end is retentive arm.
- Engage- On the proximal undercuts between the two teeth.
- Advantages
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- It can be used in anterior teeth.
- It provides addition retention.
- It has no occlusal interference.
- Disadvantage- It does not provide adequate retention if used alone.

Schwarz Clasp

- Synonym- Arrowhead clasp.
- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Parts- Arrowhead (from the canine to the first molar it is three in number and from the canine to the second molar it is four) with the connecting parts and two retentive arms with retentive tags.
- Engage- On the interproximal undercuts between two adjacent teeth.
- Disadvantage- Difficult and time-consuming fabrication along with a risk of injury to the interdental soft tissue.

Crozat Clasp

- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Parts- Circumferential arm with additional pieces of soldered wire and two retentive arms.
- Engage- On the mesial and distal proximal undercuts of the tooth.
- Advantage- It provides adequate retention.
- Disadvantage- Soldering is required.

Duyzing Clasp

- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Parts- Two separate holding ends with two retentive arms.
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- Engage- On the buccal undercuts of the molars.
- Advantages- Easy to fabricate.
- Disadvantage- It does not provide adequate retention.

Eyelet Clasp

- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Parts- It may have single or multiple eyelets depending on the number of tooth involved with two retentive arms.
- Engage- on the interproximal undercuts of teeth.
- Advantages
  - It has no occlusal interference.
  - It is easy to fabricate.
  - It is flexible and comfortable to the patient.
- Disadvantage- Single clasp does not provide adequate retention.

Delta Clasp

- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Parts- Two closed triangular shaped arrowheads connected by a bridge and two retentive arms with retentive tags.
- Engage- The arrowheads engage at the mesio-buccal and disto-buccal proximal undercuts of the premolars and molars.
- Advantages
  - It requires less adjustment.
  - It is less prone to breakage.
  - The shape is maintained.
- Disadvantage- Fabrication is difficult.
Plint Clasp

- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Parts- One coil shaped arm and one retentive arm.
- Engage- On the undercuts of maxillary molar bands,
- Advantage- It is used in removable appliance combined with fixed appliance therapy.
- Disadvantages
  - Difficult to fabricate.
  - Risk of gingival impingement.

Resta Clasp

- Wire used for fabrication- 0.7 mm round stainless steel wire.
- Parts- One ball-end and one arrowhead with one retentive arm with retentive tag.
- Engage- On the buccal undercuts of the tooth.
- Advantage- It is easy to fabricate.
- Disadvantage- It does not provide adequate retention.

Base Plate [3]

The major part of the removable appliance is the base plate which holds all the active and retentive components. This acrylic resin made component also provides anchorage.

Function of Base Plate

- It holds the other components and acts as a single functional unit.
- It aids in retention of removable appliance.
• It also provides anchorage by resisting unwanted tooth movement.
• It transmits the forces produced by the active components uniformly.
• Bite planes are incorporated in the base plate according to the treatment plan.

**Design of Base Plate**

Generally, base plates are fabricated from auto-cure acrylic resin but it can also be made by heat-cure acrylic resin. At the time of designing a removable appliance, the extension and thickness of base plate should also be kept in mind. The thickness should be such so that it is comfortable to the patient as well as strong enough able to transmit the forces of the active components. About 1.5-2 mm thickness fulfills both of the requirements. The extension of the baseplate should be planned carefully as too much extension hampers retention and is also irritating for the patient. If the extension is too small, then it does not support its function. The base plate should be extended up to the distal end of the first molar of both upper and lower jaws. The upper plates should cover the entire hard palate to enhance strength. The lower plates should not go deep as it may irritate the soft tissue at the lingual sulcus and the lingual undercuts should be blocked beforehand.

**Modifications of Bite Planes**

Bite planes are extended in various designs to meet the treatment needs [3]. These modifications are listed as follows:

• Anterior bite plane
  • Upper
    – Flat
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- Inclined
  - Sved
- Lower
  - Inclined
- Posterior bite plane
  - Upper
  - Lower

**Upper Flat Anterior Bite Plane**

This is the extension of acrylic bite plate covering the palatal rugae from canine to canine behind the incisors. The thickness should be 4-5 mm in the premolar region. This bite plane prevents occlusion of posterior teeth which causes extrusion of them [2]. It is indicated for correction of deep bite. This bite plane is flat to avoid proclining forces on the mandibular incisors. Grooves can be incorporated to support the incisal tips of the mandibular incisors. Additional acrylic is added to continue overbite reduction subsequently.

**Upper Inclined Anterior Bite Plane**

This bite plane is inclined downwards and inferiorly at 60° angle towards the occlusal plane. It guides the patient to bite forwardly thus, guiding forward growth of mandible. It is also indicated for correction of deep bite.

**Sved Bite Plane**

The bite plane is extended and covers the incisal edges of the upper incisors. It helps in reinforcement of anchorage and used in correction of deep bite.
Lower Inclined Anterior Bite Plane

It is also known as Catlan’s appliance.

Posterior Bite Plane

This type of bite plane has extension of acrylic base plate over the occlusal surface of the posterior teeth. The thickness should be adequate to free the teeth to be moved from occlusal interference. It is indicated for correction of crossbite and to eliminate occlusal interference [4].

Steps of Fabrication of Removable Appliance [10]

- Preparation of the cast.
- Blocking out the undercuts.
- Fabrication of wire components.
- Heat treatment of wire components.
- The positioning of the wire components.
- Boxing and waxing of the springs.
- The positioning of the expansion screw.
- Fabrication of base plate.
- Extension of bite plane.
- Trimming and polishing.

Insertion of Removable Appliance [7, 8]

- Prior to insertion, the appliance is checked carefully for any irregularities or sharp edges and additional trimming is done if required.
Removable Appliances for Malocclusion

- After insertion, the active and retentive components are checked carefully. They should be positioned accurately and should not impinge on the soft tissue.
- The appliance should be checked for retention.
- The patient should be educated how to insert and remove the appliance.
- The active components are activated once the patient is comfortable with the appliance.

Instructions to the Patient [7, 8]

Some verbal and written instructions are given to the patients and also to the parents to ensure the success of removable appliance therapy. All instructions must be followed carefully.

- The patient should be instructed the removal and insertion of the appliance.
- The appliance should be handled by the bridges of the clasp, not by the springs or bow.
- The duration of wear should be advised. Most of the appliances are worn full day, except during cleaning, swimming and contact sports.
- If the appliance incorporates a screw, proper advice on activation must be given.
- Initially the patient will face difficulty in speech and excessive salivation which will subside after few days of wear.
- Oral hygiene must be maintained as there is an increased risk of plaque accumulation, caries and gingival inflammation.
- The appliance should be cleaned after every meal and should be brushed during tooth brushing. Care should be taken not to bend any wire components.
• When the appliance is not worn, it should be kept in a water containing pot.
• The patient should report to the clinic immediately in case of any irritation or damage/broken parts.
• The patient should avoid drinking very hot foods and drinks with the appliance inside the oral cavity.

REFERENCES


Chapter 11

FUNCTIONAL APPLIANCES FOR MALOCCLUSION

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ABSTRACT

Among the patients seeking orthodontic treatment, a large number are in their growing period. Functional appliances are used to treat these patients as they modify craniofacial growth by utilizing the force of orofacial musculature. There are different types of functional appliances used in orthodontic treatment. Some of them are a modification and some have a complete different mechanism of action. The indication, advantage, and disadvantage with description of the appliances are discussed in this chapter.
FUNCTIONAL ORTHODONTIC APPLIANCES

Functional appliances are used to treat malocclusion in growing children. It utilizes the force of orofacial musculature to influence the dentoskeletal structure, particularly at condylar and sutural areas [1].

Definition

Functional appliances are primarily orthopedic tools that utilize, eliminate, or guide the forces of muscle function, tooth eruption, and growth to correct a malocclusion [2, 3, 4].

Timing of Treatment

Functional appliances are used to treat malocclusion in growing children, preferably during the mixed dentition stage [3].

Classification

Functional appliances can be classified in different ways. Classification by Proffit is described below [1, 5, 6, 7]:

1. Teeth borne passive appliances- Myotonic appliances, e.g., Andersen/Häupl activator, Herren activator, Woodside activator, Balter’s bionator, etc.
2. Tooth borne active appliances- Myodynamic appliances, e.g., Elastic open activator (EOA), Bimler’s appliance, Modified bionator, Stockfish appliance, etc.
3. Tissue borne passive appliance, e.g., Oral screen, Lip bumpers, etc.
4. Tissue borne active appliances, e.g., Frankel appliances.
5. Functional orthopedic magnetic appliances (FOMA).
Types of Malocclusions Treated with Functional Appliances

Functional appliances are mostly used as a Phase One treatment, which is followed by fixed appliance therapy in the second phase. They are mostly used to treat a Class II malocclusion; few functional appliances provide treatment for other malocclusions [3].

Advantages [5, 6, 7]

1. They act by modifying/re-directing growth.
2. It produces treatment changes on the dentition, skeletal structures and soft tissues.
3. It reduces the severity of malocclusion and further need of surgical correction.
4. It is appropriate for children during mixed dentition stage, so treatment can be started early.
5. They are effective in vertical control of increased overbite.
6. Chair-side adjustment is minimal.

Disadvantages [5, 6, 7, 8]

1. Patient cooperation is a much-needed factor.
2. Delicate tooth movement is not possible.
3. Sometimes the treatment requires to be followed up by fixed appliance therapy for finalization.

Activator

Viggo Andresen designed activator in 1908, which is a modification of monoblock of Pierre Robin [4].
Design

It consists of upper and lower appliances sealed together in such a position of mandible that the masticatory force can be transmitted through the dentition. It consists of upper and lower blocks with labial bow. A jack screw may be attached to the maxillary arch. The patient needs to move the mandible forward in order to engage this loose fitting appliance, which brings in myotactic reflex, condylar adaptation, and the viscoelastic property.

Indication

1. Class I malocclusion with deep bite.
2. Class I malocclusion with open bite.
3. Class II division 1 malocclusion.
4. Class II division 2 malocclusion.
5. Class III malocclusion (reverse activator).
6. Also, can be used as space maintainer, retainer, and habit breaker.
7. Children with decreased facial height.
8. For patients with snoring complains.

Advantages

1. Both deciduous and mixed dentition children can be treated.
2. Oral hygiene can be maintained.
3. No risk of soft tissue injury.

Disadvantages

1. Patient cooperation is required.
2. Individual tooth movement cannot be controlled.
3. Bulky and uncomfortable.
**Fabrication Steps**

1. Taking impression.
2. Preparation of casts.
3. Bite registration.
4. Articulation of the cast.
5. Fabrication of wire elements.
6. Fabrication of upper and lower acrylic blocks and attaching them with inter-occlusal part.
7. Insertion of the appliance.
8. Instruction to the patient.
9. Trimming of the activator.

**Duration of Wear**

The patient is advised to wear the appliance at night, including 2-3 hours of day time wear.

**Bionator**

In 1960, Wilhelm Balter developed this appliance in Germany. The excess bulk and night time wear of the activator made it less efficient, which led to the development of bionator [4].

**Classification**

Three basic types of bionators are available.

1. Standard appliance
2. Open-bite appliance
3. Class III or reverse bionator

**Indication**

1. Class I malocclusion with narrow arch.
2. Class I malocclusion with open bite.
3. Class II division 1 malocclusion.
4. Class III malocclusion.

Advantages

1. As the appliance is less bulky it is comfortable to the patient.
2. Oral hygiene can be maintained.
3. It can be worn full time, except during meals.
4. The tongue and perioral muscles are under continuous influence of the appliance.

Disadvantages

1. Patient cooperation is required.
2. Management of the appliance is very difficult.

Components of Bionator

1. Palatal arch wire.
2. Vestibular wire.
5. Inter-occlusal acrylic part.

Duration of Wear

The patient is advised to wear the appliance full day, except during meals.

Frankel Appliance

Rolf Frankel developed functional regulator appliances as an orthopedic exercise device to aid in maturation, training and reprogramming of the orofacial neuromuscular system [4].
Functional Appliances for Malocclusion

Classification

Five basic types of Frankel’s appliance are available.

1. FR-I.
   - FR-Ia.
   - FR-Ib.
   - FR-Ic.
2. FR-II.
3. FR-III.
4. FR-IV.
5. FR-V.

Indication

1. FR-Ia: Class I malocclusion with deep bite.
2. FR-Ib: Class II division 1 malocclusion with overjet <5mm.
3. FR-Ic: Class II division 1 malocclusion with overjet <7mm.
4. FR-II: Class II malocclusion.
5. FR-III: Class III malocclusion.
6. FR-IV: Bimaxillary protrusion and open bite.
7. FR-V: In conjunction with headgear.

Advantages

1. It can be used in treatment of different types of malocclusion.
2. It provides vertical, transverse and sagittal correction.
3. It can be used for the correction of perioral muscle activity.

Disadvantages

1. Patient cooperation is required.
2. Design is complicated.
3. Oral hygiene maintenance is very difficult.

**Components of Bionator**

1. Wire parts.
   - Palatal bow.
   - Labial bow.
   - Canine extensions.
   - Upper lingual wire (in case of FR-II).
   - Lingual cross over wire.
   - Lip pads.
   - Lower lingual springs.
2. Acrylic parts.
   - Buccal shields.
   - Lip pads.
   - Lower lingual pads.

**Twin-Block Appliance [1]**

Dr. William J. Clark developed a twin block appliance in 1977. It is named so as it has two parts, an upper and a lower.

**Definition**

Twin blocks are simple removable bite blocks with occlusal inclined planes which act as functional appliance, designed for full time wear [3, 4].

**Design**

It consists of upper and lower blocks; a labial bow and an expansion screw may also be incorporated. For anchorage, Adams clasps are added in the molars, delta clasps in the premolars and additional ball clasps may be added in the lower block. The bite plane is inclined 70° to the occlusal plane.
Functional Appliances for Malocclusion

**Modifications**

1. Twin Block with Schwarz appliance.
2. Twin Block with both transverse & sagittal three-way screws.
3. Twin Block with habit breakers.
4. Reverse Twin Block for Class III malocclusion.
5. Magnetic Twin Block.
6. Attachments in Twin Block for advancement.
7. Twin Block Bio Finisher extruding lower molars by vertical traction to stabilize the temporomandibular joint.

**Indication**

1. Class II division 1 malocclusion without crowding.
2. Class II division 1 malocclusion with deep bite.
3. Class II division 2 malocclusion.
4. Class III malocclusion (reverse twin block).
5. Asymmetry.
6. In condylar displacement.

**Advantages**

1. Maximum patient compliance as it is very comfortable to the patient.
2. Both deciduous and mixed dentition children can be treated.
3. Functional mechanism is very similar to the natural dentition.
4. Appearance is noticeably improved.
5. Oral hygiene can be maintained.
6. No risk of soft tissue injury.

**Disadvantages**

1. Patient cooperation is required.
**Duration of Wear**

Patient is advised for full time wear including meals, except during brushing, swimming and contact sports.

**Herbst Appliance [1, 5]**

This was developed by Emil Herbst in 1909 and later it was popularized by Pancherz (1979). It may be fixed or removable depending upon the anchorage system.

**Design**

It consists of a bite jumping mechanism that maintains the mandible in a protruded position.

**Types**

1. Banded- Bands are incorporated on the maxillary first molars and the mandibular first premolars.
2. Casted.
3. As an acrylic splint or cantilever bite jumper.

**Indication**

1. Class II malocclusion.
2. Retroclined mandibular incisors with deep bite.
3. Skeletal Class II mandibular deficiency.

**Advantages**

1. Effective in patients without any neuromuscular imbalance.
2. Different types of modifications can be incorporated.
Disadvantages

1. Less effective in mixed dentition children.
2. High cost and less patient acceptance.

Jasper Jumper

Jasper Jumper, an American orthodontist, modified the Herbst appliance and designed Jasper Jumper.

Design

It consists of flexible plastic covered open coil springs attached to the maxillary first molar and mandibular canine either directly onto the lower arch or by an out-rigger. This fixed mechanotherapy is the most successful and widely used inter-arch force delivery system.

Indication

1. Class II malocclusion.

Advantages

1. Insertion and removal is comparatively easy.
2. It provides intrusive forces on the molars and the incisors.

Disadvantages

1. Increased risk of appliance breakage.
2. For proper force application, mouth needs to be fully closed.
REFERENCES


Chapter 12

ORTHOPEDIC APPLIANCES FOR MALOCCLUSION

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ABSTRACT

Orthopedic appliances are used in children at their growing age to modify the dentoskeletal growth. Along with the improvement, it reduces the severity of malocclusion and also reduces the risk of surgical intervention. Commonly used orthopedic appliances are described in this chapter with classification, components, mechanism of action, and indication.
Orthopedic appliances mainly focus on correction of the skeletal discrepancy rather than the dentoalveolar malocclusion. However, some dentoalveolar and soft tissue changes are also produced by these appliances. Orthopedic appliances provide heavy force in comparison to the orthodontic forces. They are basically used for growth modification, occasionally in combination with the functional appliances [1, 2, 3].

The commonly used orthopedic appliances are [4, 5, 6, 7]:

1. Headgear
2. Protraction facemask
3. Chin cup appliance

**Headgear**

This is the most commonly used orthopedic appliance. It is used in the treatment of skeletal Class II malocclusion, where the growth of the patient has not completed yet [2, 4, 5, 6, 7].

**Indication**

1. Management of skeletal Class II malocclusion in growing children by growth modification.
3. Reinforcement of anchorage.
4. Maintenance of arch length.

**Components**

**Force Delivering Unit**

- Face bow: Face bow is a large metallic framework attached to the teeth either by elastics or by a removable appliance. It has an outer
bow/Whisker bow and an inner bow connected by a junction. The inner bow is attached to the molar band. The outer bow is fabricated from a 0.051-0.062” round stainless steel wire. It may be shorter, longer or the same length as the inner bow. The distal hooks of the outer bow engage a force generating unit. The inner bow is fabricated from a 0.045-0.052” round stainless steel wire. It is inserted into the round buccal tube of the molar bands.

- ‘J’ hook

**Force Generating Unit**

The force generating unit may be springs, elastics or other stretchable materials. They are connected to the face bow via the anchor unit. They produce a heavy force to provide skeletal changes. The force is transmitted to the teeth via the face bow and then to the underlying skeletal structure.

**Anchor Unit**

Headgear uses extra-oral anchorage from rigid bones of the skull. Following attachments are used for this.

- Head cap/occipital attachment.
- Neck strap/cervical attachment.
- Combination of head cap and neck strap.

**Classification**

**Cervical Pull Headgear**

It uses nape of the neck as an anchorage unit. It provides distal movement of the maxilla along with extrusion and distalization of the molars.

**Occipital Pull Headgear**

It uses the occipital region as an anchorage unit. It causes distalization of the molar.
High Pull (Parietal) Headgear

It uses the parietal region as an anchorage unit. It causes intrusion and distalization of the teeth.

Combination Pull Headgear

It uses at least two regions for anchorage unit. It provides a distal and slightly superior force on the maxilla and to the dentition.

Force Application Principles

Force

Force is applied by the means of springs or elastics in the headgear appliance. This force provides three-dimensional movements of the dentition and the maxilla.

Origin of Force Point

The site of anchorage is the point of origin of the force. The cervical or the occipital region or both can be used as an anchorage unit. Usually, it is determined by the type of tooth or skeletal movements.

Attachment of Force Point

The point of attachment of the force element to the outer bow is the point of attachment of force. The line of action of force is modified by altering the length and angulation of the outer bow.

Center of Resistance

Desired tooth and skeletal movements are achieved by applying force at the center of resistance. The center of resistance of the maxillary first molar lies at the furcation area and the center of resistance of the maxilla is situated between the roots of two premolars. Therefore, to provide movement the force should be applied at these points.
Center of Rotation

If the force is applied away from the center of resistance, then the tooth rotates around the center of rotation. The location of this point depends upon the point of force application.

Mode of Action

Headgear applies heavy extra-oral orthopedic forces on the maxillary sutures. The sutures are then compressed and the pattern of bone apposition is modified. This causes redirection of the maxillary growth. The goal of treatment of Class II malocclusion is to correct the anteroposterior jaw relationship by restricting the maxillary growth while the mandible continues to grow forward. The success of this therapy depends on the direction and magnitude of the force applied, the duration of force application and the presence of active mandibular growth.

Treatment Effects

Skeletal Effects

The development of maxilla depends on frontomaxillary, zygomaticotemporal, zygomaticomaxillary and pterygopalatine sutures. Headgear restricts the normal growth of maxilla by compressing these sutures, whereas the mandible continues to grow normally in a forward direction. This corrects the sagittal jaw relationship.

Dental Effects

Headgear produces specific dental movements along with the skeletal changes. It causes distalization of the maxillary molars along with extrusion and intrusion.

Limitations

1. Only skeletal change is not possible. It brings dental changes along with skeletal changes.
2. Patient compliance is required.
3. It has no control over mandibular growth.

**Protraction Face Mask**

It is also known as reverse pull head gear. This appliance is used to treat Class III malocclusion in growing children by modifying or redirecting the growth of the maxilla and the mandible [4, 5, 6, 7].

**Indications**

1. Mild to moderate skeletal Class III malocclusion due to retruded maxilla or protruded mandible or by both in children at their growing period.
2. To correct post-surgical relapse after osteotomy.
3. Rearrangement of palatal shelves in cleft patients.

**Components**

Facemask is usually composed of two soft tissue pads, one on the forehead and another on the chin, connected by a midline metallic framework. This metallic framework is adjustable. The following are the components of face mask:

1. Forehead cap
2. Chin cup/pad
3. Metallic framework
4. Slots for intra-oral elastics
5. Heavy elastics
6. Intra-oral appliance

**Classification**

**Protraction Headgear**

Hickham developed this protraction headgear in 1960’s for maxillary protraction. It has two long and two short arms emerging from the chin
cup. The long arms are attached to the anchorage unit and the short arms provide attachment to the intraoral elastics. It has the advantages of better aesthetics and comfort to the patients along with the ability to apply force unilaterally.

**Delaire Type of Facemask**

It was developed by Delaire in 1960. It has a square-shaped, rigid metallic framework connecting the forehead and chin pads. For attaching the heavy elastics it has a horizontal metal wire in front of the mouth.

**Tübinger Type of Facemask**

This is a modification of Delaire face mask, where the forehead and chin pads are attached by two vertical metallic rods in the midline, on both sides of the nose. A horizontal metal wire in front of the mouth is present to attach the heavy elastics.

**Petit Type of Facemask**

Petit modified the Delaire facemask by increasing the amount of force and shortening the length of the total treatment period. It has a vertical metallic rod in midline connecting the forehead and chin pads. A horizontal crossbar is present to attach the heavy elastics. The forehead and chin pads along with the crossbar are adjustable according to the patient’s needs.

**Principles of Mechanotherapy**

The amount of maxillary advancement in 8-12 months is 2-4 mm, clinically. This amount of advancement is influenced by the following factors:

1. Age of the patient.
2. Anchorage system.
3. The level of force.
4. The direction of force.
5. The treatment period.
6. Treatment timing.

*Mode of Action*

The development of naso-maxillary complex depends upon frontomaxillary, nasomaxillary, zygomaticotemporal, zygomaticomaxillary and pterygopalatine sutures. Facemask influences these sutures and the maxillary tuberosity and thereby produces changes in the position of the naso-maxillary complex.

*Chin Cup Appliance*

This is an extra-oral orthopedic appliance used for the treatment of Class III malocclusion in growing children, where the mandible is protrusive but the maxilla has relatively normal growth [4, 5, 6, 7].

*Indication*

1. Mild Class III malocclusion due to mandibular prognathism in growing children.
2. In cases with decreased facial height.
3. Correction of proclined mandibular incisors.

*Classification*

*Occipital Pull Chin Cup*

It uses the occiput region for anchorage. It is one of the most commonly used chin cups for the treatment of Class III malocclusion with mild to moderate mandibular prognathism with proclined mandibular incisors. It is suitable for patients with a low angle or short anterior facial height.
Vertical Pull Chin Cup

It uses the parietal region for anchorage. It is used for the treatment of children having Class III malocclusion with open bite or long anterior facial height.

Components

1. Chin cup- Covers the chin.
2. Head cap- Covers the head.
3. Elastic strap- Connects the chin cup with head cap.

Treatment Effects

1. Skeletal effects
   - Redirection of the mandibular growth in a backward and downward growth.
   - Decrease in the mandibular plane angle.
2. Dental effects
   - Lingual tipping of the mandibular incisors.
3. Soft tissue effects
   - Improvement of the soft tissue profile.

REFERENCES


Chapter 13

**FIXED APPLIANCES FOR MALOCCLUSION**

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**ABSTRACT**

A major part of orthodontic appliance therapy is occupied by fixed appliance therapy. The history of the evolution of fixed appliance apparatuses is very interesting. Several steps had to be passed before reaching the modern stage of fixed appliance therapy. There are different techniques to be used in different cases. Although many years of clinical experience are required to be a great orthodontist, a thorough knowledge of every technique, the components with the properties must be learned from the very beginning. This chapter is organized with all the details of fixed appliances including the steps of fixed appliance therapy.
FIXED ORTHODONTIC APPLIANCES

Orthodontic treatment is mostly carried out by fixed appliances. This therapy began in the United States of America and with time, it has become the most delicate and sophisticated practices of orthodontics worldwide [1, 2].

Definition

Fixed appliances can be defined as the orthodontic appliances, which are fixed to the teeth and cannot be removed by the patient.

Tooth Movements by Removable Appliances [2]

- Tipping movement.
- Bodily movement.
- Torquing movement.
- Rotations.
- Extrusion.
- Intrusion.

Indication

Fixed appliances are indicated in cases where multiple tooth movements are required [3].

Advantages [2, 4]

- It provides multiple tooth movement.
- No additional retention is required as the appliance is cemented on the teeth.
- The success of therapy is not solely depended on the patient.

**Disadvantages [4]**

- Oral hygiene maintenance becomes difficult.
- Excessive force may damage the supporting structures of teeth or may lead to an undesired tooth movement.
- The appearance is less aesthetic with the metallic brackets.
- A skilled operator is required.
- More chair-side time is needed.
- The cost of treatment is high.

**EVOLUTION OF FIXED APPLIANCES**

The fixed orthodontic appliance has traveled through a revolutionary process before establishing the current platform [1, 5].

**The Standard Edgewise System**

In 1928 Dr. Edward Angle introduced this technique, which is the basis of fixed appliance therapy. In this system, the slot in the bracket was placed in the center horizontally and a rectangular arch wire was inserted. A precise three-dimensional control of tooth movement can be achieved by the inter-action of rectangular arch wire in a rectangular slot.

**The Begg System**

In 1956 Dr. P. Raymond Begg came up with the Begg system, which used Dr. Angle’s ribbon arch appliance in a modified form. In this system,
the crowns were initially tipped into the desired direction by using the inter-maxillary elastics and then the roots were uprighted using the auxiliary springs. Round stainless steel arch wire was locked by lock pins into the ribbon brackets.

**The Pre-Adjusted Edgewise Appliance**

In 1972 Dr. Lawrence Andrew developed the pre-adjusted edgewise system which was a revolutionary step in fixed orthodontic therapy. It has pre-angled slots to correct mesiodistal tooth or tip angulation with inclined bracket bases. The customized brackets reduced the need for wire bending for each tooth and a group of teeth could be moved along the arch wire.

**COMPONENTS OF FIXED APPLIANCES**

Fixed appliance is composed of the following components [3, 4, 5, 6, 7, 8, 9]:

1. Active components:
   - Separator,
   - Elastic ring separator,
   - Dum-bell shaped elastic separator,
   - Brass wire separator,
   - Kesling metallic ring separator.

2. Arch wire:
   - Gold arch wire,
   - Stainless steel arch wire,
   - Nitinol arch wire,
   - TMA arch wire,
   - Optiflex arch wire,
3. Springs:
   - Up-righting spring,
   - Torquing spring,
   - Rotating spring,
   - Open coil spring,
   - Closed coil spring.

4. Elastics:
   - Intraoral elastics,
   - Class I elastic,
   - Class II elastic,
   - Class III elastic,
   - Crossbite elastic,
   - Box elastic,
   - Diagonal elastic,
   - Triangular elastic,
   - Extraoral elastics.

5. Elastomeric:
   - E-chain long/short,
   - Elastic ligatures,
   - Elastic modules,
   - Elastic threads.

6. Palatal and lingual arches:
   - Transpalatal arch,
   - Nance palatal arch,
   - Lingual arch,
   - Quad helix,
   - HYRAX (HYgenic Rapid Expansion) screw,
   - SUPERscrew telescopic expander.

7. Magnet:
   - Passive components,
   - Bands,
Nashid Fareen and Mohammad Khursheed Alam

- Anterior,
- Posterior,
- Brackets,
- Metallic brackets,
- Ceramic brackets,
- Plastic brackets,
- Pre-coated brackets,
- Buccal tubes,
- Single,
- Double,
- Triple,
- Lingual attachments,
- Lingual buttons,
- Lingual eyelets,
- Lingual cleats,
- Lingual sheath,
- Lock pins,
- Stage I,
- Stage II,
- Stage III,
- Ligature wire,
- Preformed stainless steel ligature wire,
- Kobayashi stainless steel ligature wire,
- Spooled ligature wire.

**Separator**

*Function*

To create space between two adjacent teeth prior banding.
Classification

Elastic Ring Separator
This small elastic ring is used to create space between two adjacent teeth before banding. The elastic ring is stretched by the separator placing pliers or by a dental floss and placed one end interdentally. It is left in situ for seven days to create space. Care should be taken to insert one end only and leave the other end occlusally.

Dumb-Bell Shaped Elastic Separator
This is a dumb-bell shaped elastic used to create space between two adjacent teeth before banding. The elastic is stretched and placed interdentally. It is left in situ for four days to create space.

Brass Wire Separator
0.5-0.6 mm soft brass wire is used as a separator and placed interdentally for four days. The free ends are twisted and tucked inter-dentally. It may cause soft tissue laceration and the force is also uncontrolled.

Kesling Metallic Ring Separator
This 0.016” Australian wire-made spring has a coil, one occlusal, one gingival and one retentive arm. It is placed interdentally with the help of the bird beak pliers or Weingart pliers for two days to create space.

Arch Wire
Different types of arch wires are required to accomplish the needs of different stages of fixed appliance therapy. No single arch wire contains all the required properties. For this purpose, different types of arch wires are used throughout the therapy.
Classification
Arch wire can be classified according to the material used or according to the cross section.

1. According to the material used:
   - Gold and gold alloys.
   - Stainless steel (SS).
   - Nickel-Titanium (NiTi) alloys.
   - Beta Titanium.
   - Cobalt-Chromium-Nickel alloys.
   - Optiflex arch wires.
2. According to the cross section:
   - Round.
   - Square.
   - Rectangular.
   - Multi-stranded.

Arch Wires in Different Stages

Initial Stage
Large springback, low stiffness, high stored energy, biocompatibility, and low surface friction are the properties Orthodontists look for during initial stage of tooth alignment. Round nickel-titanium, multi-stranded stainless steel or coaxial arch wires of 0.016-0.020" diameters are generally used in this stage.

Later Stage
Leveling of dentition, beginning of overbite reduction and sliding of teeth along the arch wire are focused during this stage. For these, arch wire with high stiffness, low stored energy, biocompatibility, low surface friction, and good join ability are used. Usually, round stainless steel wires with 0.016-0.020" diameters are used during this stage.
Final Stage
Rectangular stainless steel arch wire is used during the final stage of space closure and overbite reduction.

Spring

Function
To produce force for the tooth movement as an auxiliary.

Classification

Up-Righting Springs
This 0.012-0.014" Australian wire-made springs move the root of the tooth in a mesial or distal direction. This spring is usually used with the Begg and the Tip-Edge bracket systems.

Torquing Springs
These are 0.012-0.014" Australian wire-made springs used for providing torque movements of the tooth root. They are usually used in the Begg technique at the finishing stage.

Rotating Springs
This spring is used for derotation of a tooth, usually in the Begg and the Tip-edged techniques. It provides clockwise or anti-clockwise movements according to the design. Stainless steel or NiTi alloy is used for fabrication.

Open Coil Spring
This type of spring is used to create space. The spring is compressed between two or more teeth and when the spring moves back to its original length the required space is created. This spring is fabricated from stainless steel or NiTi alloy.
Closed Coil Spring

This type of spring is used to close space. The spring is stretched between two or more teeth and when the spring moves back to its original length space become closed. This spring is fabricated from stainless steel or NiTi alloy.

Elastics

Elastics are made of latex or non-latex materials but non-latex elastics are well tolerated in the oral environment. Elastics of different strength and dimensions are used according to the treatment needs. They are color coded for easy identification.

Class I Elastic

This intra-arch elastic is stretched from molar to the anterior tooth for the closure of space or retraction of the anterior teeth.

Class II Elastic

It is used to correct Class II malocclusion. This inter-arch elastic is stretched from the mandibular molars to the maxillary anterior to reduce overjet by retracting the maxillary incisors.

Class III Elastic

It is used to correct Class III malocclusion. This inter-arch elastic is stretched from the maxillary molars to the mandibular anterior to correct overjet by retracting the mandibular and protracting the maxillary incisors.

Crossbite Elastic

Posterior crossbites are corrected by these inter-maxillary elastics. The elastic is attached from the tooth in crossbite to the anterior teeth in opposite arch.
Fixed Appliances for Malocclusion

**Box Elastic**
This elastic is used for the correction of anterior open bite. The elastic is engaged in a ‘box’ manner between the maxillary and the mandibular anterior teeth. It causes correction by a forced eruption of the anterior teeth of both arches.

**Diagonal Elastic**
This elastic is used diagonally across the mandibular and the maxillary incisors for the correction of a deviated midline.

**Triangular Elastic**
These elastics are used in the finishing phase of fixed therapy for cuspal inter-digitation. These are placed in a triangular manner involving one tooth of the maxillary arch and two teeth of the mandibular arch and vice versa.

**Extra-Oral Elastic**
These elastics are used in conjunction with an extra-oral appliance, such as face mask; head gear for the extra-oral anchorage.

**Elastomeric**
These are commercially available, polyurethane made auxiliary components of fixed appliance used to create force and also hold the arch wire into the bracket slot.

**E-Chain Long/Short**
They are available in various lengths and strengths and are used for space closure. According to the distance between the adjacent rings, these are classified as continuous, short, and long E-chains.
Elastic Ligatures
These elastic rings are available in various attractive colors and used to secure the arch wire within the bracket slots.

Elastic Modules
These are two elastic rings separated by a variable distance and used for space closure and derotation of teeth.

Elastic Threads
These are fabricated from special elasticized cotton. They create a force to provide the teeth movement for derotation correction as well as consolidation of the anterior spacing.

Palatal and Lingual Arches
These are rigid stainless steel wires soldered to the molar bands.

Transpalatal Arch
It is fabricated from 0.9 mm stainless steel wire. It reinforces the anchorage as well as maintains the inter-molar distance.

Nance Palatal Arch
It extends through the hard palate and consists of an acrylic button, which rests on the palatal mucosa. It also maintains the upper arch length along with the reinforcing anchorage.

Lingual Arch
This mandibular arch is fabricated from 0.9 mm stainless steel wire. It extends behind the cingulae of the lower anterior teeth and extends up to the first molar where it is soldered with the band.
**Quad Helix**

It is fabricated by 0.9-1 mm stainless steel or 0.95 cobalt chromium wires. It extends across the palate and banded to the first molar. It incorporates helices which on activation causes expansion of the arch.

**HYRAx (Hygenic Rapid Expansion) Screw**

It is used for expansion of the maxillary arch. This screw is either cemented through the bands at the first molar and the first premolar or cemented directly to the posterior teeth by acrylic capping.

**SUPERscrew Telescopic Expander**

It is also used for expansion of the maxillary arch. This screw is either cemented through the bands at the first molar and the first premolar or cemented directly to the posterior teeth by acrylic capping.

**Magnets**

Magnets are used in the fixed appliance therapy for space closure and regaining lost space. Attraction mode is used for space closure and repulsion mode is used to regain lost space. Commonly used magnets in the fixed therapy are as follows-

- Samarium cobalt magnets - SmCo₅ and Sm₂Co₁₇
- Neodymium iron boron magnets - Nd₂Fe₁₄B

**Bands [1]**

These are passive components made of soft stainless steel. They are cemented to the tooth and various auxiliaries may be welded or soldered to them. They are commercially available for different teeth in corresponding sizes. Usually, bands are cemented on the first molars for optimum anchorage. Bands can also be cemented on the second molars, premolars,
and the anterior teeth if additional anchorage is required. Bands can be cemented on the teeth by direct or indirect banding methods depending on the operator.

**Brackets**

Brackets are passive components of the fixed appliance through which force is transmitted into the teeth and surrounding tissue. Different types of brackets are available commercially. The operator chooses a particular type according to the treatment plan. Brackets can be welded to a band and then cemented on to the teeth. But this is a very difficult procedure and is not used nowadays. Generally, brackets are bonded to the teeth by cement. Different teeth have different shaped brackets. Brackets may be classified as follows-

1. According to materials used for fabrication
   - Metallic brackets
     - Gold
     - Stainless steel
     - Titanium
   - Ceramic brackets
   - Plastic brackets
2. According to the technique used
   - Ribbon arch brackets
   - Begg’s modified ribbon arch brackets
   - Tip-Edged brackets
   - Edgewise brackets
   - Pre-adjusted edgewise brackets
   - Lingual brackets
3. According to the mode of attachment
   - Welded brackets
   - Bonded brackets
4. According to the mode of ligation
   - Brackets using auxiliaries for ligation
   - Self-ligating brackets

**Buccal Tubes**

These horizontal hollow tubes are attached to the molars for a better control of the anchor teeth. Arch wire, face bow, and extra-oral anchorage are attached to the fixed appliance through this. These tubes can be classified in various ways.

1. According to the mode of attachment
   - Welded
   - Bonded
2. According to the shape of lumen
   - Round
   - Oval
   - Rectangular
3. According to the number of tubes
   - Single
   - Double
   - Triple
4. According to the technique used
   - Begg tube
   - Edgewise tube
   - Pre-adjusted edgewise tube

**Lingual Attachments**

These are the auxiliaries placed lingually to the teeth by cementation or by welding to the band. Different types of lingual attachments are available. These are used according to the treatment need.
Lingual Buttons
These are used for attachment of elastic or elastomeric.

Lingual Eyelets
These are used for tying elastic thread or ligature wire.

Lingual Cleats
These are also used for attachment of elastics or elastomerics.

Lingual Sheath
These are used for attachment of transpalatal arches, quad helix, NiTi molar rotators, and expanders.

Lingual Ball and Hooks
These are used for attachment of elastics or elastomerics from lingual aspect.

Lingual Seating Lugs
These are helpful in placing bands.

Lock Pins
These are brass or soft stainless steel made pins used in the Begg technique and the Tip-Edged technique to hold the arch wire within the bracket slots. Three types of pins are used according to the stages of the Begg’s technique.

- Stage I
- Stage II
- Stage III
Ligature Wire

These are 0.008-0.010” diameters of soft stainless steel wires used to secure the arch wire within the bracket slots or to tie the segment of teeth together. They can be classified in various ways.

1. According to form and shape
   - Preformed stainless steel
     - Long
     - Short
   - Kobayashi stainless steel
     - Long
     - Short
   - Spooled ligature wire

2. According to thickness (color coded)
   - Thin- Yellow
   - Medium- blue
   - Thick- Black

STAGES OF FIXED APPLIANCE THERAPY

Fixed appliance therapy is divided into different phases with specific objectives [5].

Alignment Phase

This initial phase is to level the dentition and attain alignment. Leveling is the correction of marginal ridge discrepancies and it is achieved by using NiTi or multi-stranded arch wire of small diameters. All
crowding and rotations are dealt in this phase. Required space is created before teeth alignment. The aligning arch wire is then ligated fully/partially to all the brackets. After finishing alignment, 0.019-0.020" diameters of stainless steel arch wire is used for overbite reduction and space closure.

**Working Phase**

This is the phase for correction of overbite and overjet. Different techniques can be used to reduce overbite. The Begg and Tip-Edge techniques reduce both overbite and overjet by using a combination of stainless steel arch wire and light intermaxillary elastic traction. The stainless steel arch wire is bypassed through the premolars and the intermaxillary elastic traction causes tipping of the labial teeth.

The edgewise and the pre-adjusted edgewise appliance reduce overbite by using a rectangular stainless steel arch wire with a reverse curve of Spee on the lower arch wire. Class II inter-maxillary elastic traction, utility arches or segmental mechanism may also be used to aid in this phase.

The pre-adjusted edgewise appliance is advantageous over the standard edgewise appliance in space closure by sliding mechanism. The first, second and third order bends may be incorporated to facilitate the sliding mechanism. Elastomeric chains or coiled NiTi springs are used for application of force and Class II or Class III inter-maxillary elastics are used to aid in the anchorage.

**Finishing Phase**

The beta titanium wire is perfect for the finishing phase. It provides some occlusal settling. Inter-maxillary elastics also may be used during this phase to create maximum inter-digitation. The final arch wire is left in place passively for 2-3 months before starting the retention phase.
Retention Phase

During this phase, the fixed appliance is removed and a retainer is placed. The retainer may be removable or bonded, fitted tightly around the incisors and hold the corrected rotations. Full time wear for 4-6 months and then only night time wear for additional 4-6 months is advised. The patients are reviewed every 2-3 months for any complaint.

REFERENCES

Chapter 14

MALOCCLUSION AND OTHER DISCIPLINES

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ABSTRACT

This chapter is principally focused on discussing the correlation between the dental malocclusion and other most likely dental complications like periodontal involvement and dental caries. The effects of various orthodontic teeth movement on the periodontal tissues; the management of periodontal conditions in patients undergoing orthodontic treatment according to the severity, restorative considerations, and interactions with modifications in the treatment of malocclusion are also emphasized. Surgical interventions required to correct severe malocclusion along with pre-surgical and post-surgical orthodontics are also briefly discussed.
MALOCCLUSION AND PERIODONTAL PROBLEMS

Periodontal diseases are of multifactorial origin and malocclusion is found to be one of the factor in many recent studies stating that malocclusion may contribute to the periodontal disease only when poor oral hygiene is an accompanying factor. Statistically significant difference of periodontal conditions was found in patients with crossbite, excessive overjet and crowding compared to the control group [1]. Another study found reduced alveolar bone height in the area of severe malocclusion (8mm overjet) compared to the same region in a healthy individual with ideal occlusion [2]. In a study involving 15 adults, subgingival bacterial samples were taken from both the area of anterior crowded and well-aligned dentition to evaluate the relationship between the malocclusion and periodontal disease. The level of the pathogenic bacterial count was significantly higher in anterior crowded dentition than in the anterior well-aligned dentition and also the number of subgingival microorganisms increased progressively with the degree of crowding [3]. The orthodontists, therefore, must recognize the clinical forms of the inflammatory periodontal diseases because the patient’s periodontal status before, during and after the active orthodontic treatment may influence both the short-term and long-term effect of the treatment outcome. No matter how precise and magnificent the orthodontic correction may be but failure to recognize periodontal susceptibility may damage the whole outcome.

TYPES OF INFLAMMATORY PERIODONTAL DISEASES

Gingivitis

Accumulation of microorganisms around the teeth causes gingival redness with bleeding, edema, changes in gingival morphology, reduced
tissue adaption to the teeth, increased flow of gingival crevicular fluid and other signs of inflammation. Plaque control measures should be taken to prevent the spread of initial gingival lesion into the supporting connective tissues and subsequent loss of alveolar bone. Mechanical removal of the plaque by scaling can reduce chronic gingivitis in orthodontic patients. Antibiotic rinses can be recommended for the patients with specific problems (e.g., Mouth breathing, medication induced gingival overgrowth, hormone induced gingivitis etc.) as the removal of supragingival bacterial inhibits the formation of subgingival plaque. One of the most effective antiplaque agents is Chlorhexidine digluconate but orthodontists should be aware of its side effects such as reversible staining, tissue response, and the taste alterations.

**Periodontitis**

All forms of periodontitis are characterized by loss of connective tissue attachment and gingival inflammation. Periodontitis is more severe and destructive in children compared to adults. The severe bone loss in children and adolescent is an indicator of an early sign of systemic disease that requires medical attention. Orthodontic patients are at great risk of developing the periodontal disease because of tooth movement. Therefore, it is mandatory to recognize and control the signs of inflammation and tooth mobility during treatment to prevent extensive bone loss. Periodic monitoring of the periodontal status with probing, immunologic assays for microbiological assessment, DNA probes, culturing and clinical findings are useful in determining the frequency of scaling needed and as well as detecting the areas at potential risk of attachment loss. Genetic studies may help to identify the high-risk individuals [4]. Before orthodontic treatment, each patient should be screened for the potential factors for detecting the individuals who are at risk of developing periodontal disease during the course of treatment. Patient with a history of previous periodontal disease
is more susceptible and vulnerable to the disease. Orthodontic treatment should not be started if active sites of periodontal tissue destruction are present. Other risk factors such as gingival bleeding, tooth mobility, thin and friable gingival tissues should be looked for. Recording the list of periodontal risk factors for any adult seeking orthodontic treatment may be useful. Periodontal complications are less likely to show up by the early detection and careful control of the risk factors before the treatment. Stress, diabetes mellitus, tobacco smoking, osteoporosis and genetic predisposition are examples of disease modifiers [5]. Evaluation of the transverse skeletal pattern may be used as a risk marker for periodontal disease by which potential for facial gingival recession can be predicted. Individuals with increased transverse skeletal discrepancy between the maxilla and the mandible are prone to develop gingival recession and the periodontal disease [6] following rapid palatal expansion treatment.

Preliminary periodontal therapy should be started to remove calculus, plaque, and other irritants from the periodontal pockets before the orthodontic treatment is initiated. A period of observation is required after periodontal therapy to allow healing and regeneration of the periodontal tissues before preceding the comprehensive orthodontics. In a patient with a moderate periodontal condition, periodontal maintenance therapy should be repeated at 2 to 4 months intervals depending on the severity. For severe periodontal involvement, more frequent periodontal maintenance therapy is recommended (i.e., every 4-6 weeks) preferably during orthodontic appliance adjustment visits. Orthodontic mechanics and treatment objectives must be modified to lower the force to a minimal level to prevent damaging the vulnerable periodontal tissues. Even in serious periodontal conditions, orthodontic treatment can be carried without further damage to the alveolar bone when good control over the periodontal condition is maintained. Space closure in areas of major bone loss may lead to improvement in bone height if at least one wall of the periodontal pocket remains [17].
ORTHODONTIC TOOTH MOVEMENT AND PERIODONTAL TISSUES

Extrusion (Eruption)

Extrusion of a single tooth or multiple teeth along with the reduction of the clinical crown height reported to reduce the infra-bony defects and the pocket depths [7]. Uprighting of molars without scaling or root planing have shown to reduce the number of pathogenic bacteria.

Intrusion

Intrusion is more hazardous type of movement because here force is concentrated at the root apex with root resorption as a common consequence. Light forces are always recommended. Reports of infra-bony defects found during intrusion of the anterior segment to correct overbite [9]. Intrusion also has been reported to alter the cemento-enamel junction and angular crest relationships and to create only one epithelial attachment roots which are susceptible to future periodontal breakdown.

Tipping

In tipping movement, light force should be applied, the area should be kept clean of plaque and calculus to prevent the formation of angular bony defect.

Bodily Movement

Bodily movement increases the rate of destruction of connective tissue attachment of teeth with inflamed, infra-bony pockets.
MUCOGINGIVAL CONSIDERATION

During orthodontic tooth movement, adequate amount of attached gingival tissues are required to allow orthodontic appliances exerting force without causing bone loss or gingival recession. Many studies found that inflammation is prone to occur in the areas of deficient attached gingiva than in areas with a wider zone of attached gingiva [14]. Orthodontic cases involving gingival inflammation and bodily facial teeth movement may predispose to gingival recession. However, gingival graft can be used to prevent this. Root exposure is more progressive in younger patients and because the labial bone loss is impossible to correct, it is necessary to prevent labial bone loss probably by grafting thicker gingiva to withstand inflammatory insult better during tooth movement. If the reduced area of attached gingiva or thin tissue exists particularly around the abutment teeth then free gingival graft should be provided to control inflammation before the orthodontic treatment.

GINGIVAL HYPERPLASIA

Gingival hyperplasia is usually self-limiting or responds positively to plaque removal and scaling. However, if the enlarged gingival tissue interferes with tooth movement then it should be removed surgically. Otherwise, wait until the appliances are removed to surgically correct the abnormal gingival form [10] and using the procedure to enhance the postoperative treatment stability.

MOUTH BREATHING

Mouth breathing is associated with erythematous and enlarged labial gingivae both in maxillary and mandibular anterior segment due to the drying effect on the exposed tissue. Studies found the higher gingival index
in mouth breathers [11]. The inflammation should be controlled and reduced to minimal level before the placement of the orthodontic appliances usually by the scaling and curettage.

MALOCCLUSION AND DENTAL CARIES

The etiology of malocclusion is multifactorial. The early loss of primary teeth due to dental caries is considered to be a leading cause of malocclusion. On the contrary, due to the presence of malocclusion, it becomes difficult to maintain good oral hygiene because of inaccessible areas of plaque accumulation thus susceptibility to dental caries further increases.

A cross-sectional study on 1,800 school going children aged between 11-15 years in southern India demonstrated a positive correlation between the prevalence of malocclusion and dental caries [12]. The study stated that during mixed dentition period premature loss of permanent teeth and caries in the supporting zones associated with such loss causes crowding. Another study reported that children with caries experience (decayed, filled or missing teeth) are two times more likely to have malocclusion than children with no caries experience [13]. The most commonly found malocclusion traits were midline shift, spacing, and open bite. A midline shift may due to unilateral loss of primary canine or first molar due to caries. Untreated proximal caries in primary molars or early loss of second primary molar may lead to the forward drift of the first permanent molar thereby causing a change in the molar relationships.

Fluoridation can be done as a preventive measure. Temporary restorations should be placed to control caries followed by the definitive restoration which should be delayed until after the orthodontic phase of treatment. Composite is preferred as temporary restorative material while orthodontic treatment is being carried out. Cast restorations should be delayed until after the final occlusal relationships have been established by the orthodontic treatment. Pulpal involvement of caries requires endodontic treatment and orthodontic movement of an endodontically
treated tooth is not contraindicated. However, an attempt to move the such tooth may cause a flare-up of the periapical condition.

**Restorative Considerations**

During comprehensive orthodontics, the positioning of the damaged, abraded or worn tooth should be done by keeping proper restorative plan in mind. Early consultation with the restorative dentist may be useful. The positioning of restored teeth requires four important considerations: the total amount of space required, the mesiodistal positioning of the tooth within the space, the buccolingual positioning and the vertical positioning. The orthodontic positioning should provide adequate space for addition of the restorative material. The ideal buccolingual position of a damaged maxillary tooth depends on the planning of the restoration. For example, if crowns are planned then the tooth should be in the center of the dental arch without tight contact with the opposing arch. On the other hand, if the facial veneer is planned then the Orthodontists should place tooth more lingually to accommodate the thickness of the veneer on the facial surface. For better restoration orthodontist should create more space than required to allow finishing and polishing of proximal surfaces.

If a small amount of tooth structure has been lost then aesthetic crown build-up with composite resin is preferable. Earlier, when the incisal edge of one incisor was fractured orthodontic elongation was done to line up the incisal edges which resulted in uneven gingival margins.

**Severe Malocclusion and Surgeries**

Severe malocclusion which cannot be corrected either by growth modification or camouflage can only be resolved by the surgical realignment of the jaws or repositioning of the dentoalveolar segments.
Following surgery properly coordinated orthodontics and other dental treatments are required for a good overall outcome.

Growth modification is only possible in growing patients by the means of orthopedic and functional appliances. But growth modification can alter the skeletal relationship by a limited amount and after the cessation of growth, the only non-surgical treatment option is camouflage which is focused on teeth movement accepting the skeletal discrepancy and thereby compromising the facial aesthetics.

Following cases require combined surgical approach and orthodontic intervention [15]:

- Severe class II skeletal malocclusions.
- Severe class III skeletal malocclusions.
- Vertical discrepancy leading to anterior open bite or severely increased overbite.
- Skeletal asymmetries.

**COMMON SURGICAL PROCEDURES**

By the orthognathic surgeries, both jaws can be repositioned three-dimensionally but the movements are not stable in all directions. For example, mandible can be moved forward or back, moved down anteriorly and narrowed with ease but moving it down posteriorly lengthen the ramus which is highly unstable. The maxilla can be moved up and forward with excellent stability, moved down only with difficulty because of instability. Protruding anterior teeth can be moved back via segmental osteotomy. Segmental osteotomy also allows it to be widened or narrowed but widening tends to be unstable because of the stretching of the pulled palatal tissue [16]. Intra oral approach should be made to avoid unsightly scars to emphasize aesthetics.
MANDIBULAR PROCEDURES

Ramus Surgery

The most commonly adopted ramus techniques are:

*Vertical Sub Sigmoid Osteotomy*

It is mainly indicated for mandibular prognathism. This usually done by the bony cuts from the sigmoid notch to the lower border.

*Sagittal Split Osteotomy*

This procedure is used to move the mandible forward or backward or to correct mild asymmetry. The bony cut extends obliquely from above the lingula, across the retromolar region and vertically down the buccal plate to the lower border. This technique is widely used almost in all mandibular surgeries because of several advantages over other procedures.

Body Osteotomy

This is rarely used. Indicated only when there is a natural gap in the lower arch anterior to the mental foramen in a patient with mandibular prognathism.

Genioplasty

The tip of the chin can be moved almost in any direction, limited by sliding bony contact and the muscle pedicle.

Postcondylar Cartilage Graft

A block of cadaveric or autologous cartilage is inserted behind the condylar head which produces a result similar to rapid functional appliance
treatment in class II division 1 malocclusion with the remodeling of the condylar fossa. This technique is usually indicated in growing patients with severe mandibular retrognathia.

MAXILLARY PROCEDURES

Segmental Procedures

In this procedure, one or more teeth and their supporting bone is moved.

Lee Fort I

This is the most widely used technique. A horseshoe shaped incision is made on the buccal mucosa and underlying bone which results in the maxilla being pedicled on the palatal soft tissues and blood supply. The maxilla can then be moved upwards (after removing the intervening bone), downwards (with interposition bone graft) or forward [16].

Lee Fort II

It is usually indicated for midfacial advancement and usually very risky for extensive procedure

Lee Fort III

Commonly indicated in craniofacial anomalies. The surgery requires raising of a bi-coronal flap for access.

Surgically Assisted Rapid Palatal Expansion

This is indicated in adult patients with narrow maxilla. This procedure involves bone cuts to reduce the resistance followed by the expansion of the jack screw to separate the halves of the maxilla. The cuts in the lateral buttress of the maxilla decrease the resistance to the point that the mid-palatal suture could be forced open [16].
**DISTRACTION OSTEОGENESIS**

This surgical intervention is based on manipulation of a healing bone, stretching an osteotomized area before the start of calcification in order to stimulate the formation of additional bone and investing soft tissues [16]. This technique is very useful for the correction of severe congenital craniofacial deformity in a growing child. The advantages of this technique are that large distances of movement are possible compared to conventional orthognathic surgery and the deficient jaws can be increased in size at an earlier age. On the other hand, the major disadvantage is that the precise movements are not possible.

**PRE-SURGICAL ORTHODONTICS**

The principal aim of pre-surgical orthodontics is to align the arches or arch segments, making them compatible and to establish the anterior-posterior and vertical position of the incisors so that the teeth will not interfere with the desired repositioning of the jaws. Two problems often faced frequently require special attention: leveling of the accentuated curve of Spee in the lower arch of a patient with a deep overbite and leveling of the upper arch in open bite cases having a severe vertical discrepancy between anterior and posterior teeth.

**Levelling the Mandibular Arch**

In cases with accentuated curve of Spee in the lower arch, leveling can be done either by the intrusion of incisors or extrusion of premolars depending on the desired final facial height. If the face is short but the distance between the lower incisal edge and the chin is normal then leveling by the extrusion of the posterior teeth is indicated. If the incisors
are elongated and the facial height is normal or excessive then intrusion of the incisors are indicated to obtain desired facial height during surgery.

**Leveling the Maxillary Arch**

In open bite cases with severe vertical discrepancy within the maxillary arch requiring multiple segment surgery for vertical repositioning of the maxilla, conventional leveling of the upper arch should not be done. Instead, pre-surgical leveling should only be confined to each segment and then the segments are leveled during surgery. Extrusion of anterior teeth should be avoided because the orthodontic relapse may interfere with the post-surgical bite opening.

**Establishment of Incisor Position**

It is one of the critical aspects of treatment planning because the anterior-posterior positioning of the incisors is the key to determine where the mandible will be placed in relation to the maxilla during surgery. This is also important in planning the closure of the extraction sites.

In mandibular advancement, rigid internal fixation is provided to prevent the displacement of incisors.

When multiple surgical segments are planned for maxilla, axial inclination of the upper incisors and canines should be established pre-surgically to prevent any major rotation of the anterior segment during the surgery.

**Stabilizing Archwires**

After the final orthodontic adjustments, stabilizing archwires should be placed at least 4 weeks before the surgery so that they remain passive when the impression is taken for a surgical splint. This will ensure no tooth
displacement which would result in a poorly fitting splint and compromised surgical outcome. Tight intermaxillary fixation is necessary at least long enough to place rigid fixation.

POST-SURGICAL ORTHODONTICS

After achieving a satisfying range of motion and initial healing, the finishing stage of orthodontics can be started. It is important that the splint should be removed along with the stabilizing archwires and replaced by the working archwire for bringing teeth into their final position. Light vertical elastics are needed with the working archwire to disallow the proprioceptive impulses from the teeth which would otherwise cause the patient to seek new areas of maximum intercuspation. Until the removal of the splint, the teeth are held tightly in pre-surgical position. The splint should only be removed when the teeth are settled into a state of better interdigitation.

Elastics should not be discontinued until solid occlusion is achieved. Light elastics should be worn full-time including at the time of eating for the first 4 weeks, full-time except at the time of eating for another 4 weeks and only during the night for 3rd-4th week periods [16].

Retention is required to maintain transverse expansion of the maxilla after the surgery by wearing a full-time retainer in the maxilla for at least 6 months [16].

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Chapter 15

THE COMPLICATIONS OF ORTHODONTIC MALOCCLUSION TREATMENT

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ABSTRACT

The goal of orthodontic treatment is not only ensuring alignment of teeth, jaw relationships, function and aesthetics but also improving self-esteem and quality of life. However, orthodontic treatment has also related risks and complications like any other medical intervention. Though the harmful effects, risks and complications are significantly lesser than other medical interventions. Due to the practice of several techniques, plans and materials, both local and systemic unwanted effects may possibly happen like root resorption, tooth discoloration, periodontitis, gingivitis, allergic reaction, etc. Evaluation of the risks and complications is necessary before starting any treatment of malocclusion.
Therefore, this chapter’s goal is to describe briefly the risk factors and complications of orthodontic treatment of malocclusion.

**Keywords:** Complications, Malocclusion, Orthodontic treatment.

**INTRODUCTION**

If orthodontic treatment is to be beneficial to a patient, the advantages it offers should outweigh any possible damage it may cause [1]. It is recommended to evaluate the risks of treatment as well as the potential gain and balance of these points of treatment before determining to treat a malocclusion. Patient selection plays a role to minimize the risks of treatment and the clinician should be aware while evaluating every aspect of the patient along with their malocclusion. However, clinically there are plenty of areas that should lead to the concern for risk management. These are discussed in detail under the broad categories of intra-oral, extra-oral and systemic risks.

**INTRAORAL COMPLICATION**

**Enamel Demineralization/Caries**

Enamel demineralization generally occurs on smooth surfaces. Unfortunately, it is a common complication in orthodontics; it ranges from 2-96% of orthodontic patients [2]. This large variation most likely emerges as a result of the variety of techniques used to diagnose and score the presence of decalcification. Typically, maxillary lateral incisors, maxillary canines and mandibular premolars are affected [3]. However, any tooth in the oral cavity can be affected, and often several anterior teeth shows decalcification. While the demineralized surface remains intact, there is a chance of remineralization and reversal of the lesion. In severe cases, extensive cavitation is seen which requires restorative treatment.
Gorelick et al., [4] demonstrated that half of the patients had at least one white spot after treated with fixed orthodontic appliances, most commonly on maxillary lateral incisors. The duration of treatment did not affect the incidence or number of white spot formations. O’Reilly and Featherstone [5] and Oggard et al., [6] revealed that demineralization can occur immediately, within the first month of fixed orthodontic appliance treatment. This has obvious aesthetic implications and features the necessity of caries rate assessment at the beginning of treatment. Apparently, no incidence of white spot formation associated with the lingual bonded retainers was revealed by the Gorolick et al., [4]. It might suggest salivary buffering capacity and flow rate have a role in protection against acid attack.

The dominant hand may also effect the area of decalcification, as brushing is more difficult on the side of the dominant hand. While good oral hygiene is essential, dietary control of sugar intake is also needed to minimize the risk of decalcification. Fluoride mouthwashes used throughout the treatment can prevent white spot formation [7]. Other fluoride release mechanisms include fluoride releasing bonding agents, elastic ligatures containing fluoride, and depot devices on upper molar bands [8].

Precautions can minimize damage including patient selection, healthy oral hygiene measures and dietary education. Follow up of oral hygiene and dietary education should be performed at each visit. Positive reinforcement even where oral hygiene is satisfactory, will encourage the patient further. Inspection of labial surfaces of the teeth at every appointment. This will identify cases that demand more intervention and advice. In every appointment, the teeth should be needed to plaque-free while examining the teeth, otherwise, early demineralization may be missed. This can be done by advising the patient to clean their teeth in the surgery with or without the wires in placed or by professional prophylaxis. The dental auxiliaries such as dental health educators and hygienists is highly desirable. Removal of the appliance in cases with extreme demineralization or poor hygiene is the last option which should not be deducted by the clinician. Where demineralization is present post treatment
fluoride application either via toothpaste or by adjunct fluoride mouthwash (0.05% sodium fluoride daily rinse or 0.2% sodium fluoride weekly rinse) can be quite effective for remineralizing the lesion and reducing the unsightliness of decalcification [9]. Acid or pumice micro abrasion has also been advocated to improve the aesthetics of stabilized lesions [10, 11]. This procedure should be delayed at least 3 months following debond to allow for spontaneous improvement of the lesions and remineralization with fluoride applications [12]. Persistent lucencies should be rubbed with 18% hydrochloric acid in fine pumice under rubber dam in bursts of 30 seconds for maximum of 10 times. The tooth is needed to wash very well after the last application and a fluoride varnish applied [10].

**Enamel Trauma**

Careless insertion of appliances with the use of a band seater can result in enamel fracture. Care is required when large restorations are present since these can result in fracture of unsupported cusps [13]. Enamel fracture also can be occurred while debonding [14, 15]. It can happen with both metal and ceramic brackets. Care must always be taken to remove brackets and residual bonding agents appropriately to minimize the potential risk of enamel fracture. The use of debonding burs could remove enamel, especially in air turbine fast handpieces. Care and attention are needed while adhesives are removed.

**Enamel Wear**

Wear of enamel against both metal and ceramic brackets (abrasion) may occur. It is common on maxillary canine tips during retraction, as the cusp tip hits the mandibular canine brackets. It may also be seen on the incisal edges of maxillary anterior teeth where ceramic brackets are placed on mandibular incisors [16]. Ceramic brackets are very abrasive and therefore contraindicated for the mandibular anterior teeth where there is
any possibility of the brackets occluding with the maxillary teeth, taking into consideration that the overbite may increase in the initial stages of treatment. Any enamel erosion must be recorded just before treatment initiating and appropriate dietary advice given to minimize further tooth substance loss. Carbonated drinks and pure juices are the most common causes of erosion and should be avoided in patients with fixed appliances.

**Pulpal Reactions**

A small degree of pulpitis is expected with orthodontic tooth movement which is usually reversible or transient. Rarely does it result in loss of vitality, but there may be an increase in pulpitis in previously traumatized teeth with fixed appliances. Light forces are strongly suggested with traumatized teeth along with the baseline monitoring of vitality which should be repeated three monthly [17]. Transient pulpitis may also be seen with electrothermal debonding of ceramic brackets [18] and composite removal at debond [19].

**Root Resorption**

Some degree of external root resorption is eventually associated with fixed appliance treatment, although the extent is unpredictable [20]. Resorption may occur on the apical and lateral surface of the roots. However, radiographs only shows apical resorption to a certain degree. Many cases will not show any clinically significant resorption but microscopic changes are likely to have occurred on the surfaces which are not visualized with routine radiographs. Resorption however rarely compromises the longevity of the teeth [21]. Vertical bone loss through periodontal disease creates a far greater loss of attachment and support than its equivalent loss around the apex of a tooth.

The mechanism of tooth resorption is unclear. Theories include excessive force and hyalinization of the periodontal ligament leads to
excessive cementoclast and osteoclast activity. These can be summarized as:

- Blunt and pipette shaped roots show a greater amount of resorption compared to other root forms.
- Short roots are usually more at risk of resorption than average length roots.
- Teeth which previously traumatized have an increased risk of further resorption.
- Non-vital teeth and root treated teeth have an increased risk of resorption.
- Heavy forces are associated with resorption as well as the use of rectangular wires, Class II traction, the distance a tooth is moved and the type of tooth movement undertaken.
- Combined orthodontic and orthognathic procedures.

Treatment of ectopic canines may induce resorption of the adjacent teeth due to the duration of treatment and the distance of the canine is moved. Tooth intrusion is also associated with increased risk as well as the movement of root apices against cortical bone. Above the age of 11 years, risk of resorption with treatment seems to increase. Adults have shorter roots at the outset and possibility of resorption is increased.

Opinion is divided on whether duration of treatment is associated with the increased resorption. Some researchers found no correlation with treatment duration, whereas others found that there is increased resorption with increased treatment time. In a few patients, systemic causes may contribute, for example- hyperthyroidism, but for the most part no underlying cause is isolated other than individual susceptibility. Familial risk is also known.

A wide range in the degree of resorption is seen, highlighting the role of individual susceptibility over and above the risk factors identified. Research is still required in this area to identify the mechanisms of resorption, trigger factors and reparative mechanisms if treatment
modalities are to be modified in the future to minimize root damage. Currently, no case is immune from the risk of root resorption to some degree and patients should be warned early in treatment that such a risk exists. Recognition of specific risk factors, accurate radiographs and interpretation of radiographs at initial stage of treatment are important for minimized root resorption. Once resorption is observed clinically during the treatment light forces must be used, root length monitored six monthly with radiographs and treatment aims reconsidered to maximize the longevity of the dentition. The use of thyroxine to minimize root resorption has been strongly suggested by the other authors, but this is not routinely used [22, 23].

**Periodontal Tissues**

Fixed appliances make oral hygiene challenging even for the most motivated patients and almost all patients experience some gingival inflammation. Resolution of inflammation usually occurs a few weeks after debonding, bands cause more gingival inflammation than bonds which is not surprising since the margins of bands are often seated subgingivally.

In most cases, the literature suggests that orthodontic treatment does not affect the periodontal status of patients over the long term. Patients with pre-existing periodontal disease require special attention, but bone loss during treatment does not seem to be related to previous bone loss. The necessity of excellent oral hygiene during treatment must be emphasized in patients with existing periodontal disease. The use of bonds rather than bands on molars and premolars may be more appropriate to eliminate unwanted stagnation areas. Plaque retention is increased with fixed appliances and plaque composition may also be altered. There is an increase in anaerobic organisms as well as a reduction in facultative anaerobes around bands, which are therefore periopathogenic [24].

Oral hygiene instruction is essential in all cases of orthodontic treatment and the use of adjuncts such as electric toothbrushes,
interproximal brushes, chlorhexidine mouthwashes, fluoride mouthwashes and regular professional cleaning must be recommended. However, patient motivation and dexterity are vital to accomplishing hygiene and there will always be cases where oral hygiene is unsatisfactory from the outset. This should be carefully considered when counseling a patient to have treatment. Experience shows those patients who are unable to maintain a healthy oral environment in the absence of fixed orthodontics will fail spectacularly with braces in place. The benefit must therefore significantly outweigh the risk of carrying out treatment in such patients.

**Allergy**

Allergy to orthodontic components intraorally is extremely rare. However, there has been researching on the nickel release and corrosion of metals with fixed appliances. Gjerdet et al., [25] found a significant release of nickel and iron into the saliva of patients just after placement of fixed appliances. However, no significant difference was found in nickel or iron concentrations between controls and subjects where the appliances had been in place for several weeks. The clinical significance of nickel release is still not clear, but it should be considered in nickel sensitive patients. There are a few cases with severe latex allergies who may be affected by elastomers or operators gloves.

**Trauma**

Laceration to the gingivae, and mucosa seen as areas of ulceration or hyperplasia, often occur during treatment or between treatment sessions from the archwire and bonds, especially where long unsupported stretches of wire rest against the lips. The use of dental wax over the bracket may help to reduce trauma and discomfort.
EXTRAORAL COMPLICATIONS

Allergy

Allergy to nickel is more common in extra-oral settings, most commonly the headgear face bow or head strap. Over 1% of patients have some form of contact dermatitis to zips and buttons or studs on clothing. Among these patients, 3% claim to have experienced a similar rash with orthodontic appliances. The use of sticking a plaster over the area in contact with the skin is sufficient to diminish symptoms. Allergy to latex [26] and bonding materials have been reported although these are rare.

Trauma

After a well-publicized case of eye trauma in a patient wearing headgear, [27] a number of safety headgear products have been designed and explicit guidelines are now available. These measures include safety bows, rigid neck straps and snap release products to prevent the bow from disengaging from the molar tubes or acting as a projectile. A study among British orthodontists found a 4% incidence of facial injury with headgear. Of these injuries, 40% were extra-oral and 50% of these were in the mid face. Two patients were blind due to headgear trauma. Eye injury is rare but a serious risk and all available methods of reducing the risk of penetrating eye injury must be used. Every headgear and Kloehn bow must incorporate a safety feature. Failure to observe safety guidelines on the use of headgear is medico-legally indefensible.

Burns

Burns, either thermal or chemical are possible both intra- and extra-orally with inadvertent use of chemicals or instruments. Acid etches,
electrothermal debonding instruments and sterilized instruments which have not cooled down all have the possibility to burn and care should be taken in their use.

**TEMPOROMANDIBULAR DYSFUNCTION (TMD)**

Much attention in the literature has been focused on the relationship between TMD and orthodontic treatment. While TMD is common in the orthodontic aged population whether orthodontic treatment is carried out or not, there is no evidence to support the theory that orthodontic treatment causes TMD or cures it [28]. Pre-existence of TMD should be recorded, and the patient counselled that treatment will not predictably improve their condition. Some patients may experience increased symptoms during treatment which must also be discussed at the beginning of treatment. While patients experience symptoms during treatment, treatment should be directed at eliminating occlusal disharmony and joint noises when reassuring the patient. Standard treatment rules may also be indicated eg: soft diet, jaw exercises.

**PROFILE DAMAGE**

Extraction of premolars has been condemned by some with very little evidence, as altering the facial profile of the patient [29]. A large number of studies have shown that there is no significant difference in profiles treated by extraction or non-extraction means. Boley et al., [30] found that neither orthodontists nor general dentists could distinguish between extraction and non-extraction treatment by looking at profile alone. It should be remembered that soft tissue changes occur naturally with age, regardless of orthodontic intervention. Proper diagnosis should consider skeletal form, tooth position and soft tissue form to negate the possibility of any detrimental effect on profile by treatment mechanics [31].
SYSTEMIC COMPLICATION

Cross Infection

Spread of infection between patients, between operator and patient and by a third party should be prevented by cross infection procedures throughout the surgery. Use of gloves, masks, sterilized instruments and ‘clean’ working areas. A medical history must be taken for every patient to determine risk factors, although cross infection control should be of a standard to prevent cross-contamination regardless of medical status.

Infective Endocarditis

Patients at risk of endocarditis should be treated in consultation with their cardiologist and within the appropriate guidelines [32, 33]. The patient must exhibit immaculate oral hygiene; the antibiotic cover will be required for invasive procedures such as extractions, separation, band placement and band removal. It is recommended that bonded attachments are used on all teeth to negate the need for antibiotic cover for both separator and band placement, as well as removal. This also reduces the risk of unwanted plaque stagnation areas. Chlorhexidine mouthwash has been advocated just before any treatment and in some cases used daily to minimize bacterial loading [33].

REFERENCES


Craniofacial deformities and malocclusion

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Abstract

Any deformity (anatomical or chromosomal) that initiates during pregnancy and the effects of which are detected after birth are considered as congenital anomalies. Craniofacial anomalies are the deformities that occur in the head and facial bones. Craniofacial deformities are multifactorial in nature. Many factors such as genetics, environment, and vitamin deficiency are thought to be responsible for these deformities.
The most common craniofacial deformity is cleft lip and palate; comparatively, the less common deformities are Treacher-Collins syndrome, hemifacial hyperplasia/hypoplasia, craniosynostosis, unilateral facial nerve paralysis, hemangioma, etc. Affected patients suffer a multitude of problems, including both functional and aesthetic consequences. A high prevalence of abnormal facial patterns and occlusal dysfunction accompanying malocclusion are observed in these congenital deformities. Short palate, narrow maxillae or mandible, missing teeth, crowding spacing, and misalignment of teeth are the common manifestations that are observed in almost all craniofacial deformities.

Keywords: Craniofacial deformities, Malocclusion, Dental anomalies.

INTRODUCTION

Most of the infant mortality and childhood morbidity occurs because of congenital anomalies that affect almost 2-3% of newborn babies. Among those, approximately 1% of babies have syndromes or multiple anomalies at a time and craniofacial deformities are often a common part of multiple anomalies or syndromes. Multiple anomalies or syndromes consist of several deformities together and they are multifactorial in nature. The responsible causes of these anomalies are thought to be genetics, environment, and vitamin deficiency.

The medical term “craniofacial” is related to the bones of the skull and face. And the deformities of this region are known as craniofacial deformities. Cleft lip and palate is the most common of all birth defects. Others are very rare. Most of them affect how a person’s face or head looks. These conditions may also affect other parts of the body.

Craniofacial deformities may be congenital (cleft lip and palate, first arch syndromes, Treacher-Collins syndrome, auriculo-facial deformity, etc.), developmental (deformities due to hormonal imbalance, early trauma, contracture of early burn scar, etc.) or acquired (mal-united fractures, infection, tumors, loss of osseous soft tissue due to traumatic injury, etc.). Treatment of craniofacial deformities depends on the type of problem.
CLASSIFICATION OF CRANIOFACIAL DEFORMITIES

Table 1. Classification of Craniofacial Deformities (According to site)

| A) Variations in facial width | 1. Hemifacial hyperplasia or hypoplasia |
|                             | 2. Hemifacial atrophy                   |
|                             | 3. Unilateral facial nerve paralysis    |
|                             | 4. Unilateral trauma or infection       |
|                             | 5. First arch trauma or infection       |
|                             | a) Unilateral cleft-lip and palate      |
|                             | b) Unilateral auriculo-facial Hypoplasia|
|                             | c) Failure of other facial components such as fronto-nasal and ateral-nasal process |
|                             | 6. Vascular tumors                      |
|                             | a) Haemangioma                          |
|                             | b) Lymphangioma                         |
|                             | 7. Wryneck or torticollis-postural, structural and muscular |
|                             | 8. Neurofibromatosis                    |
| B) Variations in facial depth (Anterior-posterior aspect) | 1. Mandibular prognathism |
|                             | 2. Macrogenia - over development of chin|
|                             | 3. Microgenia - lack of prominence of chin|
|                             | 4. Micrognethia - short mandible        |
| C) Variations in facial height | 1. Mandibular prognathism with open bite. |
|                             | 2. Rotary displacement of maxilla and mandible (in which maxilla and mandible is bodily displaced) |

MALOCCLUSION IN DIFFERENT CRANIOFACIAL DEFORMITIES

Cleft Lip and Palate

Cleft lip and palate is one of the most common congenital anomalies present at birth. Cleft lip and palate is accompanied by a wide variety of
dental anomalies. The incidence of certain dental anomalies is strongly correlated with cleft lip and palate.

Table 2. Dental anomalies associated with cleft lip and palate

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<tr>
<td>1</td>
<td>Multiple missing teeth/hypodontia/agenesis</td>
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<td>2</td>
<td>Ectopic teeth</td>
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<td>3</td>
<td>Impaction</td>
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<td>4</td>
<td>Supernumerary teeth</td>
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<td>5</td>
<td>Microdontia</td>
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<td>6</td>
<td>Maxillary canines and premolars transposition</td>
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<td>7</td>
<td>Delayed development</td>
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<td>8</td>
<td>Crown and root malformation</td>
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<td>9</td>
<td>Multiple decayed teeth</td>
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<td>10</td>
<td>Spacing</td>
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<td>11</td>
<td>Class III malocclusion</td>
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<td>12</td>
<td>Dental arch discrepancies</td>
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</table>

**Treacher-Collins Syndrome**

It is an autosomal dominant congenital disorder which affects the craniofacial development that especially involves eyes, ears, jawbone, and cheekbones. This syndrome is also known as mandibulofacial dysostosis. Clinical features of this syndrome include not only dental anomalies, but also other problems such as breathing problems, hearing and vision loss, etc.

**Pierre Robin Syndrome**

Also known as Pierre Robin syndrome, Pierre Robin sequence, Pierre Robin malformation, Pierre Robin anomaly, or Pierre Robin anomalad. It is a congenital facial abnormality characterized by cleft palate, retrognathia
(abnormal positioning of the jaw or mandible), and glossoptosis (airway obstruction caused by a backwards displacement of the tongue base).

**Table 3. Dental anomalies associated with Treacher-Collins syndrome**

| 1.  | Micrognathia |
| 2.  | Midface hypoplasia |
| 3.  | Cleft palate |
| 4.  | Zygomatic and mandibular hypoplasia |
| 5.  | Anterior open bite |
| 6.  | Shortened of soft palate |
| 7.  | Enamel hypoplasia |
| 8.  | Retained deciduous teeth |
| 9.  | Missing permanent teeth |
| 10. | Anterior crowding |
| 11. | V-shaped lower arch |
| 12. | Microstomia |
| 13. | Dental arch discrepancies |
| 14. | Incompetent lips |
| 15. | Dental caries |

**Table 4. Dental anomalies associated with Pierre Robin Syndrome**

| 1.  | Cleft palate |
| 2.  | Retrognathia |
| 3.  | Anterior open bite |
| 4.  | Retained deciduous teeth |
| 5.  | Missing teeth |
| 6.  | Crowding |
| 7.  | Micrognathia |
| 8.  | Hypoplastic mandible |
| 9.  | Dental arch discrepancies |
| 10. | Incompetent lips |
| 11. | Dental caries |
Oculo-Auriculo-Vertebral Spectrum

It is also known as Goldenhar Syndrome. It is a congenital anomaly characterized by craniofacial anomalies such as hemifacial microsomnia, auricular, ocular, and vertebral anomalies.

Table 5. Dental anomalies associated with Oculo-auriculo-vertebral spectrum / Goldenhar Syndrome

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cleft palate</td>
</tr>
<tr>
<td>2.</td>
<td>Cleft lip</td>
</tr>
<tr>
<td>3.</td>
<td>Tongue cleft</td>
</tr>
<tr>
<td>4.</td>
<td>Tongue hypoplasia</td>
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<tr>
<td>5.</td>
<td>Gingival hypertrophy</td>
</tr>
<tr>
<td>6.</td>
<td>Retained deciduous teeth</td>
</tr>
<tr>
<td>7.</td>
<td>Spacing</td>
</tr>
<tr>
<td>8.</td>
<td>Nasoalveolar fistulae</td>
</tr>
<tr>
<td>9.</td>
<td>Missing teeth</td>
</tr>
<tr>
<td>10.</td>
<td>Crowding</td>
</tr>
<tr>
<td>11.</td>
<td>Micrognathia</td>
</tr>
<tr>
<td>12.</td>
<td>Mandibular hypoplasia</td>
</tr>
<tr>
<td>13.</td>
<td>Constricted maxillary arch</td>
</tr>
<tr>
<td>14.</td>
<td>Dental arch discrepancies</td>
</tr>
<tr>
<td>15.</td>
<td>Dental caries</td>
</tr>
</tbody>
</table>

Hemifacial Hyperplasia

Congenital hemifacial hyperplasia is a congenital deformity characterized by noticeable unilateral overdevelopment of hard and soft tissues of the face. Hemifacial hyperplasia presents malformation of the tissues of the face comprising the teeth and their associated tissues in the jaw.
Table 6. Dental anomalies associated with hemifacial hyperplasia

| 1. | Unilateral enlargement of the maxillary and mandibular quadrants |
| 2. | Macroglossia |
| 3. | Macrodontia |
| 4. | Crossbite |
| 5. | Gingival hypertrophy |
| 6. | Crowding |
| 7. | Dental arch discrepancies |
| 8. | Dental caries |

Hemifacial Atrophy

It is also known as Parry-Romberg or Romberg Disease. It is a completely unusual degenerative as well as unstated disorder, which is characterized by a slow and progressive atrophy affecting one side of the face. The cause of this disorder is unknown, although cerebral disturbance of fat metabolism is thought to be its primary cause. This can affect the cerebral sympathetic nervous system.

Table 7. Dental anomalies associated with hemifacial atrophy

| 1. | Midface hypoplasia |
| 2. | Deviated lip |
| 3. | Class II malocclusion |
| 4. | Crossbite |
| 5. | Crowding |
| 6. | Over retained deciduous tooth |
| 7. | Misalignment of permanent tooth |
| 8. | Midline shifting |
| 9. | Hypoplasia of anterior teeth |
| 10. | Dental arch discrepancies |
| 11. | Dental caries |
Mandibular Prognathism

It is a skeletal class III malocclusion, which is a dentofacial abnormality where lower incisors overlap the upper incisors. The cause of mandibular prognathism depends on different factors, such as osteogenetic disorder, mechanical factors, and heredity. Surgery is the best choice of treatment for mandibular prognathism.

Table 8. Dental anomalies associated with mandibular prognathism

| 1. | Class III malocclusion |
| 2. | Incompetent lip.       |
| 3. | Crossbite.             |
| 5. | Over eruption of maxillary incisors. |
| 6. | Prolonged retention of deciduous teeth |
| 7. | Misalignment of permanent tooth. |
| 8. | Dental arch discrepancies. |

Crouzon Syndrome

It is an autosomal dominant syndrome characterized by maxillary retrusion, exorbitism, and pseudoprognathism. Several mutations of the fibroblast growth factor receptor 2 gene (FGFR2) are thought to be responsible for this phenomenon. Different malocclusions are commonly observed in Crouzon Syndrome.

Table 9. Dental anomalies associated with Crouzon Syndrome

| 1. | Narrowed and retruded dental arch |
| 2. | Class III malocclusion |
| 3. | Premature contact of the molars |
| 4. | Anterior open bite |
| 5. | Crowding |
| 6. | Misalignment of permanent tooth |
Micrognathia and Microgenia

Micrognathia and microgenia present an uneven relationship between the hard and soft tissues of the lower and middle thirds of the face. However, microgenia refers to a hypo-plastic mentum and micrognathia refers to hypo-plastic mandible with vertical or horizontal hypoplasia of the mandible. Severe malocclusion is a common manifestation of micrognathia and microgenia.

Table 10. Dental anomalies associated with micrognathia and microgenia

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Missing tooth.</td>
</tr>
<tr>
<td>2.</td>
<td>Spacing.</td>
</tr>
<tr>
<td>3.</td>
<td>Angle class II relationship.</td>
</tr>
<tr>
<td>4.</td>
<td>Retruded mandible.</td>
</tr>
<tr>
<td>5.</td>
<td>Anterior open bite.</td>
</tr>
<tr>
<td>6.</td>
<td>Misalignment of permanent tooth.</td>
</tr>
</tbody>
</table>

REFERENCES


MALOCCLUSION AND GENETICS

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ABSTRACT

Because of the presumption that malocclusions with a genetic cause are less amendable to treatment than those with an environmental cause, some investigators and clinicians would like a definite answer to the question of whether a patient’s malocclusion is the result of genetic or environmental factors. However, the pattern of growth and development is typically the result of an interaction between multiple genetic and environmental factors over time. Malocclusions are not influenced severely by a single gene [17]. Even for monogenic traits and syndromes, evidence exists for the influence of other genes and environmental factors.

Genetic investigation could be a future diagnostic tools for better treatment outcome. Moreover, individual genetic variation has specific
role in response to treatment, which is directed to a specific environmental change.

In conclusion, genetic analysis is an important tool in clinical orthodontics. The etiological diversity is the main complicating factor for treatment and diagnosis in various types of malocclusions. The main aim of this chapter is to highlight the genetic background in terms of different malocclusion.

**Keywords:** Gene, Malocclusion, Genetic effects

**INTRODUCTION**

Genetics is the science of the study of genes. It is a vast field with practically unlimited potential. Gregor Mendel was the father of modern genetics who invented the law of segregation in genetic science. Later on, the cloning of sheep and proposed cloning of humans have again brought it in the news [3]. But there is a question why an orthodontist should be interested in genetics and this law of segregation? The best answer is the growth and development are related with the effects of different genes. Besides, more or less all orthodontic cases are linked with growth and development.

The reasons behind the abnormal occlusion, to what extent does it express in the next generation, prevalence rate and how will it react to a certain treatment plan should have known by all orthodontists. Genetics enlighten to all these questions. It benefits us to separate the cause of developing malocclusions or abnormalities of growth from genetic factors to environmental factors. Thus, it helps us to diagnose, treat and subsequently maybe prevent it from occurring in the next generation.

The relative influence of genes and the environment to the etiology of malocclusion has been a matter of dispute throughout the twentieth century. Genetic contrivances are undoubtedly playing an important role during the embryonic craniofacial morphogenesis; however environmental factors are also believed to influence dentofacial morphology postnatally, mostly in facial growth. By knowing the exact etiology of malocclusion can be able to distinguish the consequence of genes and environment on
the craniofacial skeleton in an individual. However, there is a scarcity of knowledge on the genetic mechanisms which regulate facial growth. Moreover, very few scientific reports are published for the inspiration of environmental factors on human craniofacial morphogenesis.

**GENE AND GENETICS**

The entire genetic content is contained in the genome as a set of chromosomes present within human body. Genes symbolize the smallest physical and functional units of inheritance that exist in loci for pleural or a locus for single locations in the genome. A gene can be demarcated as the whole DNA sequence necessary for the synthesis of a functional polypeptide or RNA molecule [7].

The genotype is the part (DNA sequence) of the genetic makeup of a cell, and therefore of an organism or individual, which determines a specific characteristic (phenotype) of that cell/organism/individual. In contrast, phenotypes are observable properties, measurable features, and physical characteristics of an individual [2], as determined by the individual’s genotype and the environment in which the individual develops over a period of time.

**MODE OF TRANSMISSION OF MALOCCLUSION**

There are three types of transmission of malocclusion: repetitive traits, discontinuous traits and variable traits.

**Repetitive Traits**

Repetitive traits occur when any malocclusion or any dentofacial deviation shows recurrences within the immediate family and in the ancestors. The same trait is seen generation after generation.
Discontinuous Traits

Discontinuous traits means when recurrence of a tendency for a malocclusion trait to reappear within the family background over several generations. The trait is seen in the family but not in all generations.

Variable Traits

Variable traits occur in different but related types of malocclusion within several generations of the same family. These traits are seen with a variable manifestation for example, missing teeth, which are commonly seen feature in some families, but the same teeth may not be missing in different generations and/or within the same generation.

TYPES OF GENETIC EFFECTS AND MODE OF INHERITANCE

A trait is a specific phase or representative of the phenotype. When making an allowance for genetic impacts on traits, it is appropriate to think of three types: monogenic, polygenic and multifactorial.

Monogenic Trait

Monogenic traits are the traits which are controlled by the action of a single (mono) gene. For example, earwax type is controlled by the action of one gene. Variation in the trait is explained by the presence of different alleles in that one gene [12].
Polygenic Trait

A polygenic trait, is a trait that controls non-allelic genes. These traits result from one or more genes contributing to the phenotype. An individual’s physical appearance is determined by the chromosomal inheritance and genotypic ratio. This phenomenon is known as Mendel’s Laws of Inheritance. In terms of polygenic traits, an individual’s characteristic features result from different genes interacting. The cumulative effects of genes will determine several different traits, such as height, color, weight, shape, and metabolic rate [12].

Multifactorial Trait

Multifactorial traits are accurately like they sound, traits meticulous by multiple factors, or in this case, traits controlled by multiple genes and the environment. Most of our traits fall into this category. Multifactorial trait vary slightly from individual to individual, such as height and hair color as well as the common chronic conditions such as heart disease, diabetes, and cancer [12].

INHERITANCE

The inheritance of genes should be studied over several generations of a family to be able to pinpoint its characteristics and isolate the influence of environmental factors.

Autosomal Dominant Inheritance

Characteristics of autosomal dominant inheritance are:

- The trait appears in every generations
- 50% chance to inherit the faulty gene
- Parents (either father or mother) carry the faulty gene in autosome
- Characteristic is not transmitted in the progeny of the unaffected individuals
- Both male and female children are affected (Figure 1 and Figure 2).

![Figure 1. Example of Autosomal Dominant Inheritance (if father affected).](image1)

![Figure 2. Example of Autosomal Dominant Inheritance (if mother affected).](image2)

**Autosomal Recessive Inheritance**

Abnormal recessive genes are transmitted through heterozygotes. Their existence is found out only when two heterozygotes marry and the homozygote appears.
Characteristics of autosomal recessive inheritance are:

- Two of the effective genes (one from each parent) are inherited
- Parents are carrier of the defective gene
- 25% chance to inherit the faulty gene
- The trait is visible only in siblings, but not in their parents or other relatives
- Both male and female children have equal chance of being affected (Figure 3).

**Sex-Linked Recessive Inheritance**

This type of inheritance is mostly X-linked and predominantly males are affected (due to their hemizygous condition). Heterozygous females are carriers and are expected to produce affected and normal sons in the ratio of 1:1. An affected male never produces an affected son, for example hemophilia.

**X-Linked Recessive Inheritance**

Characteristics of X-linked Recessive Inheritance are:

- Mother carry the affected gene in X chromosome
- Only male children are affected
- 50% of sons have chance to be affected and 50% of daughters have chance to carry the faulty gene
- The trait can be transmitted through several generations by carrier females
- The affected male parent cannot transmit the trait directly to his sons, i.e., the trait will skip a generation (Figure 4 and 5).

**Sex-Linked Dominant Inheritance**

Characteristics of X-linked dominant inheritance are:
- If father is affected then all daughters will carry and sons will be unaffected (Figure 6)
- Affected females (homozygous) transmit the trait to all children (either son or daughter) (Figure 7)
- Affected females (heterozygous) transmit the trait to 50% children (Figure 8).

Figure 3. Example of Autosomal Recessive Inheritance (father and mother both).

Figure 4. Example of X-linked Recessive Inheritance (if mother carrier).
Figure 5. Example of X-linked Recessive Inheritance (if father carrier).

Figure 6. Example of X-linked Dominant Inheritance (if father).

Figure 7. Example of X-linked Dominant Inheritance (if homozygous mother).
GENES AND DIFFERENT MALOCCLUSION

Malocclusion is usually an inherited condition. This means it can be passed down from one generation to the next. A twin study concluded that genetic factors are responsible for the etiology of malocclusion. More than 25,000 human genes are contributing to the development of craniofacial structure [21].

Modern technological advances show that concurrent characterization of entire genomes via genotyping of Single-nucleotide polymorphisms (SNPs) or sequencing of the genome to assess human genetic variation. Moreover, gene-environment studies of malocclusion can be performed on precisely defined phenotypes. This will provide valuable insights into the etio-pathogenesis underlying malocclusion [5].

Class I Malocclusion

Ting Yuen et al. surveyed Class I occlusion with crowding in the Hong Kong Chinese population using MassArray technique for the first time for genetic association in BMP-2 (Bone morphogenic Protein-2), EDA (ectodysplasin) and XEDAR (X-linked ectodysplasin receptor) genes.
Authors concluded that there is link in EDA and XEDAR genes in dental crowding among Chinese population [22] (Table 1).

**Class II Malocclusion**

Both genetic and environmental influences play major role in the development of Class II malocclusion. Different studies proved that patients with Class II relationship have shown that this condition is heritable and is consistent with a polygenic mode of inheritance [12]. However, only one study found by Gutierrez et al. in which genetic analysis were carried out in four Colombian families with Class II malocclusion and found the be homozygous for the rare allele in SNP on the Nog (Noggin) gene [9] (Table 1).

**Class III Malocclusion**

Evidence from previous studies also established that class III malocclusion is strongly influenced by the genetic factors [15, 16]. May be class III malocclusion had developed by polygenic or monogenic mode of inheritance. But the environmental factors also responsible for this trait.

Now-a-days genome wide linkage scan technology can detect several chromosomal regions, which is/are responsible for the mandibular prognathism. However, very few genome wide family based linkage study have been done to determine the specific gene or genes for mandibular prognathism (Table 1).

Recent studies of craniofacial growth have reported that several genes that encode specific growth factors or other signaling molecules, including Indian hedgehog homolog (IHH), insulin like growth factor-1 (IGF1), and vascular endothelial growth factor (VEGF), and variations in their levels of expression have an important role in the etiology of Class III malocclusion [24].
Table 1. Different genes identified for different malocclusion in different population

<table>
<thead>
<tr>
<th>Author and year</th>
<th>Malocclusion</th>
<th>Population</th>
<th>Total Sample</th>
<th>Associated gene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ting T. et al. (2011) [22]</td>
<td>Class I occlusion with crowding</td>
<td>Hong Kong Chinese population</td>
<td>254 (Case 133, Control 121)</td>
<td>BPA and XEDAR</td>
</tr>
<tr>
<td>Gutierrez et al. (2007) [9]</td>
<td>Class II malocclusion (Mandibular micrognathia)</td>
<td>Colombian</td>
<td>4 families</td>
<td>NOG</td>
</tr>
<tr>
<td>Frazier-Bowers et al. (2009) [8]</td>
<td>Class III malocclusion</td>
<td>Hispanic</td>
<td>57 individuals from 2 families</td>
<td>IGF1, HOXC and COL2A1</td>
</tr>
<tr>
<td>Xue et al. (2010) [25]</td>
<td>Class III malocclusion</td>
<td>Chinese</td>
<td>211 cases and 224 controls</td>
<td>EPB4I</td>
</tr>
<tr>
<td>Jang et al. (2010) [10]</td>
<td>Class III malocclusion</td>
<td>Korean</td>
<td>164 cases patients and 132 controls</td>
<td>MATN1</td>
</tr>
<tr>
<td>Li et al. (2011) [13]</td>
<td>Class III malocclusion</td>
<td>Han Chinese</td>
<td>11 affected, 10 unaffected</td>
<td>TGFB3 and LTBP2</td>
</tr>
<tr>
<td>Nikopensius et al. (2013) [16]</td>
<td>Class III malocclusion</td>
<td>Estonian</td>
<td>21 individuals</td>
<td>DUSP6</td>
</tr>
<tr>
<td>Perillo et al. (2015) [20]</td>
<td>Class III malocclusion</td>
<td>Italian</td>
<td>5 subjects from 6 generations</td>
<td>BMP3, ANXA2, FLNB, HOXA2, ARHGAP21</td>
</tr>
<tr>
<td>Bayram et al. (2014) [4]</td>
<td>Class III malocclusion</td>
<td>Turkish</td>
<td>99</td>
<td>GHR</td>
</tr>
<tr>
<td>Tomoyasu et al. (2009) [23]</td>
<td>Class III malocclusion</td>
<td>Japanese</td>
<td>167</td>
<td>GHR</td>
</tr>
<tr>
<td>Zhou et al. (2005) [26]</td>
<td>Class III malocclusion</td>
<td>Han Chinese</td>
<td>95</td>
<td>GHR</td>
</tr>
<tr>
<td>Nowrin et al. (2016) [18]</td>
<td>Class III malocclusion</td>
<td>Malaysian</td>
<td>30 cases and 30 controls</td>
<td>DUSP6</td>
</tr>
</tbody>
</table>
Evidence from population studies has demonstrated that Class III malocclusion was influenced strongly by genetic factors, and multiple environmental factors have been shown to affect mandibular growth. If there is a history of skeletal class III malocclusion among family then there is higher chance to develop adverse arch relationship like maxillary undergrowth or mandibular overgrowth [1]. According to literature, the prevalence rate of Class III malocclusion is high in Asian ethnic groups. Linkage studies and genetic determination would be helpful to find out the exact etiology of the Class III malocclusion.

**INVESTIGATING THE GENETIC FOUNDATION FOR FLEXIBLE RESPONSE TO ORTHODONTIC TREATMENT**

Improved knowledge of the several morphogenetic signaling pathways regulating growth of the craniofacies should permit for the handling of the proliferation, patterning and differentiation of tissue to treat skeletal discrepancies that contribute to malocclusion [19]. An imperative side of this is enlarged understanding of how epigenic (including environmental or treatment) factors affect expression of genes that impact postnatal growth [6]. Since the comparative influence of genetic factors on the development of an occlusion does not certainly control the response to treatment, and the aptitude to predict abnormal growth. Generally, there is limited specificity about an individual when observing family members, the future of genetics in orthodontics mostly will involve investigating the genetic basis for variable response to treatment. In other words, are there genes which influence the response to treatment? Can they be recognized before treatment to support planning the most effective and appropriate treatment, including the evading of undesirable responses [14]? These queries need to be answered with proper genetic investigations in future modern orthodontics.
REFERENCES


Chapter 18

THE IMPACT OF MALOCCLUSION ON ORAL HEALTH RELATED QUALITY OF LIFE IN ORTHODONTIC PATIENTS

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²Department of English School of Arts and Humanities Chouaib Doukkali University El-Jadida, Morocco

ABSTRACT

The demand for orthodontic treatment has increased over the last decade in Morocco as well as in other countries; it is often motivated by an increase in awareness of appearance and aesthetics and psychosocial attributes. Traditional methods of oral health examination rely primarily on clinical dental parameters but fail to provide relevant information about the functional, emotional and social dimension of people’s perception of oral well-being. In recent years, oral health related quality of life (OHRQOL) indicators have been developed and adapted.
Examples include the Psychosocial Impact of Dental Aesthetics Questionnaire (PIDAQ), developed and validated in English. However, there have been few validation studies of the PIDAQ in other population groups, including Morocco (Bourzgui et al., 2015) [1]. Its use in Morocco, an Arabic-speaking country, requires translation and transcultural adaptation. Transcultural validation is a daunting task because of the structural differences that may exist between the source culture and the target culture. In addition, the psychometric characteristics of the translated version have to be validated (Beaton et al., 2000) [2].

The aim of this was to study the various aspects of the provision of orthodontic care, namely, aesthetics, perceived need, normative need and quality of life, and to highlight the experience of the use of a quality of life assessment instrument in Moroccan orthodontic patients.

INTRODUCTION

The World Health Organization (WHO) define health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity [3].

Orthodontic anomalies have been associated with an impaired masticatory function, incisal fractures after falls [4], as well as psychosociological distress, and so should not be regarded as a health problem [5] [6].

To assess these anomalies several indices have been developed for an objective evaluation of the need for orthodontic treatment. They used to supplement the conventional clinical diagnosis which fails to offer a reliable gradation of different clinical situations.

In recent years, the ICON (Index of Complexity Outcome and Need) has been developed by Daniels and Richmond (2000) [7] to assess complexity treatment. One major limitation of ICON is that the evaluation is performed by the orthodontist only, without taking into consideration the patient’s perception. An assessment based on professional standards (normative evaluation) may, therefore, be considered insufficient. Indeed,
it is clearly established that the demand for orthodontic treatment, from the point of view of the patient, is mainly motivated by dental and facial aesthetics, whose role is fundamental in the psychosocial balance [8]. Over the past two decades oral health related quality of life (OHRQOL) as a relatively new, but rapidly growing notion, has emerged with a view to assessing patients’ needs, their overall satisfaction and the quality of care they receive.

In the preamble of its constitution, the WHO defines Quality of Life as individuals’ perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns. It is a broad-ranging concept affected in a complex way by the person’s physical health, psychological state, level of independence, social relationships, personal beliefs and their relationship to salient features of their environment [9].

The impact of health problems on quality of life, in particular, the appreciation of oral health-related quality of life, has become an essential component of surveys, clinical trials and studies of preventive and therapeutic programs to improve oral health [10, 11]. Many indicators have been developed in this respect.

Recently, there has been an increasing need for orthodontic treatment; this demand is often motivated by personal concerns about appearance and aesthetics as well as psychosocial attributes such as self-esteem and social success). Traditional methods of oral health examination rely primarily on clinical dental parameters, but fail to provide relevant information about the functional, emotional and social dimension of people’s perception of oral well-being. Currently, indicators of the quality of life have received a great deal of interest in both dentistry and orthodontics. Several measures for assessing oral health quality life, generic or specific, are now widely being used. Examples include the Psychosocial Impact of Dental Aesthetics Questionnaire (PIDAQ). The aim of this chapter was to study the various aspects of the provision of orthodontic care, namely, aesthetics, perceived need, normative need and quality of life, and to highlight the experience of the use of a quality of life assessment instrument in Moroccan orthodontic patients.
PSYCHOSOCIAL IMPACT OF DENTAL APPEARANCE

In orthodontics, it is not unusual to see children with severe malocclusions who have to endure the bullying and insults of their peers. The parents of such children are often very enthusiastic to undertake orthodontic treatment with the hope that this treatment will solve their aesthetic problems and therefore their social anxiety.

Dental appearance plays a key role in personality appreciation and social acceptability; the beauty of the oro-facial sphere contributes significantly to the overall attractiveness of the face and that certain variations in the morphology of the teeth operate as specific signs of the character of the personality. This is the case, for example, with anterior reversed occlusion, which may be associated with the intention of biting and causing individuals with the concave facial profile to be judged to be antipathetic.

Studies have shown that people who are satisfied with their face appear to be more self-confident and have higher self-esteem than those who are dissatisfied with their facial appearance. On the other hand, people are not satisfied with their facial appearance do so more because of their teeth than for any other facial feature [7]. Visible dental abnormalities, therefore, have a definite negative effect on facial attraction in general and can affect interpersonal relationships.

Aesthetic disorders associated with malocclusions can have a negative effect on the individual’s self-esteem; they can also impact the individual through the negative response they evoke with regard to the human group to which the individual belongs.

This unfavorable response is manifested in children in the form of teasing, taunting, and certain forms of mockery [12]. In older subjects, it can be insidiously translated into preconceived ideas that may lead to avoidance reactions of others. In social interactions, such prejudices can be truly damaging when it comes to entrepreneurship, friendship, certain social contracts such as marriage [12].
Evidence of the pervasive stereotypes associated with teeth in children’s everyday life is provided by numerous cartoons in which the authors represent the least intelligent characters with long, prominent upper incisors and an elongated face. In the same way, cartoonists often caricature witches with a recessed maxilla and a prominent chin.

In summary, the effect of dentofacial appearance is important in social interaction and has an effect on the development of a first impression. In the absence of any other information, the least attractive children are socially perceived to be less competent, less popular and less sympathetic. These behaviors are not usually encountered beyond adolescence. However, in adulthood, the same people may be discriminated against in many areas because of an unfavorable dental appearance.

**Facial Appearance and Orthodontics**

The need to care for one’s personal appearance is a common characteristic of human species. Behavior in some people, including women (make-up, hair removal, artificial tanning, cosmetic surgery, etc.) and which is transmitted from generation to generation reflect this assertion.

Patients who seek orthodontic treatment are concerned with improving their appearance and social acceptance, often more than they are with improving their oral function or health (prevention of periodontal disease and caries) [13, 14]. Bennett et al. (2001) [15] have shown that the parents of children undergoing orthodontic treatment expect this treatment to improve oral health and self-esteem. Tung and Kiyak, (1998) [16] argue that parents and their children generally have the same motivations for orthodontic treatments. These motivations generally revolve around improving the self-image, oro-facial functions and social life with a greater awareness of parents for these problems than their children [16]. But neither parents nor their children expect any change in health. In brief, patients seek orthodontic treatment mainly due to psychological reasons, to improve their own dentofacial appearance.
HEALTH-RELATED QUALITY OF LIFE INDICATORS IN ORTHODONTICS

Traditionally, orthodontic treatments were primarily aimed at improving health and oro-facial functions. Subsequently, it was realized that aesthetics, especially its psychosocial impact, played an important role in the expected benefits of orthodontic treatments. Many of the indicators initially developed for other aspects of oral health have been adapted to evaluate their impact on quality of life-related to orthodontic abnormalities [17]. But most indicators of Oral Health-related Quality of Life can not be applied to malocclusions because orthodontic anomalies are essentially asymptomatic and lead to aesthetic discomfort than to sensations such as pain or discomfort. For Bennett et al. (2001) [15], it is necessary to use oral health-related quality of life indicators specifically developed for orthodontics in conjunction with conventional orthodontic indices to assess treatment needs and therapeutic outcomes. Generic indicators are often too long, too complex and inappropriate for orthodontic patients, often consisting of children and adolescents. Despite these difficulties, three OHRQoL indicators specific to orthodontics have been developed:

- The Orthognathic Quality of Life Questionnaire (OQLQ), by CUNNINGHAM et al. (2000) [18].
- The Psychosocial Impact of Dental Aesthetics Questionnaire (PIDAQ) by KLAGES et al. (2006) [19].
- The Malocclusion Impact Questionnaire (MIQ) by BENSON et al. 2016 [20].

These indicators are very helpful to evaluate the personal perception of patients with dentofacial deformities and malocclusion. They also play an important role in clinical research.
**THE ORTHOGNATHIC QUALITY OF LIFE QUESTIONNAIRE (OQLQ)**

Patients with severe dentofacial dysmorphoses may require orthognathic surgery. Improving their quality of life should be one of the objectives of this form of intervention. The objective of the OQLQ is to assess the quality of life in patients with severe dentofacial malformations. This questionnaire can also be used to assess the impact or outcome of orthognathic treatment on the quality of life in these patients. It assesses the quality of life in 4 dimensions: Social, functional, aesthetic dentofacial and sensitivity to dentofacial aesthetics. It was originally developed in English by Cunningham et al. In 2000 [18] and validated in 2002 [21] (appendix 1). In Morocco, oral quality of life in patients has become central to dental and orthodontic research. The need to validate the oral quality of life measurement tools in Morocco has become very important. The use of Anglo-Saxon scales validated in these countries could alleviate the problem of the remarkable lack of tools for measuring the quality of life noted in this field. It also provides internationally recognized standards and makes comparisons between populations of different cultures. In this respect, we carried out a cross-cultural translation of the OQLQ into Moroccan Arabic and validated its psychometric properties in order to use to assess the quality of life of patients presenting with dentofacial malformations (appendix 2).

**Methods and Materials**

A total of 43 patients took part in the study. Patients underwent orthognathic surgery for dentofacial deformity and orthodontic treatment at Casablanca Dentofacial Orthopedic Ward. They were fluent Moroccan Arabic speakers, who had no physical or mental disability. The age of the patients varied between 16 and 55 years with an average age of 25.93 years and a standard deviation of 7.998.
We carried out the translation of the OQLQ following the recommendations of the International Tests Commission [24]. The final version in Moroccan Arabic was finally cross-translated into English by two native bilingual translators from the source country who did not participate in the first translation or the source questionnaire. All translations, as well as changes in form and cross-cultural adaptation of the questionnaire, were analyzed at an expert meeting, including all the people involved in the transcultural adaptation process, namely the translators, the coordinator, An orthodontic teacher from the Casablanca Dentistry College and two cross-cultural validation methodologists. The final version was developed after this meeting where the objective was to make the questionnaire comprehensible to patients. It is important to emphasize that the translation was made directly from English to Arabic. Semantic, idiomatic, experiential, and conceptual equivalences were discussed in order to preserve the content validity of the questionnaire. Then the OQLQ validated for its properties. The properties studied were reliability (internal consistency, reproducibility) and validity (validity of the construct and validity of divergence).

**Results**

The mean and standard deviation of the scores obtained by the subjects for each of the OQLQ domains are presented in Table I. The field “social aspects” obtained the highest score, with 5.67 ± 8.03 points. The field “oral function” had the lowest score, with 2.67 ± 4.23.

**Table I. The scores obtained for the different areas of the Moroccan Arabic version**

<table>
<thead>
<tr>
<th>Domains (number of items)</th>
<th>Average Scores ± S.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social aspects (8)</td>
<td>5.67 ± 8.03</td>
</tr>
<tr>
<td>Facial aesthetics (5)</td>
<td>4.32 ± 5.41</td>
</tr>
<tr>
<td>Oral function (5)</td>
<td>2.67 ± 4.23</td>
</tr>
<tr>
<td>Sensitivity to dentofacial aesthetics (4)</td>
<td>4.88 ± 5.26</td>
</tr>
</tbody>
</table>
All items showed good correlation with their domains. The item-score correlation matrix is presented in Table II. No item-total correlation coefficient was less than 0.5. This is favorable since a low coefficient means that the item is not correlated with its domain. Similarly, no coefficient indicated a negative correlation. All items were correlated with each other.

**Table II. Analysis of the internal coherence between the four domains of The Moroccan Arabic version of the OQLQ**

<table>
<thead>
<tr>
<th>Domains/questions</th>
<th>Correlation item-score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Social aspects of dentofacial deformation</strong></td>
<td></td>
</tr>
<tr>
<td>15- Cover mouth when meeting people</td>
<td>0.768**</td>
</tr>
<tr>
<td>16- Worry about meeting people</td>
<td>0.836**</td>
</tr>
<tr>
<td>17- Worry people will make hurtful comments</td>
<td>0.878**</td>
</tr>
<tr>
<td>18- Lack confidence socially</td>
<td>0.902**</td>
</tr>
<tr>
<td>19- Do not like smiling</td>
<td>0.779**</td>
</tr>
<tr>
<td>20- Get depressed about appearance</td>
<td>0.857**</td>
</tr>
<tr>
<td>21- Sometimes think people are staring</td>
<td>0.624**</td>
</tr>
<tr>
<td>22- Comments about appearance upset me</td>
<td>0.815**</td>
</tr>
<tr>
<td><strong>Facial aesthetics</strong></td>
<td></td>
</tr>
<tr>
<td>1 - Self-conscious about appearance of my teeth</td>
<td>0.663**</td>
</tr>
<tr>
<td>7 - Don’t like seeing side view of face (profile)</td>
<td>0.820**</td>
</tr>
<tr>
<td>10 - Dislike having photograph taken</td>
<td>0.839**</td>
</tr>
<tr>
<td>11 - Dislike being seen on video</td>
<td>0.855**</td>
</tr>
<tr>
<td>14 - Self-conscious about appearance</td>
<td>0.857**</td>
</tr>
<tr>
<td><strong>Oral function</strong></td>
<td></td>
</tr>
<tr>
<td>2 - Problems biting</td>
<td>0.780**</td>
</tr>
<tr>
<td>3 - Problems chewing</td>
<td>0.847**</td>
</tr>
<tr>
<td>4 - Avoid eating some foods</td>
<td>0.838**</td>
</tr>
<tr>
<td>5 - Don’t like eating in public</td>
<td>0.770**</td>
</tr>
<tr>
<td>6 - Pains in face/jaw</td>
<td>0.597**</td>
</tr>
<tr>
<td><strong>Sensitivity to dentofacial aesthetics</strong></td>
<td></td>
</tr>
<tr>
<td>8- Spend time studying face</td>
<td>0.822**</td>
</tr>
<tr>
<td>9- Spend time studying teeth</td>
<td>0.779**</td>
</tr>
<tr>
<td>12- Stare at people’s teeth</td>
<td>0.839**</td>
</tr>
<tr>
<td>13- Stare at people’s faces</td>
<td>0.841**</td>
</tr>
</tbody>
</table>

**. The correlation is significant at the 0.01 level (bilateral).
Test-Retest Reliability

The Cronbach α-coefficient of domains varied from 0.845 for “sensitivity to dentofacial aesthetics” to 0.993 for “oral function”. The intraclass correlation coefficient of the response scores obtained after administering the questionnaire twice at a one-month interval to a random sample of 22 subjects varied from 0.91 for “sensitivity to dentofacial aesthetics” to 0.99 for “oral function” (Table III). The reproducibility is, therefore, very satisfactory.

Construct Validity of the Moroccan Arabic Version of the OQLQ

The data on the convergence validity are presented in Table IV. The results show that the overall structure is good except for:

- Item 21 “sometimes I think people look at me” is rather correlated with domain 2 (facial aesthetics), than with domain 1 (social aspects of dentofacial deformation)
- Item 7 “I do not like to see my profile” which is correlated with domain 3 (oral function) rather than domain 2 (facial aesthetics)
- Item 6 “I feel the pain in my face and my jaw” is correlated with domain 2 (facial aesthetics) rather than domain 3 (oral function)

Table III. Intra-class correlation coefficient between scores of 4 Domains of the OQLQ during the test/retest

<table>
<thead>
<tr>
<th>Domains (number of items)</th>
<th>Cronbach α coefficient</th>
<th>Intraclass correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social aspects (8)</td>
<td>0.902</td>
<td>0.948</td>
</tr>
<tr>
<td>Facial aesthetics (5)</td>
<td>0.948</td>
<td>0.973</td>
</tr>
<tr>
<td>Oral function (5)</td>
<td>0.993</td>
<td>0.996</td>
</tr>
<tr>
<td>Sensitivity to dentofacial aesthetics (4)</td>
<td>0.845</td>
<td>0.916</td>
</tr>
</tbody>
</table>
- Item 12 “often I look at people’s teeth “and 13” often look at the faces of people “are correlated with domain 2 (facial aesthetics) than with domain 4 (sensitivity to dentofacial aesthetics)

An item is correlated with its domain if it is > 0.60.

**Table IV. Factorial analysis**

<table>
<thead>
<tr>
<th>Social aspects</th>
<th>Facial aesthetics</th>
<th>Oral function</th>
<th>Sensitivity to dentofacial aesthetics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 15</td>
<td>0.652</td>
<td>0.393</td>
<td></td>
</tr>
<tr>
<td>Question 16</td>
<td>0.836</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 17</td>
<td>0.792</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 18</td>
<td>0.864</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 19</td>
<td>0.576</td>
<td>0.399</td>
<td></td>
</tr>
<tr>
<td>Question 20</td>
<td>0.787</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 21</td>
<td>0.381</td>
<td>0.600</td>
<td></td>
</tr>
<tr>
<td>Question 22</td>
<td>0.750</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Facial aesthetics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 1</td>
<td>0.418</td>
<td>0.413</td>
<td>0.401</td>
</tr>
<tr>
<td>Question 7</td>
<td>0.431</td>
<td>0.643</td>
<td></td>
</tr>
<tr>
<td>Question 10</td>
<td>0.423</td>
<td>0.664</td>
<td></td>
</tr>
<tr>
<td>Question 11</td>
<td>0.491</td>
<td>0.703</td>
<td></td>
</tr>
<tr>
<td>Question 14</td>
<td>0.505</td>
<td>0.380</td>
<td>0.465</td>
</tr>
<tr>
<td><strong>Oral function</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 2</td>
<td>0.800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 3</td>
<td>0.803</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 4</td>
<td>0.810</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 5</td>
<td>0.638</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 6</td>
<td>0.661</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sensitivity to dentofacial aesthetics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 8</td>
<td></td>
<td></td>
<td>0.879</td>
</tr>
<tr>
<td>Question 9</td>
<td></td>
<td></td>
<td>0.869</td>
</tr>
<tr>
<td>Question 12</td>
<td>0.717</td>
<td>0.452</td>
<td></td>
</tr>
<tr>
<td>Question 13</td>
<td>0.722</td>
<td></td>
<td>0.451</td>
</tr>
</tbody>
</table>
**DISCUSSION**

The Moroccan version of the OQLQ had good psychometric qualities. In terms of validity, the questionnaire presented a very good convergence validity. The relationship between the OQLQ score and the patient’s perception of oral problems was very statistically significant.

The reliability of the questionnaire was confirmed by internal consistency with a Cronbach $\alpha$ coefficient ranging between 0.83 and 0.93 ($>0.7$). The test-retest procedures also showed excellent reproducibility between 0.91 and 0.94.

Thus, the Moroccan version of the OQLQ has shown satisfactory psychometric properties and can be considered as a valid, reliable and practical instrument for its use among the Moroccan population.

In terms of the test-retest reliability of the OQLQ in its Moroccan version, the intra-class correlation coefficients were excellent with values of 0.94, 0.97, 0.99, 0.91, which shows that the OQLQ index is a stable measure. This result is superior to other OQLQ validation studies: Original English (0.88, 0.92, 0.76, 0.89) [21], Brazil (0.93, 0.81, 0.83, 0.80) [22], Iran (0.83, 0.84, 0.91, 0.90, 0.88, 0.89) [23].

In terms of internal reliability analysis, all correlated item-total correlations were above the recommended level of 0.2 [24, 25]. Moreover, all inter-item correlations were positive and no correlation was sufficiently high, making no element redundant.

The Cronbach alpha coefficients for the various OQLQ domains were 0.91, 0.86, 0.83, 0.93 indicating an almost ideal internal coherence. Cronbach $\alpha > 0.7$ is accepted as good [9, 34], but if it is equal to or very close to 1, it may reflect the redundancy of some elements.

Moreover, the internal consistency of the different domains of the Moroccan Arabic version of the OQLQ compared well with those of the original version ($\alpha = 0.93, 0.86, 0.83, 0.87$) respectively for the social aspects of dentofacial deformation, ($\alpha = 0.91, 0.85, 0.75, 0.85$) [26], but remains higher than the Brazilian version ($\alpha = 0.89, 0.78, 0.78$ and 0.82) [22].
The results show a very good convergence validity with a good correlation between the questions and the domains of the OQLQ.

Based on the OQLQ factorial analysis, the 22 items were divided into four distinct domains, as follows: Domain 1 included “Social Aspects of Dentofacial Distortion”, Domain 2 consisted of questions related to “Facial aesthetics”, domain 3 included items concerning “oral function” and domain 4 included items related to “Sensitivity to dentofacial aesthetics”.

To our knowledge, the only one validation study of the OQLQ included factorial analysis is, that of the Serbian version [26]. In our validation study, there is a slight difference between the results of the factor analysis and some models of the original version concerning the classification of items in the four domains. The item 21 “sometimes I think people look at me” was classified in the “social aspects” area of the dentofacial deformity, while in our study the matrix of the rotating components classified it under “facial aesthetics”.

We could assume that these slight divergences could be linked to linguistic and cultural specificities. However, it should be emphasized that the Moroccan Arabic version of the OQLQ supports the original structure and classification of the items in the 4 domains.

In conclusion, the transcultural adaptation of the OQLQ in Moroccan Arabic has successfully demonstrated its validity and reliability. It will, therefore, be possible to use this instrument of measurement of the quality of life in subjects candidates for orthognathic surgery for dentofacial dysmorphosis.

**Psychosocial Impact of Dental Aesthetics Questionnaire (PIDAQ)**

The PIDAQ (Psychosocial Impact of Dental Aesthetics Questionnaire) is a quality-of-life instrument developed and validated specifically for orthodontics following a series of preliminary investigations in the years 2004, 2005 and 2006 by Klages and coworkers [19]. It includes items
derived from the previously developed OQLQ (Orthognathic Quality of Life Questionnaire) (Cunningham et al., 2000, 2002) [21, 18].

The PIDAQ comprises 23 items divided into four domains, Self-confidence (six items), Social impact (eight items), Psychosocial impact (six items) and Aesthetic concerns (three items). Each item consists of an assertion written in the first person singular and in the present tense to be evaluated using a five-point Likert scale with numerical values 0 = “not at all”, 1 = “a little”, 2 = “somewhat”, 3 = “strongly” and 4 = “very strongly”.

Initially developed and tested for young adults, the PIDAQ is considered to work well with both children and adolescents.

We have already translated and culturally adapted the original English version of the PIDAQ into Moroccan Arabic and assessed the psychometric characteristics of the version thereby obtained. The Moroccan Arabic version of the PIDAQ obtained following a thorough adaptation of the original version is both reliable and valid [1].

MALOCCLUSION IMPACT QUESTIONNAIRE (MIQ)

MIQ is a condition-specific measure of the oral health-related quality of life, designed to measure the impact of malocclusion on young people, aged 10 to 16 years. It is intended for use in the longitudinal evaluation of interventions for malocclusion, i.e., orthodontic treatment, although it has not been tested in young people with a cleft of the lip and/or palate or those who may require surgery to correct abnormalities of the jaws.

The questionnaire currently consists of 17 items, each with a 3-point severity or intensity response format. At the present time, it is only available in English, but a request has been approved to translate it into Arabic.

Initially, 37 questions were chosen following interviews with 30 young people, referred for orthodontic treatment, to two dental teaching hospitals (Patel et al., 2016) [27]. These were broadly divided into three sections or themes:
• How I feel about the way my teeth look;
• How my teeth affect my life;
• Eating and the health of my teeth, including knocks and bangs to my teeth.

A 5-point severity or intensity response scale was chosen because previous work has suggested that this is more important to young people than frequency (Marshman et al., 2010) [28]. The wording for the options was based upon the work carried out by Stevens (Stevens, 2010) [29].

A cross-sectional evaluation of the initial questionnaire was undertaken at the Charles Clifford Dental Hospital, a dental teaching hospital affiliated with the University of Sheffield (Benson et al., 2016) [20]. This involved 216 young people, aged 10 to 16 years, who were invited to take part and 184 completed the questionnaire (response rate 85%). The mean age of respondents was 12·9 years (SD 1·4) and more girls took part than boys (113 females: 71 males; 61%:39%). The fit and function of the initial questions were examined using an item response theory (IRT) Rasch model. This reduced the number of questions from 28 to 17 and lead to a reduction in the response format from a 5 to a 3-point scale. This questionnaire was tested for validity, reliability and test-retest repeatability. The remaining items demonstrated good internal consistency (alpha = 0.91) and the total score showed significant correlations with the Child Perceptions Questionnaire (16-item short form) ($r = 0.751$; $P < 0.001$) and the global scores, suggesting the measure is valid. Test-retest repeatability was also good (ICC 0.78; 95% CI 0.61–0.88) [20].

We are currently working on translating this tool into Moroccan Arabic and validating its psychometric properties.

**CONCLUSION**

Orthodontics is a very special medical discipline where both the orthodontist and the patient and/or his/her parents may have quite different motivations and expectations. From the perspective of quantifying occlusal
anomalies for epidemiological purposes, management of health systems and research, orthodontic indices that objectively assessed the need for care have been developed. These indices claim to play the role for which they were created only to the extent that they support the patient’s personal perception of the impact of orthodontic anomalies on his or her mental and social well-being. The aesthetic aspect is an integral part of the majority of the indices currently used.

In recent decades, the paradigm in the assessment of care needs and therapeutic outcomes and more general health systems has changed dramatically, moving from a strict medical model with a preeminence of the practitioner’s judgment to a biopsychosocial model integrating both pure medical aspects and more patient-centered aspects in his everyday life.

**APPENDIX 1**

**The Orthognathic Quality of Life Questionnaire**

Please read the following statements carefully. In order to find out how important each of the statements is to you. Please circle 1, 2, 3, 4 or N/A where:

1 means it *bothers you a little*
4 means it *bothers you a lot*
2 and 3 lie between these statements
N/A means the statement does not apply to you or does not bother you

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bothers you a little</td>
<td></td>
<td></td>
<td>Bothers you a lot</td>
</tr>
</tbody>
</table>
1. I am self-conscious about the appearance of my teeth &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
2. I have problems biting &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
3. I have problems chewing &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
4. There are some foods I avoid eating because the way my teeth meet makes it difficult &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
5. I don’t like eating in public places &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
6. I get pains in my face or jaw &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
7. I don’t like seeing a side view of my face (profile) &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
8. I spend a lot of time studying my face in the mirror &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
9. I spend a lot of time studying my teeth in the mirror &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
10. I dislike having my photograph taken &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
11. I dislike being seen on video &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
12. I often stare at other people’s teeth &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
13. I often stare at other people’s faces &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
14. I am self-conscious about my facial appearance &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
15. I try to cover my mouth when I meet people for the first time &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
16. I worry about meeting people for the first time &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
17. I worry that people will make hurtful comments about my appearance &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
18. I lack confidence when I am out socially &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
19. I do not like smiling when I meet people &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
20. I sometimes get depressed about my appearance &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
21. I sometimes think that people are staring at me &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A
22. Comments about my appearance really upset me, even when I know people are only joking &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; &nbsp; 1 &nbsp; 2 &nbsp; 3 &nbsp; 4 &nbsp; N/A

APPENDIX 2

التقييمية الفك جراحة بعد الحياة جودة عن خاصة استمارة
عفاك لب عليك بالنية جملة كل دوال الأهمية درجة تعرف يمكن بائي مزيان العمل هاد قرا عفاك
(مغ) (معنى غير أو 1, 2, 3, 4 الأرقام من واحد على دور)
شوي لا كتير عج بآلك يعني 1
يعني بذلك أنك تزعج.

الكل منزعج غير بالجملة معنى غير أنك تعني غ.

شوي منزعج

<table>
<thead>
<tr>
<th>رقم</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>أنا واعي بالغضب ديال سناني.</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>عدي مشاكل مع العضة.</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>كاين مكنش نشوف في اليوم ديال وجوه في.</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>كنحاول ندرق فمي منين كنتلاقى مع الناس أول مرة.</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>كنخاف منين كنتلاقى مع الناس أول مرة.</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>كخفل كسر في كنانة كتجرح بخصوص المظهر ديالي.</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>كنفقد الثقة في نفس كنكون وسط الناس.</td>
<td>4</td>
<td>3</td>
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