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Early Treatment of Class III Malocclusion

A Project Submitted to the
College of Dentistry, University of Baghdad,
Department of Orthodontics in Partial Fulfillment
for the Bachelor of Dental Surgery

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Certification of the Supervisor

I certify that this project entitled "**Early treatment of class III malocclusion**" was prepared by **Mustafa Maroof Majid** under my Supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

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The Supervisor
23/4/2022

Dedication

I would like to dedicate my humble effort to my sweet and lovely **Father and Mother.** Their affection, love, encouragement and prays, day and night, helped me succeed.

Mustafa Maroof Majid

Acknowledgment

First and foremost, praises and thanks to **Allah** Almighty for helping me fulfill my dream, for his blessings throughout my work to complete it successfully.

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CR	Centric relation
CO	Centric occlusion
VPCC	Vertical-pull chin cup
BAMP	Bone anchored maxillary protraction

Introduction

Class III malocclusion has long been considered a complicated maxillofacial disorder that is characterised by a concave profile, which may exhibit mandibular protrusion, maxillary retrusion or a combination of both **(Chang *et al*., 2006)** as well as possible anatomic heterogeneity of this malocclusion. The prevalence of Class III malocclusion varies greatly both among and within populations, and the highest prevalence of 15.8 % has been observed in Southeast Asian populations in previous studies **(Ngan and Moon, 2015)**. It has been widely accepted that both genetic inheritance and environmental factors contribute to Class III malocclusion **(Cruz *et al*., 2008; Yamaguchi *et al*., 2005)**, and diversity loci and suspicious genes associated with Class III malocclusion have been identified using linkage analysis and association studies **(Perillo *et al*., 2015; da Fontoura *et al*., 2015; Tassopoulou-Fishell *et al*., 2012)**. Although informative, the previous genetic studies have limitations, including modest sample sizes, the exclusion of environmental factors, the lack of a systematic estimation of genetic variants associated with the disease, and perhaps more importantly, limited phenotypes that cannot capture the complexities of Class III malocclusion **(Uribe *et al*., 2013)**. Owing to the limited knowledge of the underlying aetiologies of this condition, it is still a challenge for dentists to diagnose and treat Class III malocclusion. Distinguishing phenotypes that are related to different expressions of a genotype is an essential step in establishing the genetic contribution to Class III malocclusion.

Lateral cephalometric radiographs provide rich phenotypic data, which provide information about the cranial, facial bony and soft tissue structures. Cephalometric analysis is an economic and convenient accessory examination and plays a predominant role in approaching the definition of phenotypes among and within the Class III population **(Bui *et al*., 2006)**.

Aim of the Study

This study aims to investigate the different strategies used in early treatment of this type of malocclusion

Chapter One: Review of literature

1.1 Class III malocclusion

Class III malocclusion represents a complex three-dimensional facial skeletal imbalance between maxillary and mandibular growth along with varying degrees of dentoalveolar and soft tissue compensations which can be expressed in many morphological ways. Class III malocclusion may be associated with maxillary growth deficiency (and/or maxillary retrognathia), mandibular growth excess (and/or mandibular prognathism), or a combination of both along with vertical and transverse malformations **(Staudt and Kiliaridis, 2009)**. Based on the position of the maxilla relative to the craniofacial skeleton, classified Class III malocclusions into three basic types: true mandibular prognathism type A - individual with normal maxilla and prognathic mandible; type B - individual with excessive growth of maxilla and mandible, but with relatively more growth of mandible; type C – individual with maxillary hypoplasia, obtuse nasolabial angle, and concave facial profile. Type C individuals can easily be camouflaged orthodontically by dentoalveolar compensation **(Park and Baik, 2001)**.

Common skeletal features such as shortened anterior (N-S) and posterior cranial base (S-Ar/Ba), reduced saddle angle (N-S-Ar), and an increased gonial angle (Ar-Go-Gn) were identified to lead to a more forward positioning of the glenoid fossa resulting in Class III malocclusion **(Innocenti *et al*., 2009)**. Studies about the skeletal and dental components of Class III malocclusions have revealed the establishment of a facial pattern at early childhood which has a tendency to worsen with growth **(Baccetti *et al*., 2007; Alexander *et al*., 2009)**. Skeletal Class III malocclusions can be a result of various factors:

1. prognathic and/or macrognathic mandible with a normal maxilla both in position and in size;

2. retrognathic and/or micrognathic maxilla with a normal mandible both in position and in size;
3. combination of retrognathic and/or micrognathic maxilla with prognathic and/or macrognathic mandible;
4. normal skeletal jaw relationship with reverse overjet in the presence of centric relation (CR)–centric occlusion (CO) discrepancy, also known as a “pseudo” Class III relationship.

Dental features of Class III individuals include Class III molar and canine relationship, maxillary incisors protrusion and mandibular incisors retrusion with edge-to-edge bite or anterior crossbite. Based on various combinations of skeletal components, patients with Class III malocclusion exhibit a wide range of underlying skeletal and craniofacial features similar to the prevalence of Class III malocclusion, which can vary among different racial and ethnic groups as shown by comparative studies. For example, Mongoloid populations (Japanese, Koreans, and Chinese) with Class III phenotypes present with characteristic features such as acute anterior cranial base angle and a prominent and elongated mandible with a short and hypoplastic maxilla, while normal maxillary size and position were observed for Caucasians **(Mouakeh, 2001)**.

1.2 Prevalence

Existing literature regarding the global prevalence of Class III malocclusions has shown that its prevalence varies greatly among and within different races, ethnic groups, and geographic studied regions (Tables 1 and 2). There is a wide range of reported prevalence, even with conflicting results, and the discrepancies in the prevalence rate might be attributed to the variation among samples, the timing of investigation, and type of analysis performed **(Hardy *et al*., 2012)**.

A systematic review **(Hardy *et al*., 2012)** reported a global prevalence of Angle Class III malocclusion within the interval of 0%–26.7% for different populations. Prevalence rates of 15.80%, 15.69%, and 16.59% were revealed for Southeast Asian countries, Chinese, and Malaysian groups, respectively. Among Japanese it was around 14%, for Koreans 9%–19%, and about 1.65% for Taiwanese. For Indian children aged from 5 to 15 years, the prevalence varied within 0%–4.76%. Further, from a global viewpoint, Indians had the lowest prevalence of 1.19% among all other racial groups. A prevalence of 10.18% was reported for Middle Eastern populations, and among them, for Israeli Arabs it was 1.3%, Iranians about 15.2%, Turkish about 10.30%–11.5%, and Egyptians showed a rate from 4% to 11.38%. Regarding African countries, the prevalence rate was found to be 4.59% and varying for Kenya, Tanzania, and Nigeria (between 1% and 16.8%). Class III malocclusions have been found to be more prevalent in Hispanic than in African or Caucasian groups. Prevalence of about 9.1% and 8.3% were reported for Americans and Mexican Americans, respectively. Factors such as the method of malocclusion study and the age group studied may influence the varying prevalence in Caucasians between 3% and 5%. Prevalences of about 5% and from 2% to 6% have been found in Latin and European populations, respectively **(Silva and Kang, 2001)**. Furthermore, the White population in United Kingdom and Scandinavia had a Class III incidence of about 3%–5%, and about 6% for Sweden **(Prabhat *et al*., 2013)**.

For Americans, the prevalence was found to be about 5% **(Proffit *et al*., 2019)**. Studies on US African-American population groups found the prevalence in the range of 3%–6%. Similar studies conducted on other nationalities revealed a Class III malocclusion prevalence of about 3% for Brazilian,14% for Syrian, and 9.4% for Saudi Arabian individuals **(Kawala *et al*., 2007)**.

Table 1: Reported prevalence of Class III malocclusion globally and in different continents (Zere et al., 2018).

Continents	Prevalence (%)
Globally	**0-26.7**
East Asian	**4-14**
Southeast Asian	**15.80**
African	**4.59**
Middle Eastern	**10.18**
Indian	**1.19**
European	**4.88 (2-6)**
Northern European	**0.8-4.2**
American	**5**

1.3 Etiology of Class III malocclusion

Similar to most of the malocclusions and dentofacial deformities, the etiology of Class III malocclusion is multifactorial. It results from a distortion of normal development, rather than from any pathological process. Expressions of Class III malocclusion are results of interaction between innate factors or genetic hereditary with environmental factors **(Jena *et al*., 2005)**.

Studies of human inheritance have provided sufficient evidence to establish the fact that mandibular growth is mainly affected by heredity. Familiar genetic inheritance has a strong influence on skeletal craniofacial dimensions contributing to Class III malocclusion and a significantly higher incidence of this malocclusion has been found to have a familial occurrence between members of many generations **(Mossey, 1999)**. The best-known example of familial inheritance is Habsburg Jaw, in which mandibular prognathism recurred over multiple generations in the European royalty. The pattern of transmission of Class III malocclusion still remains an issue of controversy. According to some authors, the transmission is autosomal recessive, and according to others, it is autosomal dominant with complete or incomplete penetrance; yet, some others support the polygenic transmission mode **(Cruz *et al*., 2008)**.

Environmental factors known to contribute and influence this malocclusion include wrong postural habits of the mandible which pathologically alter the mandibular condyle positioning within the fossa and as a result the final mandibular spatial position expressed with a forward slide of the mandible. Various factors such as growth stimulus, history of prolonged sucking or resting tongue habits, atypical swallowing, nasal airway obstruction, mouth breathing, functional mandibular shifts because of respiratory needs, tongue size and pharyngeal airway shape and size altered (enlarged tonsils, large tongue, adenoids), hormonal imbalances and disturbances such as gigantism or pituitary adenomas, trauma, premature loss of primary teeth, congenital anatomic defects (ie, cleft lip, cleft palate), and muscle dysfunction alone or in combination with other environmental factors play a definitive etiological role **(Chung *et al*., 2006; Cortés and Granic, 2006; Sugawara *et al*., 2016)**.

1.3 Treatment of anteroposterior and vertical maxillary deficiency

Both anteroposterior and vertical maxillary deficiency can contribute to Class III malocclusion. If the maxilla is small or positioned posteriorly, the effect is direct; if it does not grow vertically, there is an indirect effect on the mandible, which then rotates upward and forward as it grows, producing an appearance of mandibular prognathism that may be due more to the position of the mandible than its size. In order of their effectiveness, there are three possible approaches to growth modification to correct maxillary deficiency: Frankel's FR-III functional appliance, reverse-pull headgear (facemask) to a maxillary splint or skeletal anchors, and Class III elastics to skeletal anchors.

1.3.1 FR-III functional appliance

The FR-III appliance (Fig. 1) is made with the mandible positioned posteriorly and rotated open and with pads to stretch the upper lip forward. In theory, the lip pads stretch the periosteum in a way that stimulates forward growth of the maxilla. In a review of cases selected from Frankel's archives, Levin et al reported that in patients with Class III skeletal and dental relationships and good compliance who wore the FR-III appliance full-time for an average of 2.5 years and then part-time in retention for 3 years, there was significantly enhanced change over controls in maxillary size and position. There was improved mandibular position combined with more lingual lower incisor bodily position, so the patients had more overjet. This held up at the long-term follow-up over 6 years after active treatment **(Levin *et al*., 2008)**.

Fig. 1: The FR-III appliance stretches the soft tissue at the base of the upper lip (Proffit *et al*., 2019).

The available data from most other studies, however, indicate little true forward movement of the upper jaw **(Ulgen and Firatli, 1994)**. Instead, most of the improvement is from dental changes. The appliance allows the maxillary molars to erupt and move mesially while holding the lower molars in place vertically and anteroposteriorly. The appliance tips the maxillary anterior teeth facially and retracts the mandibular anterior teeth (Fig. 2). Rotation of the occlusal plane as the upper molars erupt more than the lowers also contributes to a change from a Class III to a Class I molar relationship (Fig. 3). In addition, if a functional appliance of any type rotates the chin down and back, the Class III relationship will improve because of the mandibular rotation, not an effect on the maxilla. In short, functional appliance treatment, even with the use of upper lip pads, has little or no effect on maxillary deficiency and, if considered, should be used only in mild cases. If this appliance is used, there are long treatment and retention periods that require excellent compliance to maintain limited changes **(Proffit *et al*., 2019)**.

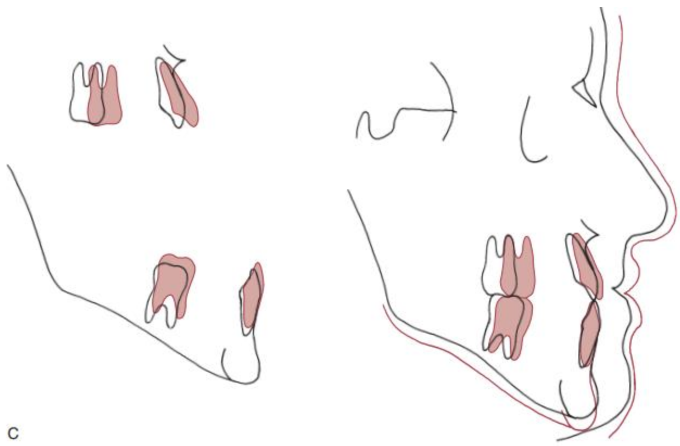

Fig. 2: Response to a FR-III functional appliance. (A) Pretreatment profile. (B) Posttreatment profile. (C) Cephalometric superimpositions. (Proffit et al., 2019).

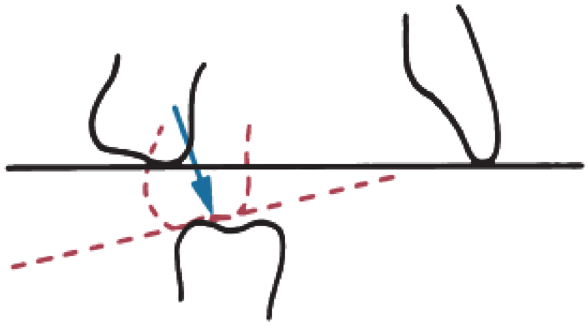

Fig. 3: To facilitate Class III correction, the mesial and vertical eruption of the maxillary molar can be emphasized so that the occlusal plane rotates down posteriorly (Proffit et al., 2019).

1.3.2 Reverse-Pull headgear (facemask)

Dental Anchorage. After Delaire's demonstration that at an early age, a facemask attached to a maxillary splint could move the maxilla forward by inducing growth at the maxillary sutures**,** this approach to maxillary deficiency became popular in the late 20th century (Fig. 4). The age of the patient is a critical variable. It is easier and more effective to move the maxilla forward at younger ages. Although some recent reports indicate that anteroposterior changes can be produced up to the beginning of adolescence, the chance of true skeletal change appears to decline beyond age 8, and the chance of clinical success begins to decline at age 10 to 11 **(Wells *et al*., 2006)**.

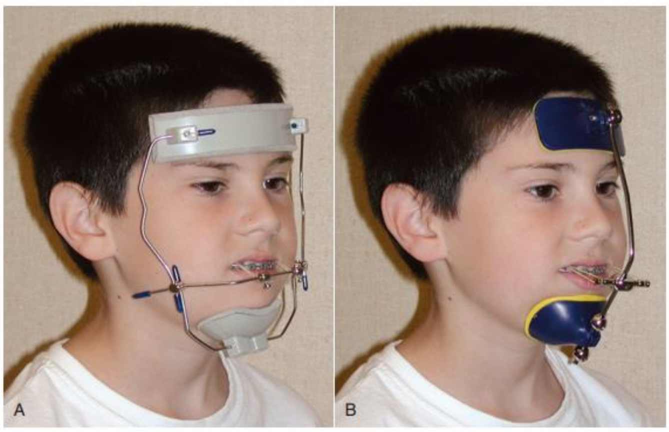

Fig. 4: (A) This Delaire-type facemask (reverse headgear) offers good stability when used for maxillary protraction. (B) This rail-style facemask provides more comfort during sleeping and is less difficult to adjust (Proffit *et al*., 2019).

When force is applied to the teeth for transmission to the sutures, tooth movement in addition to skeletal change is inevitable. Whatever the method of attachment to the teeth (Fig. 5), the appliance must have hooks for attachment to the facemask that are located in the canine–primary molar area above the occlusal plane. This places the force vector nearer the purported center of resistance of the maxilla and limits maxillary rotation (Fig. 6). Facemask treatment is most suited for children with minor-to moderate skeletal problems, so that the teeth are within several millimeters of one another when they have the correct axial inclination. This type of treatment also is best used in children who have true maxillary problems, but some evidence indicates that the effects on mandibular growth during treatment go beyond changes caused by clockwise rotation of the mandible **(Proffit *et al*., 2019)**.

Fig. 5: A maxillary removable splint used to make the upper arch a single unit for maxillary protraction. (A) The splint incorporates hooks in the canine and premolar region for attachment of elastics (B). Note that the hooks extend gingivally. (C) and (D) A banded expander or wire splint also can be used for delivery of protraction force (Proffit *et al*., 2019).

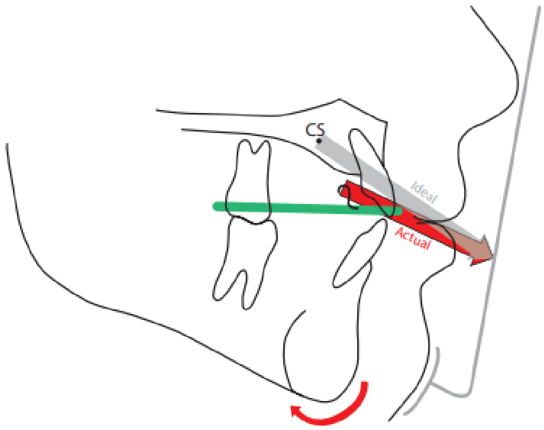

Fig. 6: With the splint attached to the maxillary arch, the ideal line of force would be directed at the center of resistance (CS) of the maxilla, so the hooks on the splint should be above the occlusal plane (Proffit et al., 2019).

In general, it is better to defer maxillary protraction until the permanent first molars and incisors have erupted. The molars can be included in the anchorage unit and the inclination of the incisors can be controlled to affect the overjet. Many clinicians use protraction with a facemask following or simultaneously with palatal expansion, on the theory that this increases the responsiveness of the sutures above and behind the maxilla to the protraction force—but that is not correct. A randomized clinical trial showed that simultaneous palatal expansion made no difference in the amount of anteroposterior skeletal change **(Vaughn *et al*., 2005)**, and this has also been shown by a recent retrospective study **(Halicioglu *et al*., 2014)**. If the maxilla is narrow, palatal expansion is quite compatible with maxillary protraction and the expansion device is an effective splint; there is no benefit, however, from expanding the maxilla just to improve the protraction.

1.3.3 Facemask traction to skeletal anchorage

Clearly, a major negative side effect of conventional maxillary protraction is tooth movement that detracts from the skeletal change. With bone screws and miniplates now readily available as temporary implants, skeletal anchorage for maxillary protraction is straightforward. Single alveolar bone screws are not adequate, but a facemask can be attached to miniplates on the anterior maxilla (Fig. 7). Although varying results have been reported, three acceptable randomized clinical trials show that greater skeletal change can be obtained with facemasks to skeletal rather than dental anchorage, with 4 to 5 mm of advancement about the limit **(Cordasco *et al*., 2014)**. The greatest difficulty with this approach is that miniplate placement on the anterior surface of the maxilla is invasive and bone maturity is not adequate until around age 11, well after the preferred time window for facemask therapy (age 8 to 10).

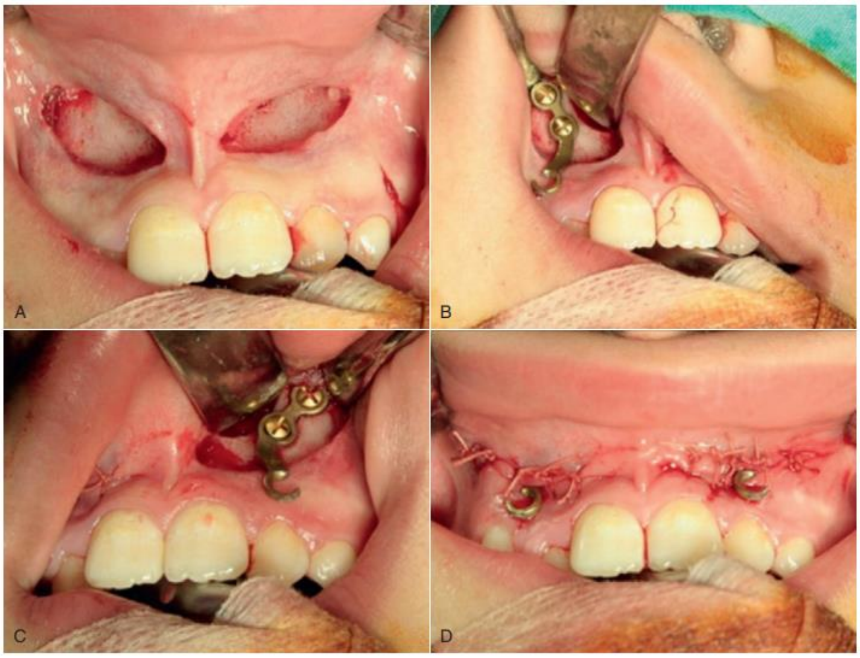

Fig. 7: Skeletal anchorage for attachment of a facemask for maxillary protraction. (A) Exposure of the anterior surface of the maxilla. (B) and (C) Placement of a miniplate held by with two screws. (D) Attachments for the facemask extending into the anterior vestibule (Sar et al., 2014).

Class III Elastics to Maxillary and Mandibular Miniplates The most effective approach to protraction of the maxilla is Class III elastics between bone-supported miniplates at the base of the zygoma above the maxillary molars and the anterolateral surface of the mandible, so that light force is delivered to the jaws rather than the teeth. This method was introduced by **De Clerck et al. (2010)** and has been studied extensively since then Sequence and Timing of Treatment. The first step is placement of the bone anchors, with a three-screw plate at the base of the zygomatic arch and a two-screw plate on the anterolateral surface of the mandible (Fig. 8). This requires reflection of a flap and, especially in the maxilla, careful contouring of the surface of the miniplate to follow the curving surface of the bone. It is technique sensitive and is best done by a surgeon with training and experience in doing this **(Cornelis *et al*., 2008)**. To reduce the risk of infection at the implant site, it is important to bring the intraoral connector into the mouth just below the upper extent of attached gingiva rather than through mucosa, and the connector should be both smooth and round to minimize soft tissue irritation.

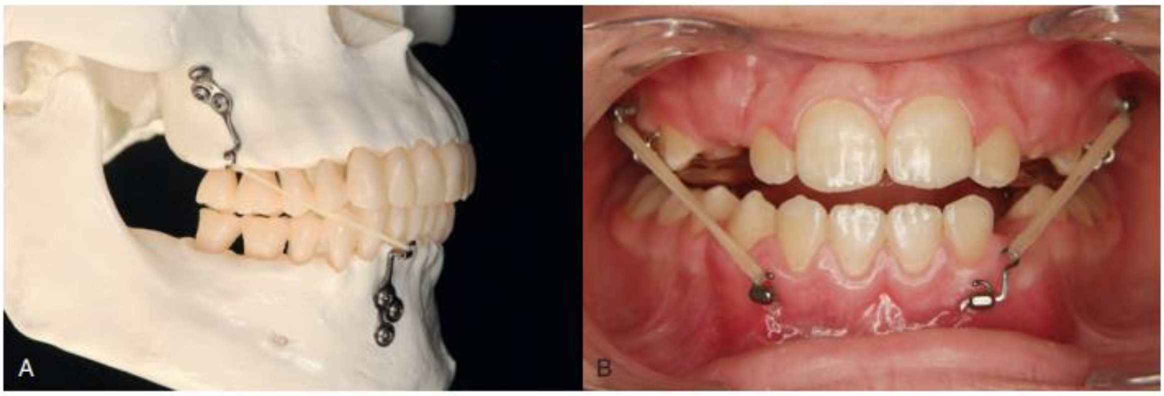

Fig. 8: (A) Y-shaped miniplates on a skull, to show where they are placed high on the posterior maxilla at the base of the zygomatic arch and on the mandible mesial to the mandibular canines. (B) A maxillary-deficient child wearing Class III elastics to mandibular miniplates (Proffit et al., 2019).

In the timing of treatment, two related factors are important. First, adequate bone density to retain the screws does not develop until approximately age 11; second, the mandibular bone plates should not be inserted until the permanent mandibular canines have erupted, which should not be a problem because they usually erupt at approximately 9 years of age. This means treatment with this method cannot begin until the patient is already too old for a good response to facemask therapy—but it also means that now there is a way to obtain excellent maxillary protraction for patients who are too old to hope for a good response to facemask therapy. With the skeletally anchored Class III elastics, a favorable growth response can be obtained throughout the adolescent growth spurt, so treatment for about 1 year between the ages 12 and 14 is the best plan.

1.4 Mandibular excess

Children who have Class III malocclusion because of excessive growth of the mandible are extremely difficult to treat. There are three possible treatment approaches: Class III functional appliances, extraoral force to a chin cup, and Class III elastics to skeletal anchors.

1.4.1 Functional appliances in treatment of excessive mandibular growth

Functional appliances for patients with excessive mandibular growth make no pretense of restraining mandibular growth. They are designed to rotate the mandible down and back and guide the eruption of the teeth so that the upper posterior teeth erupt down and forward while eruption of lower teeth is restrained. This rotates the occlusal plane in the direction that favors correction of a Class III molar relationship (see Fig. 6). These appliances also tip the mandibular incisors lingually and the maxillary incisors facially, introducing an element of dental camouflage for the skeletal discrepancy **(Proffit *et al.*, 2019)**.

To produce the working bite for a Class III functional appliance, the steps in preparation of the wax bite, practice for the patient, and use of a guide to determine the correct vertical position are identical to the procedure for patients with Class II problems. However, the working bite itself is significantly different: The mandible is rotated open on its hinge axis but is not advanced.

This type of bite is easy to obtain because light force can be placed on each side of the mandible to guide the mandible and retrude it **(Proffit *et al*., 2019)**.

How far the mandible is rotated open depends on the type of appliance and the need to interpose bite blocks and occlusal stops between the teeth to limit eruption. The general guideline is that the mandible should be rotated at least 3 and not more than 5 to 6 mm beyond its postural rest position. If this is not enough or would produce excessive anterior face height, the problem is too severe for functional appliance treatment, Class III functional appliance treatment is applicable only to patients in whom a large and prominent mandible is combined with vertical maxillary deficiency, so that they have both mandibular excess and short anterior face height **(Proffit *et al*., 2019)**.

1.4.2 Chin-Cup appliances

The Orthopedic Chin Cup The oldest of the orthopedic approaches to the treatment of Class III malocclusion is the chin cup. The effects of this appliance have been investigated thoroughly **(Sugawara and Mitani, 1997)**, with much of the research conducted on Asian populations because of the higher incidents of Class III malocclusion in these groups.

Although a wide variety of chin cup designs are available commercially, in general, these appliances can be divided into two types. The occipital-pull chin cup is used in instances of mandibular prognathism, and the vertical-pull chin cup (VPCC) is used in patients with steep mandibular plane angles and excessive lower anterior facial height **(Graber *et al*., 2016).**

The occipital-pull chin cup (Fig. 9-A) frequently is used in the treatment of Class III malocclusions. It is a soft elastic appliance with a soft chin cup. Patients can use cloth baby diaper material cut in squares inside the cup to provide more comfort. This type of chin cup is indicated for use in patients with mild to moderate mandibular prognathism. Success is greatest in patients in the primary and mixed dentition who can bring their incisors close to an edge-to-edge position when in centric relation. This treatment is useful particularly in patients who begin treatment with a short lower anterior facial height because this type of treatment can lead to an increase vertical facial height. The direction of force is determined by the position of the head cap. If the pull of the chin cup is directed below the condyle, the force of the appliance may lead to a downward and backward rotation of the mandible. If no opening of the mandibular plane angle is desired, the force should be directed through the condyle to help restrict and redirect mandibular growth. The use of a variable-pull headcap combined with a hard chin cup (Fig. 9-B) allows for variable vectors of force to be produced on the lower jaw. The direction of pull can be adjusted according to the placement of the elastics **(Graber *et al.*, 2016)**.

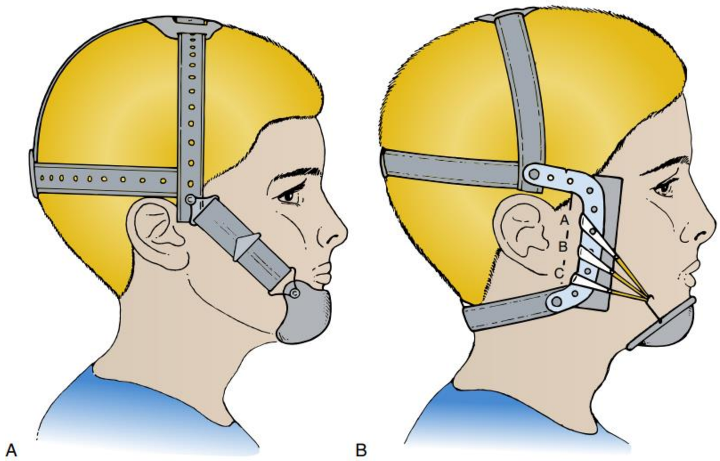

Fig 9: A, The occipital-pull chin cup. B, Variable-pull headgear (McNamara et al., 2001).

If no increase in lower anterior facial height is desired, the VPCC can be used (Fig. 10-A). Pearson has reported that the use of a VPCC can result in a decrease in the mandibular plane angle and the gonial angle and an increase in posterior facial height in comparison with the growth of untreated individuals **(Pearson, 2000)**. This type of extraoral traction can be used not only in individuals who have a Class III malocclusion but also for patients in whom an increase in the anterior vertical dimension is not desired. A study by Schulz and coworkers **(Schulz *et al*., 2005)** that compared the VPCC combined with the bonded acrylic splint expander with the bonded expander used alone in high-angle patients indicated that a modest improvement can be obtained in the mandibular plane angle and in lower anterior facial height with the use of the VPCC. They noted, however, that the effect of the vertical orthopedic treatment was observed only during early phase I therapy, not during comprehensive fixed appliance treatment.

It is difficult to create a true vertical pull on the mandible because of the problems encountered in anchoring the appliance cranially. One of the easiest of the vertically directed chin cups to manipulate clinically is shown in (Fig. 10-A). A padded band extends coronally and is secured to the posterior part of the head by a cloth strap. A spring mechanism is activated by pulling the tab inferiorly and attaching the tab to a hook on the hard chin cup **(Graber et al., 2016)**.

Another type of chin cup that produces a vertical direction of force is shown in (Fig. 10-B). This appliance incorporates a cloth headcap that curves around the crown of the head and is secured posteriorly with two horizontal straps. A throat strap also secures the appliances to the head of the patient. This particular design is useful in patients in whom anchorage in the cranial region is difficult to achieve. Either of these designs may be modified further with the construction of a custom chin cup that may be fabricated from acrylic. If customized, the attachment hook may be placed more to the posterior of the cup, closer to the throat angle, providing a more effective vertical direction of pull **(Graber *et al*., 2016)**.

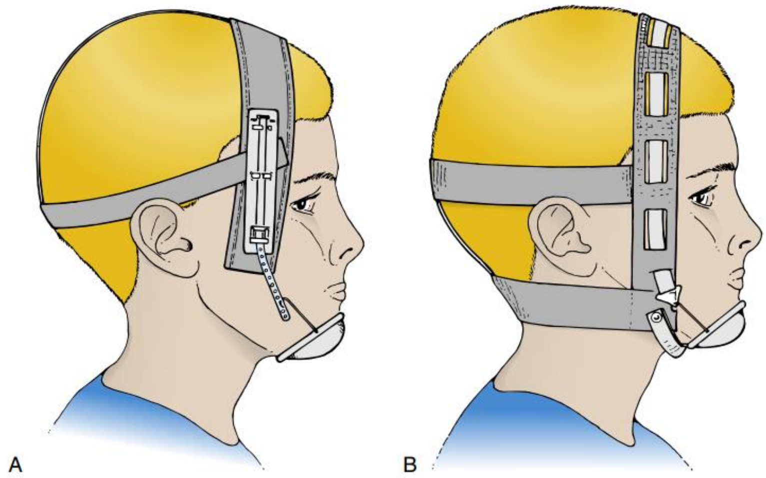

Fig. 10: The vertical-pull chin cup. A, Unitek design. A spring force design is used to create a vertical direction of pull. B, Summit Orthodontics design (McNamara et al., 2001.)

One of the substantive concerns regarding chin cup therapy is whether the growth of the mandible can be retarded through wearing a chin cup. **Sakamoto (1981)** and **Wendell et al. (1985)** have noted decreases in mandibular growth during treatment. Wendell and associates, when examining a group of Class III patients treated in the mixed dentition, noted that the mandibular length increases in the treated group were only about two thirds of those observed in the control group of mixed dentition individuals who received no treatment. **Mitani and Fukazawa (1986)**, however, noted no differences in mandibular length in Class III individuals who began treatment during the adolescent growth period in comparison with control values. In addition, in a study of long-term adaptation to the chin cup, **Sugawara and Mitani (1997)** noted that such treatment seldom alters the inherited prognathic characteristics of skeletal Class III profiles over the long term. Changes in the vertical direction of mandibular growth, however, have been noted. In a sample of young Class III patients with mandibular prognathism, the predominantly horizontal mandibular growth pattern was redirected more vertically, with changes noted in both the maxilla and mandible. The orthopedic chin cup usually produces an increase in lower anterior facial height while correcting the anteroposterior malrelationship **(Graber *et al*., 2016)**.

chin cup works best when used in the primary and early mixed dentition and when the adverse mandibular growth has been mild to moderate in nature. The earlier the problem is addressed, the more successful treatment appears to be. Multiple "stages" of active chin cup home wear are often required to be successful in the case of moderate prognathism. Thus, even the "corrected" patients need to be monitored at 4- to 6-month intervals until major growth has ceased. This need for follow-up treatment is to be expected for any orthopedic treatment that is redirecting excessive jaw growth or a severely deficient jaw growth pattern because of the genetic basis for growth and development. As noted earlier, parents must be apprised from the start of treatment that growth guidance may be needed in multiple stages and that the patient must be monitored throughout the growing years **(Graber et al., 2016)**.

1.4.3 Bone-Anchored maxillary protraction

The most recent addition to the armamentarium of Class III treatment is the bone anchored maxillary protraction (BAMP) therapy of **De Clerck *et al*. (2009)**, This approach involves the surgical placement of bone plates in the infrazygomatic region of the maxilla and the canine region of the mandible. Class III elastics that are attached to these surgical plates allow the forces produced to be transmitted to the bony bases (Fig. 11). De Clerck and coworkers **(De Clerck *et al*., 2010; De Clerck and Timmerman, 2014)** have shown dramatic results in young adolescent patients when Class III elastics (150-250 g) are worn full time, in that the force of the elastics is applied directly to the bones rather than on the teeth. Treatment changes are seen in the maxilla as well as the mandible, including remodeling in the temporomandibular joint. Interestingly, the effects of the BAMP therapy closely mimic findings from Class III nonhuman primate studies completed in laboratories in the 1970s.

Fig. 11: Cone beam computed tomography scan of patient with Bollard plates placed surgically in the infrazygomatic region of the maxilla and the canine region of the mandible (De Clerck *et al*., 2010).

There are several limitations to this procedure, including patient age; De Clerck recommends using this approach in patients at least 10 to 11 years of age. The quality of bone is insufficient in younger patients to anchor the bone plates, especially in the maxilla. In addition, the lower permanent canines should be erupted before the lower bone plates are secured mesial to the canines.

Although this technique has an added surgical procedure (and related cost), there are biomechanical and patient management advantages in the technique that reduce the potential adverse effects of other treatment protocols. In addition, the appliance can be worn 22 to 23 hours per day without social liability to the patient. The timing of treatment is critical, balancing dental eruption and bone density maturation with the need to control the adverse Class III growth. Use of this technique at a later stage of growth, though, allows for decreased time for adverse catch-up Class III growth when treatment is completed **(De Clerck *et al*., 2010; De Clerck and Timmerman, 2014).**

Chapter Two: Discussion

Class III malocclusion is best described by discrepancies of dental or skeletal components in antero-posterior or vertical directions. Retrognathic and narrow maxilla, prognathic and wider mandible, and/ or a combination of both are the common clinical presentations of skeletal class III malocclusion. The magnitude of the discrepancy may compromise facial esthetics variably and motivates individuals to seek orthodontic correction **(Proffit *et al.,* 2019).**

One of the most difficult types of malocclusions to treat is a Class III malocclusion. The occurrence of an end-to-end incisor relationship or a frank anterior crossbite is identified easily by both the family practitioner and the parent as an abnormal occlusal relationship. Thus, it is common for Class III patients to be referred for early treatment **(Graber *et al.*, 2016).**

Almost all patients undergoing early treatment will require a final phase of fixed appliances. Usually, the treatment time is reduced to 12 to 18 months because the majority of patients undergoing comprehensive therapy will be treated as non-extraction patients with Class I or near Class I molar relationships. Parents must be informed at the start and reminded at the end of mixed dentition treatment that a second stage of orthodontic treatment will be required after permanent teeth erupt **(Graber *et al.,* 2016).**

Early treatment will not eliminate the need for corrective jaw (orthognathic) surgery in all patients with severe skeletal and neuromuscular imbalances. Functional jaw orthopedics (FJO) or maxillary distalization can be used to minimize substantially the sagittal maxillomandibular imbalance, but it may be impossible to eliminate this imbalance entirely without compromising the facial aesthetics of the individual. In these instances, orthognathic surgery in combination with fixed appliances is the treatment of choice. The need for orthognathic surgery also is obvious in patients with a Class III malocclusion characterized by significant skeletal imbalances, especially in those with a family history of significant Class III malocclusion. There may well be, however, an important psychological benefit for both child and parent in reducing a malocclusion and providing an "interim" aesthetic smile, knowing that orthognathic surgery for skeletal balance may or will be required after growth has been completed **(Graber *et al.*, 2016).**

Patient compliance usually is excellent in patients treated in the mixed dentition, particularly if the appliance that is selected requires no or minimal patient cooperation other than that usually associated with a routine orthodontic treatment (e.g., good oral hygiene, diet control, and wearing of retainers). By initiating treatment in the mixed dentition, many of the skeletal and dentoalveolar problems associated with malocclusion often are eliminated or reduced substantially, thus lessening the need for prolonged fixed appliance therapy in the adolescent years **(Graber *et al.*, 2016).**

Early intervention is not always necessary or appropriate. In some instances, early treatment does not change appreciably the environment of dentofacial development and permanent tooth eruption. In such instances, early treatment may serve only to increase treatment time and cost and may result in a lack of patient cooperation in later years **(Graber *et al.*, 2016).**

Chapter Three: Conclusions and Suggestions

The occurrence of Class III malocclusion is believed to be hereditary although environmental factors such as habits and mouth breathing may play a role. The prevalence of Class III malocclusion varies among different ethnic groups. Individuals with Class III malocclusion may have combinations of skeletal and dentoalveolar components. Protraction facemask therapy has been advocated in the treatment of Class III patients with maxillary deficiency. The dental and skeletal effects of this appliance are well documented in the literature. However, one of the reasons orthodontists are reluctant to render early orthopedic treatment in Class III patients is the inability to predict mandibular growth. Patients who have received early orthopedic treatment could still require surgical treatment at the end of the growth period. The ability to identify Class III patients with excessive mandibular growth at an early age could help orthodontists to plan for future orthodontic care.

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