Universidad Europea

TRABAJO DE FIN DE GRADO

Grado en Odontología

TREATMENT OF SKELETAL CLASS II IN GROWING PATIENTS

Madrid, 2020/2021

Número identificativo 224

RESUMEN

Introducción: La maloclusión de Clase II esquelética se debe a una alteración en la relación entre el crecimiento del hueso maxilar y el mandibular. La cause más común es la retrognatia mandibular, y su manejo en pacientes en crecimiento consiste en aprovechar el potencial de crecimiento del paciente y estimular, el crecimiento anterior de la mandíbula corrigiendo la Clase II. Se han diseñado varios dispositivos con efecto ortopédico para ello, sin embargo, se ha comprobado que también producen efectos dentales.

El objetivo de esta revisión bibliográfica es comparar y estudiar las indicaciones y contraindicaciones, y revisar los efectos a largo plazo de los tratamientos más comunes utilizadas para la corrección de la Clase II esquelética en pacientes en crecimiento.

Materiales y Métodos: Se han incluido aquellos artículos y trabajos publicados a partir de 2010 en Medline, Pubmed, Google Scholar y la Cochrane Library. Para la búsqueda se utilizaron las palabras clave: *aparatología funcional*, *tratamiento de la maloclusión de Clase II* y *pacientes en crecimiento*. Se seleccionaron 58 artículos según los criterios de inclusión y exclusión.

Discusión de resultados: Las terapias más comunes investigadas fueron los aparatos funcionales (removibles y fijos), los elásticos de Clase II, los anclajes óseos, y los alineadores invisibles. Su indicación depende sobre todo de la conformidad del paciente, la fase de crecimiento, la gravedad del caso, las capacidades del ortodontista y sus preferencias.

Conclusión: Basándonos en la literatura actual, podemos afirmar que existen varios tratamientos eficaces para la maloclusión de Clase II esquelética en pacientes en crecimiento.

A largo plazo, todos parecen obtener resultados similares a través de cambios esqueléticos y/o dentales.

ABSTRACT

Introduction: Skeletal Class II malocclusion is due to an alteration in the relationship between maxillary and mandibular bone growth. The most common cause is mandibular retrognathia, and its management in growing patients consists of taking advantage of the patient's growth potential and stimulate, if possible, the anterior growth of the mandible to correct the Class II. Several devices with orthopedic action were designed for this purpose, however, it has been proven that they also produce dental effects.

This literature review aims to compare and study the indications and contraindications, and to review the long-term effects of the most common treatments used for the correction of skeletal Class II in growing patients.

Materials and Methods: Articles and papers published from 2010 onwards found in Medline, Pubmed, Google Scholar, and the Cochrane Library, were included. The keywords used for the research were: *functional appliances*, *Class II malocclusion management*, and *growing patients*. 58 articles were selected according to inclusion and exclusion criteria.

Discussion of results: The most common therapies considered were functional appliances (removable and fixed), Class II elastics, anchorage with bone screws, and clear aligners. Their indication most importantly depends on patient compliance, growth stage, the severity of the case, physician's abilities, and preference.

Conclusion: Based on the current literature, we can state that there are various effective treatments for skeletal Class II malocclusions in growing patients. In the long-term, they all seem to reach similar outcomes through either skeletal and/or dental changes.

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INTRODUCTION

Skeletal class II malocclusion is described by an anteroposterior skeletal discrepancy with the mandible positioned excessively backwards in relation to the maxilla. This is often due to maxillary prognathia, mandibular retrognathia, or an amalgamation of both in varying severities. This aberration results in an unfitting relationship between the jaws, which distorts the normal equilibrium of the face because of difficulties with dental occlusion and the temporomandibular joints (1).

Extra-oral features such as the presence of a protrusive midface and/or a retrusive chin, hypotonic upper lip, hyperactive mentalis, and palatal interposition of the lower lip to the upper incisors, are clinical indicators of a possible Class II. Diagnostic aids such as cephalometric analysis, cast analysis, history, and photographic analysis are vital in confirming the diagnosis of true skeletal Class II malocclusion (2). Assessment of the occlusion is easily done with dental casts of the arches of the patient. Findings that should awaken our suspicion of the presence of a developing Class II malocclusion during the mixed dentition are the following:

(i) Distal step relation of the second deciduous molars or first permanent molars.

(ii) Distal canine relation.

(iii) Large overjet and overbite.

(iv) Narrow maxillary basal bone; most of the time they create the need to start orthodontic treatment by correcting maxillary transverse deficiency for subsequent sagittal relationship correction (3).

(v) Tooth-size discrepancy.

Most moderate cases are due to genetics and can be worsened by environmental factors including deleterious habits such as thumb sucking, tongue thrusting, and oral breathing. However, the latter can be eliminated through preventive or interceptive treatment at the appropriate time (4).

It is necessary to correct malocclusions or attempt to alleviate them as they can have a detrimental impact on mastication (nutritional deficiencies), respiration (airway obstructions, sleep apnoea), speech, and even the TMJ (5). Studies have revealed that this type of individual is more prone to dental trauma, low self-esteem, and poor quality of life due to facial and dental esthetics. Furthermore, they have a greater predisposition to dental caries, periodontal disease, occlusal trauma, and consequently, loss of tooth substance, reduced jaw function, and masticatory ability (6). The accumulation of all these factors can heavily interfere with the well-being of the recipient and thus, inevitably entail treatment.

Their management depends on the age of the patient, severity of the skeletal or dental malocclusion, patient's esthetics, growth potential, and the compliance of the patient with treatment (7)(8).

Generally, treatment approaches of class II malocclusion are categorized according to the growing and non-growing status of patients. Authors have noted that the ideal time to alter a skeletal class II is during the optimal maturation stage, at 12 years of age. The growth spurt commonly occurs in girls of 10 to 13 years of age, and in boys of 11 to 14 years of age (8). Significant dissimilarities in the development among individuals of the same chronological age have made skeletal age assessment a necessity in formulating effective orthodontic treatment plans (9). According to the American Journal of Orthodontics and Dentofacial Orthopaedics, “skeletal maturation refers to the grade of development of ossification in bone” and is determined through analysis of lateral cephalometric radiographs. At each level of skeletal development the anatomy of the cervical vertebrae differs. As a result, its evaluation has been used as a tool to evaluate the growth potential of patients. **Baccetti**, **Franchi,** and **McNamara** modified the original Cervical Vertebral Maturation analysis to simplify the method and make it applicable to the majority of patients, they did so by limiting the number of vertebral bodies to C2, C3, and C4 and defined their morphology in six developmental stages [*see Figure 1*] (10). The initial two stages are differentiated by the concavity of the inferior border of C2 at cervical stage 2 (CS2). Cervical stage 3 (CS3) is the ideal stage to begin functional jaw orthopaedics as it correlates with the peak of mandibular growth, and it is identified by a visible concavity at the lower border of C3. At CS4, the bodies of both C3 and C4 are rectangular and with maturity they become square; at CS5 at least one of them is squared in shape. Finally, once CS6 is identified through the rectangular vertical shape of either C3 or C4, it can be deducted that more than two years have passed since the peak in mandibular growth (11).

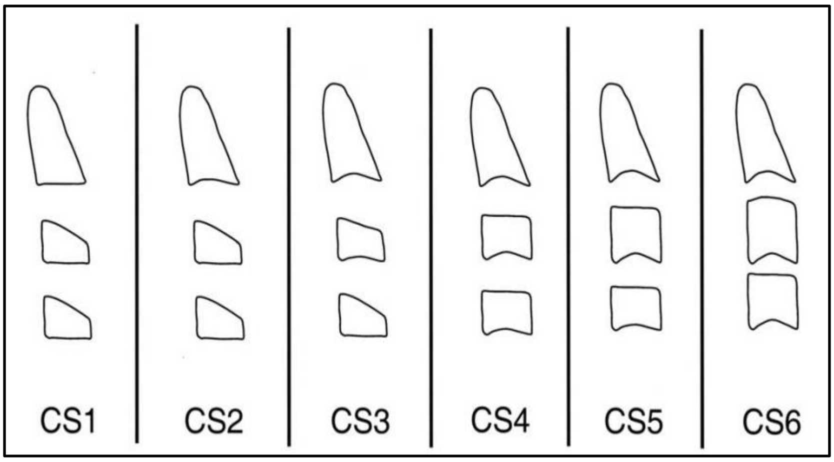

Figure 1: Schematic illustration of the stages of cervical vertebrae

Classification of the malocclusion can also be useful for treatment planning. Angle described a subcategory of the Class II malocclusion featuring two divisions differentiable by distinct dental and soft-tissue features. The Class II Division 1 (II/1) is characterized by proclined upper incisors and an excessive overjet (8). Commonly, nasal obstruction and mouth breathing is associated with II/1 cases. The Class II Division 2 (II/2), on the other hand, is often associated with retroclined maxillary incisors among other features. When it comes to treating them, the first step is to fix the incisor retroclination to obtain a II/1 and then treat the anteroposterior discrepancy.

In the literature, some of the possible therapies for the management of dentoskeletal class II malocclusions in growing age include functional appliances, fixed orthodontic appliances, temporary skeletal anchorage devices, clear aligners, orthognathic surgery, and extra-oral appliances such as the headgear (12).

Generally, functional appliances are recommended for the correction of class II malocclusions associated with mandibular retrognathism, which is the more prevalent cause. Whether removable (Bionator, Twin-Block, Frankel, Activators) or fixed (Herbst, Forsus, Mandibular anterior repositioning appliance [MARA], Jasper Jumper) they tend to be used during pubertal growth in childhood.

Treatment objectives in a skeletal Class II are the modification of convex profile to orthognathic profile, the correction of Class II molar and canine relationship into a Class I malocclusion with proper functional normality and esthetic, and finally, the improvement of facial appearance by stimulating mandibular growth and inhibiting vertical maxillary growth (13). Patients tend to manifest lower anterior crowding, an overjet, and overbite, hence their alteration will also be targeted. Early therapy in severe cases, where overjet is greater than 7mm, helps decrease the risk of traumatic damage to the incisors. An increased overbite is also a sign to start treatment early since the bite can deepen with time and make later treatment more complicated. Overall, treatment should consist of restoring the balance in facial harmony and occlusion to improve the aesthetics, self-image, and social well-being of the patient.

The early modification of occlusion is intended to avoid the development of more severe discrepancies, and it is said to be the greatest aid in the promotion of health of the denture by allowing the proper development of normal masticatory and facial habits (14).

Commonly, orthodontists proceed in two working phases when treating "early" the malocclusion. The first one consists in correcting the skeletal problem by stimulating the growth of the mandible or halting the overgrowth of the maxilla through the use of functional appliances. The second phase is responsible for the settlement of the occlusion through the use of orthodontic fixed appliance therapy. It acts on the finer changes of the occlusion, allowing the orthodontist to obtain optimum results that will satisfy the patient's needs. It is possible to go through a single-phase treatment, which involves the use of elastics with orthodontic fixed appliance simultaneously with the appliance.

Depending on the complexity of the case, the practitioner will measure the benefits and risks of each possible treatment option and choose the most adequate one.

OBJECTIVES

The main objectives of this study are:

1. Describe the different treatment options for the correction of skeletal class II in growing patients and indicate the most effective option according to the bibliography.
2. Discuss the indications & contraindications of each treatment.
3. Compare the long-term effects of therapy with functional appliances, Class II elastics, miniscrews, and clear aligners in the treatment of skeletal class II in growing patients.

MATERIALS AND METHODS

A pertinent literature review was performed in online databases such as Medline, The Cochrane Library, Google Scholar, and PubMed, using the following keywords: “dentoskeletal class II”, “orthopedic treatment”, “Class II malocclusion management”, “functional appliance”, “activators”, “growing patients”, “therapeutic approach”, “clear aligners”, “class II elastics”, “miniscrews”, and “long-term effects”.

The inclusion criteria being:

- Studies in growing patients
- Treatment with functional appliances, miniscrews, Class II elastics, and clear aligners
- Research published from the years 2010 to nowadays for the discussion
- Studies published from any timeframe for the introduction
- Works in the English, Spanish and French language

The exclusion criteria being:

- Literature papers older than 10 years (previous to the year 2010) for the discussion
- Research including patients with craniofacial syndromes and/or cleft lip palate

We have accepted 58 articles.

DISCUSSION OF RESULTS

1. FUNCTIONAL APPLIANCES

A functional appliance is defined as an appliance that alters growth to generate a more acceptable relationship of the jaws, this is done by the stretching of muscles which generates forces that have a postural effect on the mandible. Functional appliances have an orthodontic and orthopedic effect, and also could correct parafunctional problems. Their mode of action is based on the theory that an imbalance of the neuromuscular component of the orofacial complex results in malocclusions. Hence, when orthodontists treat their Skeletal Class II patients with these appliances, they aspire to obtain a correction in the muscular imbalance, an improvement in soft tissue tone and in the oro-nasopharyngeal complex function.

Myofunctional appliances work by force application and force elimination of the abnormal and restrictive forces, thus allowing the proper growth and development of the area. The lower jaw is repositioned in a forward position with the help of protrusive bite registration, this leads to the remodelling of the glenoid fossa and displacement of the condyles in a forward and downward position. Furthermore, these devices act on the maxilla by restraining its growth (7).

Functional appliances can be categorized into either removable or fixed ones. Another important categorization would be whether one requires patient compliance or not since this could possibly influence the treatment outcomes (15). In non-cooperative patients, the use of fixed appliances will be favoured. Removable functional appliances are also inadequate in cases with extractions or excessive crowding that demand more complicated dental movements.

It is important to note that not all patients respond the same way to the same functional appliance and nor do all appliances function the same way. The treatment outcome may be similar but the mechanisms and pathways differ with different systems.

Several studies have expressed the benefits of early treatment with functional appliances, with the main perk being the possibility of preventing or minimizing the need for a complex intervention involving extractions or surgery thanks to the lengthening of the mandible. However, a lot of controversy surrounds this idea as not all authors agree on this statement, with some pointing out that the mandibular lengthening achieved through these appliances is clinically irrelevant. Another debate in the literature would be whether an early dual-phase treatment truly has important advantages over single-phased ones at a later age (16).

During the initial phase of treatment, the sagittal jaw relationship is regularised commonly through the use of functional appliances, and in the later phase of treatment the teeth's position is adjusted normally with fixed appliances (17). For optimum results and detailing of the occlusion functional therapy tends to be followed by a full fixed appliance treatment. The second phase of treatment is normally commenced once the permanent dentition has fully erupted.

1.1) REMOVABLE FUNCTIONAL APPLIANCE (RFA)

Removable functional appliances are known to be more efficient in stimulating the mandible forward than fixed ones due to their greater contact area with lower teeth and lingual mucosa. They are indicated in Class IIs by mandibular retrognathism, to prevent and correct oral habits such as thumb and lip sucking, and mouth breathing. They are contraindicated in skeletal Class IIs by maxillary prognathism, when there is crowding and, or labial tipping of lower incisors, and in vertical directed growers (18).

The removability of these devices means that patient collaboration is indispensable and dictates the success of the treatment. All orthopedic devices require a minimum wear of 12 to 14 hours per day, mostly nocturnal, for about 10 to 12 months. The advantages and disadvantages of removable functional appliances are listed in *Table 1* (19). Most of them allow the adding of screws and wires to correct gap problems and the malposition of individual or groups of teeth. Multi-bracket therapy tends to follow the end-of-wear of removable functional appliances since it enhances the treatment effects of functional jaw orthopaedics and controls relapse (20).

ADVANTAGES	DISADVANTAGES
Offer immediate improvement in lip function	Designed for growing individuals only
Low risk of caries	Require good patient cooperation
Can be used in the mixed dentition	Limitation in the control of individual teeth
Predominantly used at night	Initial limited fixed appliance may be needed
Minimal chair time for adjustment	Often are bulky and interfere with speech
	Discouraged in mouth breathers

Table 1: Advantages and Disadvantages of RFAs

1.1.1. MONOBLOC ACTIVATOR

The modern activators are descendants of the Monobloc designed by Robin in 1902. Andreson and Haupl developed their own mobile and loose-fitting version of the appliance in 1908 and gave it the name of "Activator" due to its capability to activate the muscle force (21). Both dental arches articulate in a position of maximum intercuspation in the acrylic and the muscles of mastication have no other choice in this position but to exert an isometric contraction (activation of the muscles without variation in length).

The modernised Activator [Figure 2] is composed of:

- A maxillary acrylic base plaque in contact with the palate and that extends over the palatal surface of the upper teeth.
- A mandibular acrylic base plaque that covers the mandibular incisors to prevent their proclination during overjet reduction.
- A passive maxillary labial bow.
- For certain cases, where we have narrow arches and desire transversal expansion, a screw at the midline can be placed.

Figure 2: An example of the Andresen Activator from the BOS Museum collection

Among the functional appliances, the activator appliance is the one inducing a mandibular position different from the one normally occupied. This device is worn at night, as it is loose it drops in the mouth during sleep and subsequently, the protractor and elevator muscles activate to hold it in place. The mandible is forced forward creating a new pattern of mandibular closure. Another orthopedic effect of this appliance is the inhibition of the horizontal growth of the maxilla, this leads to an increased growth of the mandible and allows the anterior relocation of the glenoid fossa. However, some authors believe that the Activator has sole influence on the dentoalveolar system, this would mean it doesn't stimulate mandibular growth and only hinders maxillary growth. Therefore, the Activator would not be able to increase nor reorient mandibular growth in the long term.

Studies [*Table 2*] have indeed shown that the Activator had minimal impact on the protrusion of the mandible, however, it is important to note that most studies performed combined the Activator appliance with the headgear due to the fact that combined therapy offers grander cumulative skeletal benefits than a single appliance alone (17), (22), (23), (24), (25). Together, the Activator and Headgear retrude upper incisors, protrude lower incisors, distalize upper molars, and cause extrusion of the lower molars. This allows the improvement in sagittal relationship, overjet and overbite.

When comparing the Activator with the Jasper Jumper subtle differences were noticed. The Jasper Jumper was able to induce a greater mesialization of the mandibular molars and exerted less extrusion of the maxillary molars.

Authors	Year	Appliances compared	Diagnosis	Results at the end of treatment
Santiago de Lima, Henriques, Janson, da Costa Pereira, Santos Neves, Hermont Cançado	2013	Jasper Jumper (JJ) & Activator-headgear (AH) followed by fixed orthodontic treatment	72 subjects. Inclusion criteria: - Bilateral Class II div 1 - No craniofacial syndromes or systemic diseases - No tooth agenesis or missing permanent teeth - Mandibular arch with minimal or no crowding All patients were in early permanent dentition with all first permanent molars & all premolars erupted.	- Both appliances showed significant & similar restriction of maxillary forward displacement compared with the control group. - Upper incisors had greater palatal inclination in the AH group & greater retrusion & extrusion in the experimental groups. - Maxillary molars were distalized in both JJ & AH groups, & were more extruded in the AH group. - Lower incisors had greater labial tipping in the AH group than in the control group, but greater protrusion & extrusion in the JJ group than in the control group. - Lower molars had greater mesialization in the JJ group. - Overjet, overbite & molar relationships were greatly improved in the experimental groups.
Franchi, Pavoni, Faltin Jr, McNamara Jr, Cozza	2013	Activator (AA) & Bionator	40 subjects divided into 2 groups: 1 treated before puberty, 1 at puberty. Mean age of 10 years. Overjet >5mm. Full Class II, or end-to-end molar relationship, maxillomandibular differential <23mm	- Both AA & Bionator induced a significant elongation of the mandible over the controls (3.6mm) that was maintained in the long term. - Both were effective in reducing the overjet and overbite (approx. 3 mm & 1.5 mm, respectively) & in improving the sagittal molar relationship (approx. 3 mm). - Results confirmed that treatment that includes the peak in mandibular growth appears to be more effective than treatment before the peak.
Spalj S, Tranesen K, Birkeland K, Katic V, Pavlic A, Vandevska-radunovic V	2017	Activator-Headgear (AH) & Twin Block (TB)	50 subjects with Class II/1 aged 8-13 years Distal molar occlusion Overjet >5mm Patient's recommended to use appliance 12-14h/day	- TB led to more protrusion & proclination of the mandibular incisors. - Treatment with TB resulted in some added mandibular length growth while AH exerted more control of the vertical dimension of the lower anterior facial height.
Santamaría-Villegas A, Manrique-Hernández R, Álvarez-Varela E, Restrepo-Serna C	2017	Removable Functional Appliances (RFA)	Systematic review randomized clinical trials studies published between 1966 and 2016. Studied efficacy of RFAs in participants between 6-18 years of age with Class II malocclusion by retrognathism.	- Frankel presented the least variation in mandibular length. - TB followed by Bionator obtained the greatest increase in mandibular length.
Da Mommio L, Vompi C, Carreri C, Germano F, Musone L	2019	Bionator & Frankel II	Review of articles, case report studies, case-control studies. Exclusion of studies involving syndromic patients.	- Major effects of Bionator & FR-2 were dentoalveolar, with a smaller but significant skeletal effect. - Bionator obtained more mandibular protrusion & showed a greater increase in posterior facial height. - Similar labial tipping & linear protrusion of lower incisors in both treatment groups.

Table 2: Results of various articles on functional appliances

1.1.2. BIONATOR

The Bionator [Figure 3] was developed by Wilhelm Balters in 1964 and is considered as a modification of the Activator since the only difference between these appliances is the lack of palatal coverage replaced instead by a metal bar in the Bionator. The reduced bulkiness allows to obtain a high level of comfort for the patient, and therefore, increases its daytime use, and it also permits more normal speech patterns.

The Bionator is formed by:

- A block of acrylic resin interposed between the arcades.
- A labial bow with canine loops.
- An omega palatal bar.

Additionally auxiliary can be added to the appliance depending on the patient's needs, such as springs and screws to align individual teeth, Adams hooks to increase stability or screws for the transversal expansion of arches (26).

Figure 3: Bionator appliance

This appliance focuses on restoring the equilibrium of the tongue with the circumoral muscles as Balters believed that their discoordination led to abnormal growth and deformities. He also believed that a high construction bite would cause the tongue to acquire a thrust habit, and for this reason, the construction bite was made low.

Unlike the Activator, the Bionator modulates muscle activity instead of activating them. By stimulating the dorsal surface of the tongue with the palatal bar and by repositioning the bite in an edge-to-edge position it can guide the tongue and lower jaw anteriorly.

Franchi *et al*'s study [Table 2] analysed the long-term dentoskeletal outcomes of treatment with Bionator or Activator followed by fixed appliances. Both induced an important elongation of the mandible over the controls (3.6mm), this was maintained in the long term. In the short and long term, there was an improvement of the skeletal sagittal intermaxillary relationship, reduction in both the overjet and overbite (about 3.0mm and 1.5mm, respectively), improvement of the sagittal molar relationship (3.0mm) through the distalization of the maxillary molars and mesialization of the mandibular molars. There was no significant change in the inclination of mandibular incisors, this demonstrated that the lack of coverage of the lower incisors had no particular effect on their inclination (22).

Overall, it can be stated that the Bionator has a skeletal effect but only if used adequately during the growth spurt. Both ramus and mandible are elongated and there is condylar growth in the posterior direction. However, no maxillary effect is produced in terms of restriction of the maxillary growth. Finally, the constant wear of the Bionator makes its action faster than the Activator and allows to obtain quicker improvements.

1.1.3. FRANKEL APPLIANCE

The Frankel Appliance [Figure 4] is a functional device established by Rolf Frankel in the 1950s. It is often called ´tissue born appliance´ as it focuses on limiting inappropriate muscular forces in labial and buccal areas that restrict skeletal growth. According to Frankel, a regular pattern of muscular behaviour encourages normal skeletal and dental development, conserving the new mandibular position (5), (27).

There are several types and the suitable ones for the treatment of Class II would be the Frankel Regulator I (FR-I) and II (FR-2).

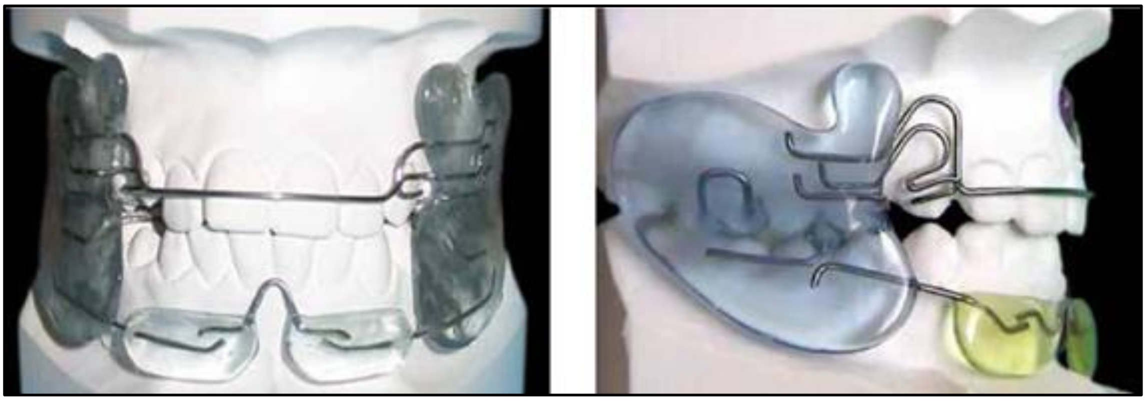

Figure 4: FR-2 Appliance

The device is formed by:

- Two vestibular shields: they extend down into the vestibular folds and limit the pressure of the buccinator and orbicularis oris muscles.
- Two lower labial shields: they limit the stress exerted by a hyperactive mentalis muscle.

- A lower lingual shield: it activates the protractor muscles and allows forward movement of the mandible.
- Labial bow with canine loops.
- Palatal bow.
- Lingual arch.

Mandibular protraction is achieved thanks to the repositioning provided by the inferior border of the vestibular shields, the lower lip and, labial shields. The buccal shields allow to increase the blood circulation in the muscles and thus, facilitate muscle adaptation into the new position. Furthermore, passive expansion of the arches in the transversal and anteroposterior plane is obtained due to shaping force exerted by the unhindered tongue. The labial shields allow the rectification of the lacking orofacial muscle tone resulting in a better lip seal (26).

It is indicated for the mixed and early permanent dentition stages, and treatment generally lasts for 18 to 24 months. Alike the Bionator, it has not shown any restricting effect on the maxilla and thus is contraindicated in cases with maxillary prognathism.

Exactly how the FR-2 achieves the correction of class II malocclusion is debatable. Some studies have shown it achieve it through the stimulation of mandibular growth, others also reported restraint on the maxilla, while some observed only dentoalveolar effects and no skeletal actions from the appliance. The most recent study released on the long-term treatment effects of the FR-2 appliance (Angelieri *et al*. 2014) showed that:

- There were no significant vertical skeletal changes at the end of the treatment period. This differed from other studies that had observed increases.

- There was interference in the mesial displacement of the maxillary first molars thanks to the mesial movements of the mandibular molars.
- The amount of increased mandibular length noted was alike to that observed in other studies (between 3 to 4 mm) and remained stable over 7.1 years post-treatment.
- There was no noteworthy proclination of the lower incisors, this result contradicted with previous studies (McNamara *et al.* 1985, Perillo *et al*. 2011)

In terms of stability over long periods of time, out of the dentoalveolar effects only the mesial migration of the mandibular molars proved to be unchanged. Thus, it can be concluded that the Frankel regulator-II rectifies the Class II malocclusion mainly due to skeletal changes rather than dentoalveolar changes in the long period (28).

1.1.4. TWIN BLOCK

William Clark, in 1982, developed a two-piece appliance that could be worn during eating unlike the previous ones mentioned. The Twin Block retains the mandible in an adjusted forward position to encourage adaptive skeletal growth (23). It can be removable or fixed.

The Twin Block [Figure 5] consists of:

- An upper and lower removable appliance with bite blocks composed of bite ramps set at a 70-degree angle (29). This angle can be reduced if the patient has difficulty adapting to the new position.

- Bite blocks can be cut off at the level of lower molars to allow their extrusion [see Figure 6] and solve hypodivergence.
- An upper and/or lower midline screw can be placed for transversal expansion.
- If removable, we will find Adams or Delta clasps on the first upper molars and first lower premolars or molars. Anterior ball clasps for better retention. An upper labial bow.

Figure 5: Twin Block Appliance

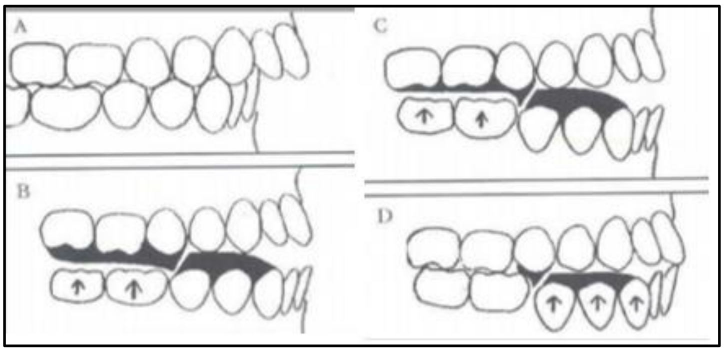

Figure 6: Extrusion of the teeth in areas where acrylic is lacking

The Twin Block's mode of action is based on the philosophy of the occlusal inclined plane. Occlusal forces of the dentition provide continual proprioceptive stimuli that influence the growth of the supporting bone. In cases where the mandibular inclined planes are distal to those of the maxilla, the forces acting on the mandibular teeth have a distal force vector that worsens the Class II growth tendency. Thus, the goal of the appliance is to stop the action of unfavourable cusp contacts by modifying the inclined planes to achieve a favourable growth pattern. This is attained with the bite blocks that unlock the malocclusion by freeing the mandible from an entrapped position of distal occlusion. It is used in permanent dentition and treatment tends to last for a period of 12 to 18 months.

Various comparative studies [see Table 2] have shown that the Twin Block is the most successful in obtaining mandibular protrusion and results in greater skeletal changes. **Baysal *et al*** reported that, in general, the increase in mandibular length tends to be statistically significant compared to the control group: at the end of treatment around 3.37mm is obtained in mandibular length and 12 to 16 months post-treatment, an increase of 1.46-4.75mm is observed (30).

The appliance is capable of greatly improving soft tissue aesthetics by flattening the labiomental fold and reducing the protrusion of the lower lip. Nonetheless, it increases the nasolabial angle and if this one is too great it will result in an unappealing facial profile. Some of the other noted disadvantages are the proclination of the lower incisors and the development of posterior open bites, however, these can be prevented or adjusted by adding accessories onto the appliance or by future treatment with full fixed orthodontic appliance.

The Twin Block can be considered as the first choice in the category of removable functional appliances due to its wide acceptance, adaptability, ease of handling, reparability, versatility and ability to eliminate etiological factors (sucking habit) (31). It was also reported that it managed to increase mandibular length greater than any other mentioned appliance.

1.2) FIXED FUNCTIONAL APPLIANCE

Fixed functional appliances are generally selected over removable ones due to the "non-compliance" of the young patient. Due to their attachment to the teeth, all compliance-free Class II devices produce orthodontic movement and some are designed to obtain orthopedic results as well. If the patient is in his late stages of puberty or reports after the growth spurt, it will be wiser to choose a fixed functional appliance instead of a removable one. It is indicated in growing or young adult patients with a mild to moderate skeletal Class II discrepancy and suitable facial pattern. It is suitable in cases of Class II with mandibular retrusion or maxillary protrusion, it can also be used as anchorage in cases with extraction or not and after distalization of the maxillary molars. But, its use will be restricted in patients with periodontal problems, tipped mandibular incisors, gummy smiles, open bite, and with thin gingiva in the anterior region of the mandible (32).

Fixed functional appliances can furthermore be categorized into either flexible, rigid, and hybrid. Flexible appliances are those consisting of an intermaxillary coil spring or fixed spring. They allow free movement of the mandible but are more prone to breakage and are not very esthetic, an example would be the Jasper Jumper. Rigid fixed functional appliances are different from flexible ones due to the fact that they are not easily fractured and that the mandible is not free of movement, because of this, they deliver better skeletal results than the other types. The patient is forced into a forward biting position instead of the typical maximal intercuspation one (32). Examples of these rigid ones are the Herbst and mandibular advancement repositioning appliance (MARA).

Unlike removable functional appliances, fixed functional appliances do not require a second phase of treatment since they can be used conjointly with brackets at the same time. The Jasper Jumper and Forsus Fatigue Resistant Device require an alignment and levelling phase with the multibracket appliances since they are attached to the teeth through this system (33). To ensure long-term stability with fixed functional appliances, the axial inclination of the incisors of the lower jaw is assessed and should be increased to certify that the dental changes have stabilized. It is recommended the use of occlusal positioners to ensure the position of the mandible. The occlusion could also be settled with Class II elastics before debanding.

There has been some controversy on whether fixed functional appliances truly have an orthopedic effect, many studies have shown that the correction of Class II was majorly due to dentoalveolar changes (15). In 2016, a thorough systemic review on the assessment of skeletal mandibular changes in circumpubertal patients with fixed functional appliances installed on multibracket appliances compared with untreated patients was released by the Department of Orthodontics of the Cairo University (33). In regards to effective mandibular length, no difference was observed between the treated and control patients in neither the pubertal nor post-pubertal groups. However, they did end up agreeing that more clinical trials were needed to fully confirm this notion, as there exist many articles contradicting each other on this notion. Other detrimental aspects of fixed functional appliances would be their proneness to breakage, higher cost, and marked tipping of the teeth. They are known to have shorter treatment period but this increases the risk of relapse.

1.2.1. HERBST APPLIANCE

The Herbst appliance [Figure 7] has for many years been baptized as the gold standard of fixed functional appliance. It is the most popular functional appliance in the United States for the correction of mandibular retrognathism. One of its particularities is that it can still be used in the post-pubertal period in young adults, however, greater anchorage loss will occur compared to treatment results during the pubertal period.

Figure 7: Herbst Appliance

The Herbst is composed of four crowns cemented to the first molars and of two telescoping arms. It is considered as a passive activator since it works with tube forces to maintain the mandible in a continuous propelled position, namely during closure and opening movements, by exerting an upward-backward force on the maxilla and a downward-forward force on the mandible. The device can induce the remodelling of the condyle, the glenoid fossa, and the articular tubercle by causing an anterior and downward movement of the condyle (LeCornu *et al*. 2013. reported an anterior displacement of the condyles of 0.38-0.56mm (34)). As noted in *Table 3*, the Herbst has proven to be efficient in correcting Class II malocclusions by restricting maxillary growth, increasing mandibular length (1.2mm per year), distalizing (maximum 4.5mm) and intruding (maximum 3.5mm) maxillary molars, mesializing (0.8mm to 2.2mm) and extruding mandibular molars. It is one of the few appliances with available long-term stability evidence (2), (35), (36).

It may be used in association with multibracket appliances or clear aligners to correct both jaw growth and tooth alignment problems, consequently avoiding a second treatment phase. The use of brackets or aligners reduces the buccal version of the mandibular incisors related to the treatment. The proclination of the lower incisors may be beneficial to patients with initial retroclined incisors but will be unfavourable in those with proclined mandibular incisors at the start of treatment.

Clear aligners [Figure 8], in addition, allow the control of the molars and so, of the posterior vertical dimension, and this by the possibility of varying the thickness of the acrylic resin at the molar level.

Figure 8: Herbst appliance in conjunction with clear aligners

The appliance is broadly used for a span of 8 to 12 months, the latter being the best to prevent relapse. Condyles must be centred in the glenoid fossa at the time of removal. Additionally, one should always consider patients will undergo a relapse in terms of dental relationship, thus, it is fundamental to overcorrect molar relationship and, if possible, reach a Class III. Once the appliance is withdrawn, a fixed appliance should be assembled to reach a perfect detailing of the occlusion (37).

Dentists from the past have stated that treatment with the Herbst was mostly successful but there were many complaints from patients due to the irritation that it caused on the lips and cheeks. Another negative aspect would be its high cost.

Authors	Year	Appliances compared	Diagnosis	Results at the end of treatment
Siara-Olds, Pangrazio-Kulbersh, Berger, Bayirli	2010	Bionator, Herbst, Twin Block & MARA	80 patients with similar Cl II characteristics. CVM between stage 2 & 3	- Herbst followed by MARA demonstrated significant effect on restricted maxillary growth - TB showed stability of the skeletal changes. - TB, Herbst & MARA patients showed an increase in mandibular length of 1.5, 1.2 & 0.94mm per year, respectively. - Herbst demonstrated the most restriction on maxillary growth & the most upper lip retrusion. - No significant soft tissue changes in any of the groups studied.
Brindeiro de Araújo Brito, Castanha Henriques, Foncatti Fiedler, Janson	2019	Jasper Jumper (JJ), Herbst & Mandibular Protraction Appliance (MPA)	Class II/1 with bilateral Cl II molar relationship. Mandibular arch with minimal or no crowding. Patients' average age was of 12 years. Groups were similar regarding sex distribution, minimum of 18 subjects per group. Similar anteroposterior severity among the experimental groups.	- JJ & Herbst group showed significantly greater maxillary anterior displacement restriction. - No statistical difference observed among the experimental & control groups concerning the mandibular length → these appliances do not seem to significantly influence mandibular growth - All experimental groups showed greater improvement of the apical base relationship than the control group → effective in correcting Class II skeletal anteroposterior discrepancy. - MPA group demonstrated significantly greater palatal inclination of the maxillary incisors. - All three appliances showed significant mandibular incisor proclination, with the JJ group showing the most protrusion in comparison with the control group.
Ardeshna, Bogdan, Jiang	2019	MARA	24 patients with no previous orthodontic treatment & Cl II dental malocclusion with at least a cusp to cusp molar & canine relationship present, an anterior deep bite of >10% & ANB of min 4º. Mean age: 12.40 years	- Normalization of the molar relationship to a Cl I of 7mm. - Reduction in overjet of approx. 4.72mm - Greater bone remodelling response to the appliance in the body of the mandible than in the condylar-glenoid fossa region (2.2mm vs 1.8mm) - No skeletal effect on the maxilla - No dental effect on the maxillary incisor

Table 3: Results of studies on fixed functional appliances

1.2.2. MARA APPLIANCE

Figure 9: MARA Appliance

The MARA [Figure 9] is the abbreviation for Mandibular Anterior Repositioning Appliance and was developed by Toll as a solution to the dislike expressed by patients in regards to the Herbst. Unlike the Herbst, it is considered an active appliance since it requires the patient to posture forward without the help of a spring. It acts by guiding the patient to bite into Class I, when the patient tries to bite naturally (into Class II) the fixed lower arms interfere with closure and force the patient to bite forward in front of the upper elbow. During Class I closure, the lower arm should slip in front of the elbows.

Some of its advantages are:

- It eliminates the compliance factor.
- Its esthetics.
- The possibility of associating it with other fixed gears due to the presence of upper and lower archwire tubes: Analogous to the Herbst, it can be used simultaneously with pre-

adjusted Edgewise appliances but will necessitate some levelling of the molars and premolars with more flexible wires. This extends the overall treatment time (4).

- Breakage is minimal and speech and hygiene are unproblematic due to the absence of inter-jaw restrictions.
- It possesses fewer anchorage points, which results in fewer secondary effects.
- The patient's profile looks immediately better once the appliance is inserted.

The MARA is composed of [Figure 10]:

- Stainless steel crowns on all first molars:
    - The upper molar has a rectangular archwire tube and a large square tube in which slides an adjustable square elbow (removable attachment) that hangs vertically.
    - The lower molar has a rectangular tube and a round wire arm on the mesial side projecting buccally.
- Lingual arch or lower braces.

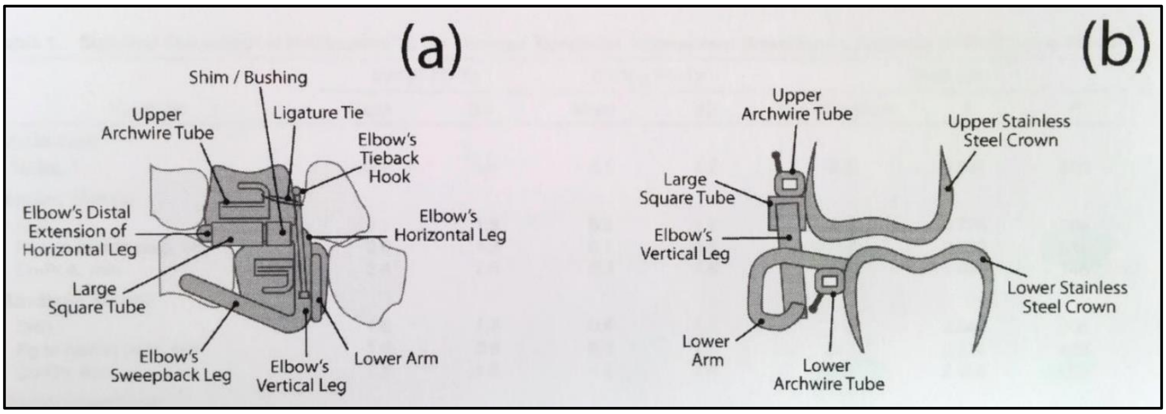

Figure 10: The MARA and its elements, (a) sagittal view, (b) frontal view

Table 3 depicts two different studies including the MARA appliance***:*** **Ardeshna *et al***'s study showed that the MARA treated Class II sagittal relationship cases into a Class I. There was a molar correction of 7mm with 2.6mm coming from skeletal changes and the remaining 4.4mm from dental changes (37). It can be said that the effects on mandibular growth are minimal and not important enough to suggest that the appliance has the ability to stimulate sufficient mandibular growth to correct distal sagittal discrepancy, this assumption is confirmed by another article, **Pangrazo *et al***'s (38). However, for the reduction of the overjet (4.7mm), skeletal changes contributed more with 55% of correction versus 45% from labial version of the mandibular incisors (2.6mm versus 2.2mm). The device appears to have an inconsequential effect on the maxillary incisors. Unlike the Herbst, the MARA showed no headgear-like effect except in few cases where the patient's growth phase was ideal (37).

Similar to the Herbst appliance, the MARA can be used to alleviate temporomandibular symptoms and is useful to recapture anteriorly displaced discs and to unload the joints. Even though this appliance has several advantages and is seen as an adequate non-extraction solution of Class IIs, its use is not common. This probably is due to its higher cost, the handling and placement complications, and longer chair time.

Some of the potential side-effects are (39):

- Mobility of the mandibular first molars caused by contact of the elbow with the posterior surface of the lower arm. However, this can simply be fixed with full-fixed orthodontic appliances.

- Distal tipping and intrusion of the upper first molars due to force exerted by protrusive lower molars. The placement of a transpalatal arch can counter-effect the forces received by the molars.

The appliance is indicated for patients in the late mixed dentition stage and stays intraorally for a period of 6 to 8 months.

1.2.3. JASPER JUMPER

The Jasper Jumper (JJ) unlike the Herbst or MARA is considered as a fixed flexible functional device and was developed in 1987 by James Jasper. It has a similar mechanism to the Herbst but to minimize the problems produced by the rigidity of the latter it is composed of two flexible force modules that exert light and continuous force through mandibular advancement. One of its particularities along with the Forsus Fatigue Resistant Device is that it is attached to the arch wire or bands on teeth, however, the prerequisite of having a stiff arch wire before its placement delays the treatment of the Class II relationship until the arches are adequately aligned to allow the placement of a straight stainless steel arch wire.

More comfort is provided to the patient as he has autonomy over mandibular movements. Other advantages are its lower cost and shorter treatment period thanks to its association with fixed appliances (40). Its flexible structure permits lateral jaw movements which is a disadvantage.

The upper end of the spring is hooked from the first upper molar headgear tube to the lower arch wire in between the canine and first premolar [Figure 11]. The upper molars receive a distal and intrusive force, while the lower incisors a mesial and intrusive force (4).

Figure 11: Jasper Jumper device

Although the Jasper Jumper has no significant effect produced on the mandible it has a “headgear” effect, meaning it inhibits the anterior displacement of the upper jaw and thus significantly reduces maxillary protrusion, the results have proven to remain stable in the long term. There are noteworthy and important dentoalveolar changes at the level of both jaws: dentoalveolar retrusion and extrusion of the maxillary incisors, protrusion, and intrusion of the mandibular incisors, distal tipping of the upper molars, mesial tipping of the inferior molars, decreased overjet and an amelioration of the molar relationship.

In the post-treatment period **Foncatti *et al***.’s study observed considerable anterior movement of the upper incisors, thus, increasing the affinity toward reversion of the anteroposterior correction. To counter-effect this problem the active retention time should be increased in the post-treatment period (41).

Authors such as **Kuçukkeles *et al*** have concluded that the correction of Class II by the Jasper Jumper device is obtained through 80% of dentoalveolar changes and 20% skeletal changes, and because of this, it can also be used in non-growing patients. However, if an anterior bite plane is used in conjunction with the appliance, **Bassarelli *et al*** have reported that correction would be provided skeletally at a percentage of 75 compared to 25 percent of dentoalveolar correction in growing patients (42).

1.2.4. FORSUS FATIGUE RESISTANT DEVICE

The Forsus Fatigue Resistant Device (FRD) [Figure 12] is a hybrid appliance meaning it is a combination of flexible and rigid ones. It is a modification of the original "Forsus" device developed by Vogt in 2001. It is a semi-rigid appliance with a telescoping system that integrates a super elastic nickel-titanium coil spring. It serves to replace conventional Class II elastics and applies continuous force 24 hours a day. It is a newer type of appliance that has the benefit of being easily assembled in the chair side and thus, requires no lab work and saves time (43). Treatment with the device tends to last for an average of 6 months.

Figure 12: Forsus Fatigue Resistant Device

In the same manner as the Jasper Jumper, the Forsus FRD works with existing braces by attaching itself to the first upper molars and to the mandibular arch wire, distal to the canine or first premolar bracket. As the coil compresses, constant antagonistic forces are transferred to the sites of attachment, a mesial force on the mandible and a distal force on the maxilla [see Figure 13]. There are also intrusive forces on the molars, these can help decrease the posterior vertical dimension and fix cases with posterior open bites.

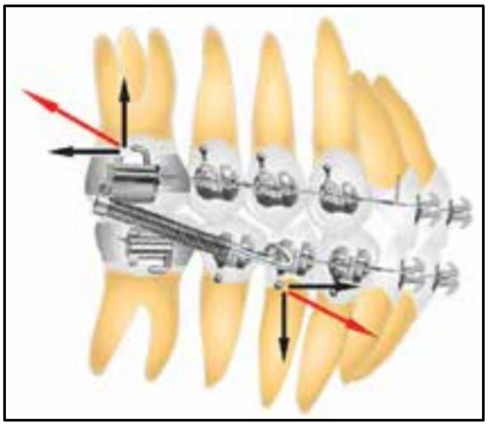

Figure 13: Force vectors associated with the Forsus FRD

The Forsus can control the overbite, modify dental eruption and lead to a good soft tissue profile of the face. A literature study on the appliance has revealed that active treatment with the Forsus induced mainly dentoalveolar changes with considerable mesial movement of the mandibular dentition (3.7mm of molar correction) (43). The greatest skeletal effect is the restraint of maxillary growth, however, when compared to the Jasper Jumper, **Buyuk *et al***'s study demonstrated that the Jasper Jumper had superior restrictive control on the maxilla than the Forsus FRD. Nevertheless, both appliances result in similar outcomes, in regards to the soft tissue profile, it improves with the retraction of the upper lip and protraction of the lower lip. Many studies in the literature have obtained comparable results and have reported that both the Jasper Jumper and Forsus FRD cannot act skeletally on the mandible even though the Class II correction show skeletal improvement in patients using them, this is probably due to the action they have on the maxilla (42).

Its treatment results are also comparable to those of Class II elastics as they both obtain more or less the same outcomes, but a greater lower mesial movement is observable in the Forsus FRD group.

The various benefits of this appliance are that it is aesthetic and easy to use, it requires no adjustment during treatment, it works consistently, is resistant to fatigue as its name suggests it, it is comfortable due to its minimal size and it allows for more accurate predictions in treatment time and outcome thanks to its chronic and consistent forces. It possesses a wide range of clinical possibilities for its use, for example, it can be used to handle unilateral class II division 1 cases with a skeletal component, and here differential forces will be applied on each of the rods.

2. CLASS II ELASTICS

Class II elastics are accessories of force that can be classed as active elements over a fixed device. They are used for inter-maxillary correction and the forces they emit (200 to 400g) are considered intermittent since elastics can be fixed and detached by patients. They were founded in the 1890s by Calvin Case and Henry Baker for the orthodontic correction of class II malocclusions.

Figure 14: Class II Straight on U3 – L6

Several patterns for the adjustment of class II exist, the most common one connects the maxillary canine [U3] with the mandibular first molar [L6] on the same side [Figure 14]. They have expectable effects on the maxillary teeth: (1) they pull back the entire upper arch, (2) extrude the upper anterior segment, and (3) rotate the plane of occlusion clockwise. On the other hand, the reciprocal elastic forces are able to protract the buccal segments, extrude the mandibular molars and intrude the lower incisors to flatten and thus, correct the curve of Spee (44). The combination of anteroposterior and vertical effects corrects the Class II buccal relationship to a Class I. Habitually, skeletal modifications are induced by devices that apply heavier forces over long periods of time. Yet, when comparing long-term results of Class II elastics with functional appliances such as the Herbst or Forsus FRD, changes were observed to be similar [*see Table 4*] (45). **Petrovic *et al*** showed that in certain cases they were capable of augmenting the amount and rate of condylar cartilage proliferation, this was manifested morphologically by the lengthening and clockwise rotation of the mandible in growing patients. However, due to the seniority of their article and the lack of recent papers demonstrating the skeletal effects, this notion will be considered as a hypothesis that needs further proof. It can be asserted that the correction of the malocclusion mainly results from dentoalveolar changes, this is supported by **Janson *et al***'s (45) systematic review on the effects of Class II elastics. Other important functions achievable with Class II elastics are the opening of the bite, correction of the midline, and labial buccal tipping of the lower incisors (46).

Diagnosis
Review of 11 articles on Class II elastics to determine the most frequent uses & main effects of Cl II elastics in Cl II malocclusion
Results at the end of treatment
- Restraint of forward maxillary growth - Forward growth of mandible - 18.9% of skeletal change & 71.1% of dental change - Mainly dentoalveolar changes: lingual tipping, labial tipping, extrusion of maxillary incisors, mesialization & extrusion of mandibular molars. - Findings show that effects are similar on a long term basis to those produced by functional appliances

Table 4: Results of Janson et al.'s study on Class II elastics (2013)

The most well-known side-effects of inter-arch elastics are:

- The increase in posterior vertical dimension associated with extrusion of the mandibular molars. Because of this, they will be contraindicated in long face patients but indicated in deep bite cases.
- Unaesthetic upper anterior gingival exposure also known as gummy smile. This appears due to the lingual and distal tipping of maxillary incisors. This normally can be controlled by choosing a high torque bracket for the upper incisors and low torque ones for the lower incisors.

Other authors have noted the possibility of root resorption, however, **Janson *et al.***'s study demonstrated that this was improbable since the forces produced by the elastics were distributed evenly among the maxillary and mandibular teeth (47). No study has truly been able to identify any significant secondary effects, thus, Class II elastics can be used alone or in association with other accessories to correct the malocclusion without the patient nor the dentist having to worry about significant side effects.

The main difference between a fixed functional appliance and elastics would be that the latter acts only when placed in position while the other acts continuously and thus, in the short term obtains results faster (45). For effective treatment of Class II with elastics it is vital to have excellent patient cooperation, their full-time usage is recommended and their removal is only indicated during meal times. Generally, the correction of the discrepancy takes 8 to 9 months.

3. CLEAR ALIGNERS: INVISALIGN®

Clear aligners have been used as early as the 1940s to correct small tooth movements but their usage was minimal due to the consequential time it took to fabricate them. Today one of the most famous systems of aligners is "Invisalign", which was developed in 1997 by ***Zia Chishti***, a Stanford student. A few years ago, Invisalign could only correct simple malocclusions. Nowadays, thanks to the innovation of treatment techniques, new materials, and three-dimensional software, it is possible to treat almost all types of malocclusions with Invisalign.

Each aligner is custom-made with an elastic thermoplastic material that is thin but strong enough to cause tooth movement. Some advantages that they have over fixed appliances would be shorter treatment duration, it generally lasts 12 to 18 months depending on the severity of the case. With fixed appliances, there are steps to follow and the adaptation with different wire types and thickness tends to elongate the therapy time. The complete coverage of the occlusal surfaces helps eliminate or reduce the canting of the occlusal plane that can occur with brackets and elastics if there's a lack of anchorage (48). The patient's comfort isn't compromised by any metal appliance, wire, or bracket. The aligner can easily be cleaned and its removability allows the teeth to be cleaned and flossed without hindrance. Finally, the orthodontist will have fewer unexpected visits from patients, however, for the patient the requirement to often change aligners means they will have to dedicate a great amount of time on trips to the orthodontist. Generally, aligners need to be changed every 2 weeks and must be worn for 22 hours a day to truly be effective. Tooth movement accuracy with Invisalign treatment is at 41%, on the other hand, anteroposterior movement through upper molar distalization is very predictable with 88% of accuracy (49).

In the treatment of Class II patients with Invisalign it is necessary to combine it with elastics to have anchorage, rubber bands should be worn all night and for a minimum of 3 hours during the day. The wear of elastics permits more complex movements, for example, the closure of spaces after extractions. To maintain the elastics the aligner must have a small notch. When a greater movement is desired it is then preferable to add an orthodontic button that is directly glued onto the tooth since the vertical force of the bands can easily dislodge the aligners [Figure 15] (50).

Figure 15: Orthodontic button glued onto the first molar and notch on buccal aspect of the aligner at the level of the upper canine

In 2017, Align Technology announced the innovation of a new type of clear aligner to be used solely for the correction of skeletal Class II, Invisalign with Mandibular Advancement Feature (IMAF) [Figure 16]. It is designed to reproduce the action of both elastics and functional appliances through *precision wings* placed between the 2nd premolars and 1st molars of the upper and lower aligners. These interlock and hold the mandible in a forward position during occlusion and simultaneously straighten the teeth. The progress is gradual and every two months the mandibular advance is increased by 2mm. Align Tech claims that IMAF is a simpler, more proficient, and patient-friendly treatment option than functional appliances and has the advantage of not requiring the use of elastics like previous clear aligners. By avoiding the need of using elastics the orthodontist needs to rely less on patient conformity, this is because patients generally avoid wearing their elastics during the daytime for esthetic reasons. However this statement is controversial since for a full Class II correction in a patient with more than 6mm of discrepancy elastics will be recommended. The company also states that therapy with this aligner can be indicated in growing patients with mild to severe mandibular retrusion, in late mixed dentition phase, or permanent dentition from ages of 10 to 15.

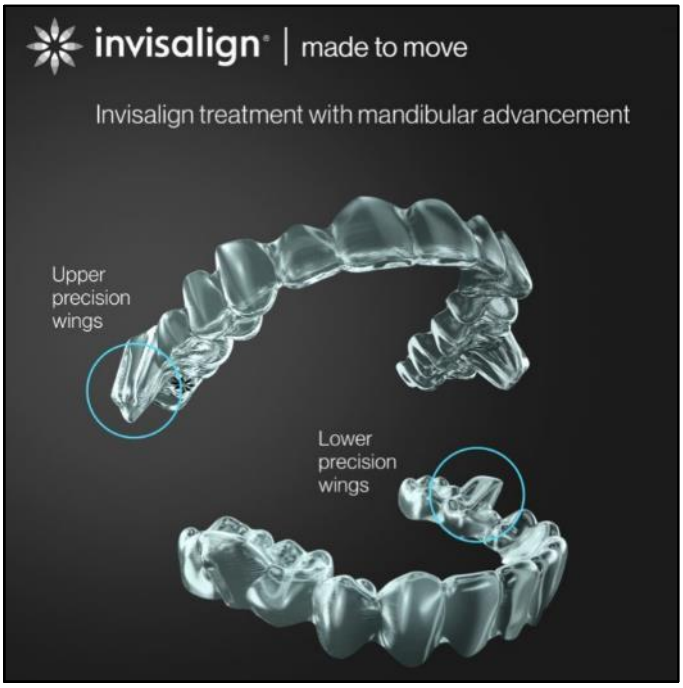

Figure 16: Invisalign with Mandibular Advancement advert

Diagnosis
Comparison of 3 groups (Twin Block, Invisalign MA, Control) comprised of 32 subjects per group. Phase 2 treatment for TB was with full fixed edgewise appliance and for Invisalign MA with Invisalign.
Results
▪ Treatment length longer in TB group. ▪ Mandibular length: it increased 4mm more in TB group than in the IMAF group. ▪ Overjet reduction: 4.5mm in TB group & 2.55m in IMAF group. ▪ Lower incisor extrusion was greater in TB group (1.43mm difference). ▪ 1st molar mesialization was greater in TB group. ▪ Neither Invisalign or fixed edgewise appliances as a treatment modality in the 2nd phase of treatment offered any significant dental or skeletal outcomes over the other.

Table 5: Most significant results obtained from the study by Blackham comparing Class II malocclusion treatments with Twin Block and Invisalign Mandibular Advancement

Blackham's study compared the treatment effects of IMAF and Twin Block appliance [Table 5]. The Twin Block group was treated for longer and obtained greater results in mandibular length (TB: 8.81mm, IMAF: 4.81mm), these results further assert its superiority compared to other treatment modalities. It was demonstrated that the small cumulative changes in dental and skeletal variables from the IMAF therapy, individually were not statistically significant, however when combined they amounted to a clinically significant correction in dental malocclusion and improvement in the skeletal relationship (51). The study stated that a major contraindication for IMAF treatment is the presence of supernumerary teeth buccal to the premolars since the location of the wings of the aligners over that area can place unwanted pressure.

Due to the novelty of the appliance there is still no scientific evidence about its results and further research is needed to assess the long-term effects of this system and confirm its benefits (52).

Sabouni *et al.*'s article elaborates on three therapeutic approaches with aligners that depend on the growth stage of the patient: (i) Early treatment before patient reaches Cervical Stage 3 (CS3); (ii) treatment in optimum phase with CS3 - CS4; (iii) Late treatment after CS4 (53).

Early treatment consists of equilibrating the orofacial functions to normalize the growth of the patient and to allow him to obtain a harmonious development. Class II patients with mandibular retrusion tend to present a narrow maxillary arch and thus the first step of rehabilitation would be to treat it. Therapy generally lasts 12 months and focuses on correcting excessive overjet to decrease the trauma risk, regulate the transversal dimension of the jaws, and improve the relationship of the vertical and sagittal aspects [Figure 17].

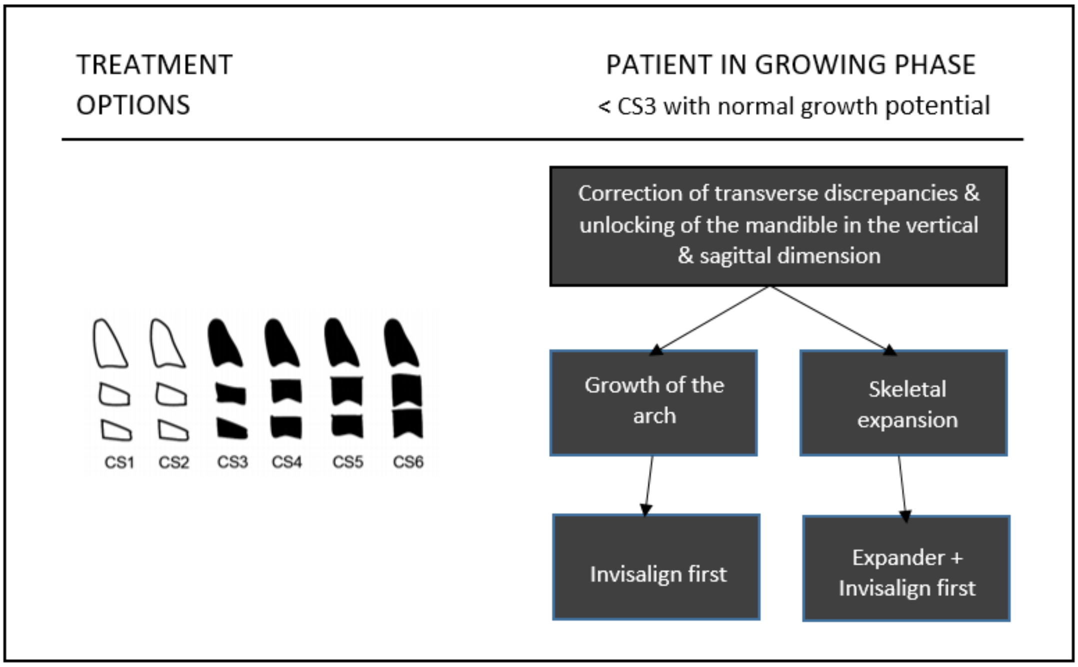

Figure 17: Decision tree before CS2

Treatment in the optimum phase corresponds to the growth spurt of the patient. The therapy protocol will depend on the importance of the malocclusion in the sagittal dimension [Figure 18]. If the sagittal malocclusion is inferior to 2mm, rubber bands of heavy force (6 Oz) will be used to stimulate mandibular growth. If it is between 2 and 5mm, the mandibular advancement (MA) system will be elected. If it is greater than 5mm, the first phase will consist in using the MA system and then distalize the upper molars with serial aligners.

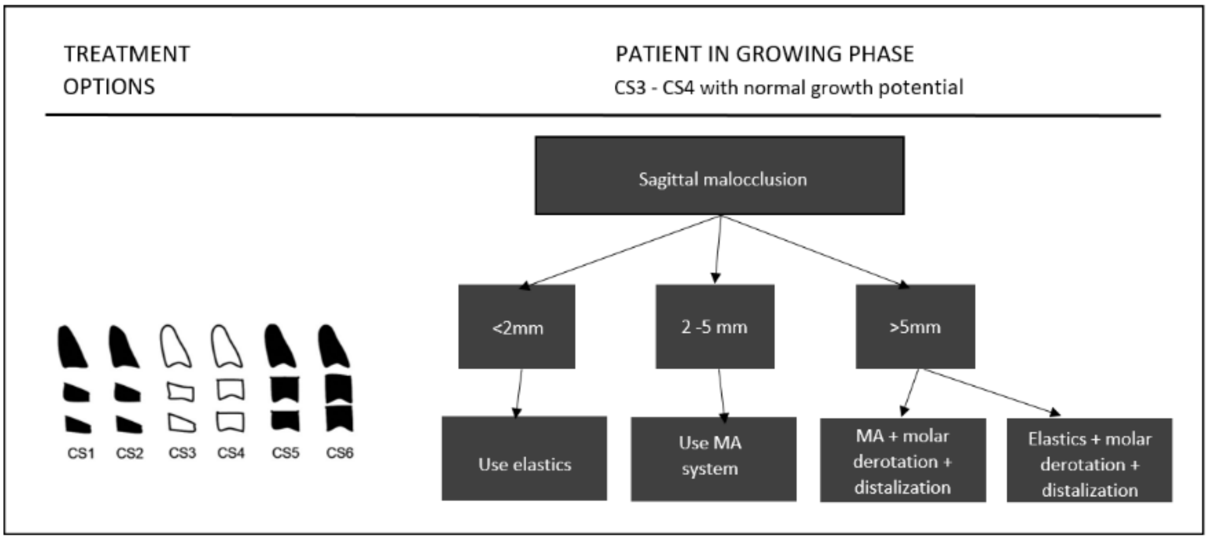

Figure 18: Decision tree for patient between CS3 and CS4

Sagittal malocclusion is also important for the decision making in late treatment. There are three different clinical approaches depending on the discrepancy [Figure 19]:

- If it is inferior to 3mm, a correction will be done through distalization with sequential aligners.
- If it is between 3 and 5mm, depending on the clinical conditions, the orthodontist will perform a progressive distalization associated or not with interproximal reduction, a derotation of the molars, or use inter-arch elastics.
- On the other hand, if it is superior to 5mm, extraction or surgical protocol will be planned. This will depend on the complexity of the case and the patient's choice.

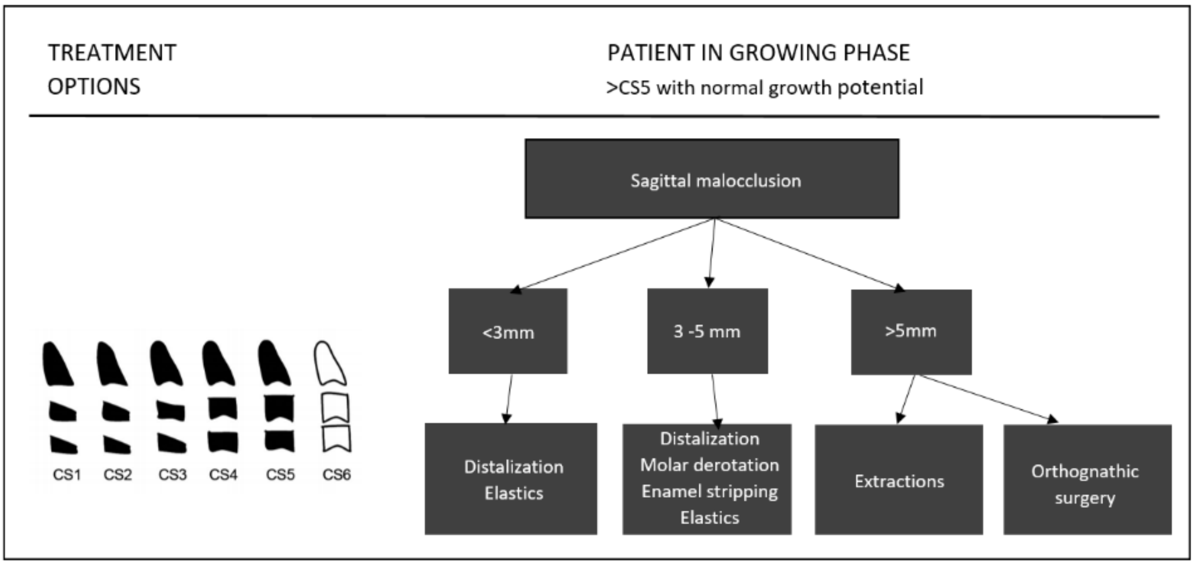

Figure 19: Decision tree after CS5

4. TEMPORARY ANCHORAGE DEVICES: MINISCREWS & MINI-IMPLANTS

Temporary anchorage devices (TADs) are miniscrews placed into the alveolar bone of the jaws that have for goal to maximize wanted tooth movements and minimize undesired ones. They remain in place as long as orthodontic therapy lasts and are removed once it is over. It can be said that teeth are moved against a rigid fixation which allows more precision in regards to their movement. The notion of temporary skeletal anchorage was first brought up in 1945 by Gainsforth and Higley who tried to use screws and stainless steel wires in dogs as appliances for traction (54).

Skeletal anchorage systems are used in Class II children to retract the maxillary arch to correct the sagittal discrepancy and relieve crowding. They can also eliminate or prevent the unwanted effects caused by some fixed functional appliances and Class II elastics, and accelerate orthodontic treatment. The secondary effects of fixed functional appliances are due to dentoalveolar changes, the profile isn't as decent as if we were to purely move the mandible forward. Dental changes cause the long axis of the upper and lower incisors to worsen: the upper incisors retrocline, the lower ones procline, and the occlusal plane tilts downward anteriorly. The teeth are then positioned in an unstable way, of course, this doesn't apply for all cases but is common in patients with severe Class IIs or with additional encumbering factors such as excessive crowding. Due to the latter statement it may be important to consider using a skeletal anchorage device such as miniscrews. The headgear could be an option but in today's modern period its use is socially unacceptable due to its poor esthetics, and since it requires patient consent its consideration is made more difficult. Also Class II skeletal cases are generally due to a problem with the mandible and not the maxilla, thus we would be treating the wrong jaw.

Other benefits of TADs are the elimination of the need to use teeth as anchors, heavy forces on anchor teeth can cause them to move, and thus avoiding this is important to have a stabilized arch. Their use is intended to begin after the eruption of the permanent dentition and is most commonly indicated for mass retraction, molar distalization, post-extraction retraction, and as we said earlier, as an accessory to fixed functional appliances for better results and long-term stability (55). Their use is indicated for palatal expansion, extrusion or intrusion of teeth, protraction of teeth, and uprighting of molars. However, it is important to state that the success rate of miniscrews is lesser and less predictable in growing patients since they possess less mature alveolar bone, fewer steady insertion sites, and have an active bone metabolism. Due to this, their use isn't recommended during deciduous or early mixed dentition. Thus, a contraindication would be insufficient cortical bone thickness (<1mm) since it leads to inadequate primary stability and increased vulnerability to stresses that can cause bone resorption in the region where the screw is placed. Other contraindications include immunodeficiency, bleeding pathologies, pathological bone quality, problematic healing, and poor oral hygiene since it increases the risk of peri-implantitis (56).

There are different sizes of bone screws for diverse sites of placement. Smaller screws (6-11mm in length and 1.3-2mm in diameter) are positioned in between the roots of teeth (intra-radicular), while bigger screws (10-14mm in length and 2mm minimum in diameter) are placed further away from the roots (extra-radicular). In the maxilla, the insertion location is in the infra-zygomatic crest, and for the mandible in the buccal shelf region. The infra-zygomatic crest is situated higher and lateral to the 1st and 2nd molar region [Figure 20], there is a debate on the exact placement point, ***Ghosh***'s article on *Orthodontic Bone Screws* demonstrates the possibility of two sites, an anterior one close to the mesial-buccal root of the 1st molar (Author Liou), and a posterior site in the 1st and 2nd molar region (Author Lin). For the mandible, the buccal shelf area is located lower and lateral to the 2nd molar zone [Figure 21]. Ideally, the screw is placed at the vestibular area of the distal-buccal cusp of the 2nd molar since bone depth is greater there (57), (58).

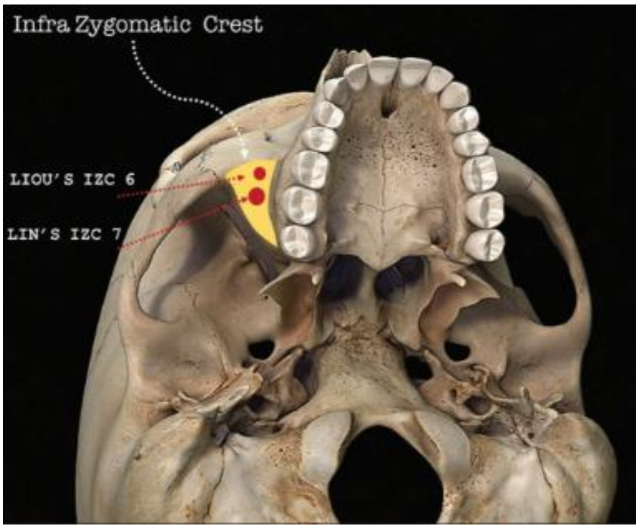

Figure 20: Sites for placement of bone screws in the infra-zygomatic crest

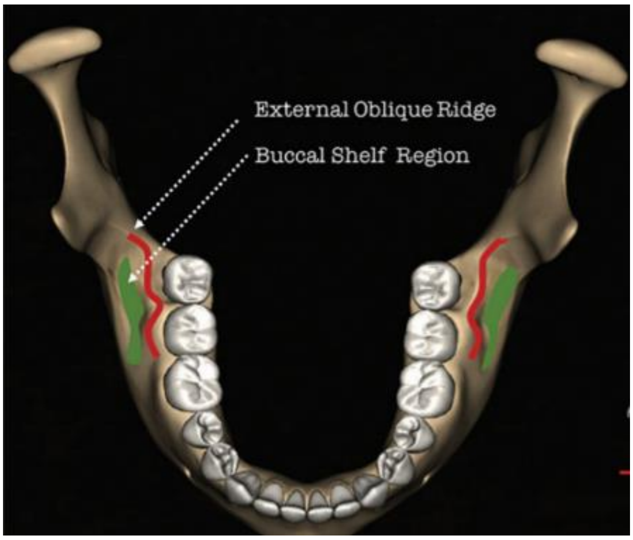

Figure 21: Localization of the buccal shelf region of the mandible

One positive feature of the use of bone screws is that it almost always requires no pre-drilling nor raising of the flap (except in mandibular cases where bone density is too thick). It can be immediately loaded after its placement and supports up to 300-350g per screw. When compared to mini-implants, the success rate and stability of mini-screws are far more superior, this is mainly due to their superior size and location.

CONCLUSION

To conclude, this paper has answered the previously set objectives, the answers being:

1. The treatment options for the correction of skeletal Class II in growing patients are the single-use or combination of the following: removable functional appliances (Activator, Bionator, Frankel, Twin Block appliances), fixed functional appliances (Herbst, MARA, Jasper Jumper, Forsus Fatigue Resistant appliances), Class II elastics with full arch brackets, and clear aligners with Class II elastics or built-in mandibular advancement, and/or temporary anchorage devices. The Twin Block and Herbst appliances are the most effective according to the literature. The Twin Block achieves greater sagittal skeletal changes by being able to stimulate up to 7 to 8mm of mandibular growth, and the Herbst thanks to its considerable restrictive effect on the maxilla can distalize the maxillary molars up to 4.5mm.
2. The indications and contraindications depend on the patient's skeletal age, phase of growth, compliance and preference, the severity of the case, length of therapy, cost, geographical zone, and orthodontist's knowledge and skills. The optimal treatment time is during or around the growth spurt.
3. In the long-term, most authors agree that orthopedic appliances lead to skeletal and dentoalveolar changes. All of the removable functional appliances have proven capable of inducing at least 3 to 4mm of mandibular growth and keeping these results stable. On the other hand, fixed functional appliances have a greater skeletal effect on the maxilla instead of the mandible and can restrain its growth considerably except for the MARA. Almost all orthopedic devices result in the mesialization of the

mandibular arch (mesialization and extrusion of molars; protrusion and intrusion of incisors), and distalization of the maxillary arch (distalization and intrusion of molars; retrusion and extrusion of incisors), each in different proportions. The Forsus Fatigue Resistant Device obtains the greatest results in regards to the proclination of lower incisors. In the category of fixed orthopedic devices, Herbst followed by the MARA are the ones with the greatest probability of achieving optimal results.

It can be established that Class II elastics are useful in the correction of this type of malocclusion and share similarities with fixed functional appliances in terms of the modifications they engender in the long-term: about 20% of skeletal changes and 80% of dental changes.

In regards to clear aligners, they are effective for the alignment or levelling of the patient's arches but often require auxiliaries to achieve greater predictability of movement and in particular elastics for Class II correction. The innovation of clear aligners directed for mandibular retrognathism therapy could be a valid option in the future, however, the level of data from these studies is not sufficient enough to obtain strong evidence-based conclusions.

Skeletal anchors also make it possible to eliminate some of the harmful effects of conventional devices by limiting certain undesirable dentoalveolar effects such as the protrusion of the lower incisors and can be used to retract the maxilla. Detailed long-term effects of TADs in the treatment of Class II could not be properly assessed because of the lack of number of trials comparing treatments with and without TADs.

RESPONSIBILITY:

This thesis meets the criteria of social sustainability since it focuses on the possible therapies that can improve the oral health, self-esteem, esthetics, and functional problems of a patient suffering from the effects of a skeletal class II. It offers several solutions to improve the quality of life of these patients.

It also applies to the economic sustainability category since it proposes early treatment options that may correct or at least improve and prevent progressive permanent soft tissue or bony changes related to Class II malocclusion. By preventing the problem from becoming too severe, the need for complex, more lengthy and costly treatments can be avoided later on.

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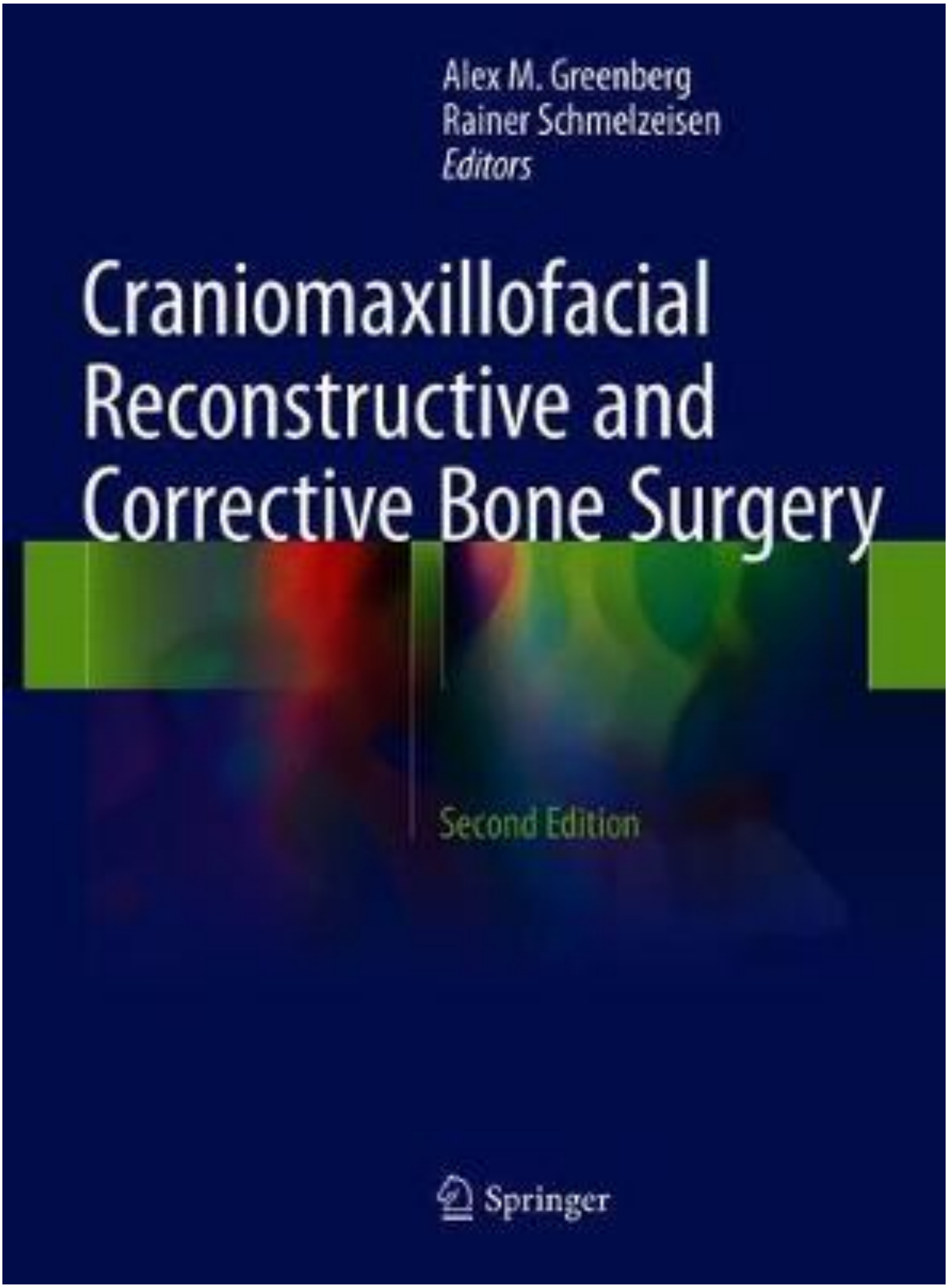
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Chapter 20

Advances in Management of Class II Malocclusions

Azita Tehranchi, Hossein Behnia,
Farnaz Younessian and Sahar Hadadpour

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/63348

Abstract

Although mandibular advancement by bilateral sagittal split osteotomy seems to be a good mandibular treatment option to treat skeletal class II malocclusion, it is less stable than setback; relapse depends on a wide range of patient-centered and surgeon-centered factors relating to the skill and experience of the surgeon, proper seating of the condyles, the exact amount of mandibular advancement, the tension of the muscles and soft tissues, the mandibular plane angle, and the patient's age. In fact, patients with low and high mandibular plane angles have increased vertical and horizontal relapses, respectively. Nonsurgical management of class II malocclusion may be an option by which to effectively manage such cases. The present chapter discusses different treatment modalities for clinical management of class II malocclusion in growing and non-growing patients.

Keywords: class II malocclusion, diagnosis, treatment, management, advances

1. Introduction

Class II malocclusion is among the most common developmental anomalies with a prevalence ranging from 15 to 30% in most populations [1, 2]. This malocclusion is likely to produce significant negative esthetic, psychological, and social effects [3–6]. This dentofacial anomaly can be divided into two different categories based on the involved arch to maxillary excess or mandibular deficiency [7, 8]. The resulting anomaly may demonstrate various severities of class II malocclusion in different ages, which dictates the preferred approach to clinical management.

Research Article

iMedPub Journals
http://www.imedpub.com

Journal of Orthodontics & Endodontics
ISSN 2469-2980

2016
Vol. 2 No. 4: 17

DOI: 10.21767/2469-2980.100034

Studying the Prevalence and Etiology of Class II Subdivision Malocclusion Utilizing Cone-Beam Computed Tomography

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Citation: Anderson WM, Marsh CM, Kessel NC, et al. Studying the Prevalence and Etiology of Class II Subdivision Malocclusion Utilizing Cone-Beam Computed Tomography. J Orthod Endod. 2016, 2:4.

Abstract

Objective: The purpose of this study was to investigate the prevalence of subdivision malocclusions in Class II/1 and Class II/2 patients and to see if the II/2 group had greater skeletal asymmetry.

Materials and methods: From a sample of over 1500 records, 256 Class II malocclusions met inclusion criteria. Of these, 214 were Class II/1 and 42 were Class II/2. Seven landmarks identified on CBCT scans were used to make 8 bilateral linear measurements. Right and left side differences were calculated for each subject, and median values were compared. Linear measurements from the Class I side of the subdivision malocclusion to the Class II side were compared.

Results: 22.9% of II/1 subjects had a subdivision malocclusion versus 50% of the II/2. Significant side-to-side differences existed between II/1 and II/2 subjects in two of eight measures. There were greater differences in the II/2 group between the Class I side of subjects to the Class II side than in the II/1 group.

Conclusion: All mandibular variables indicated greater degrees of mandibular asymmetry in the II/2 group; only Co-Po proved statistically significant.

Keywords: Mandibular asymmetry; Cone-Beam Computed Tomography (CBCT); Malocclusions

Received: July 15, 2016; **Accepted:** September 24, 2016; **Published:** September 30, 2016

Introduction

The Class II malocclusion is broadly defined as a distal relationship of the mandibular teeth relative to the maxillary teeth. Angle [1] recognized a subset of the Class II malocclusion, the Class II Division 2 (II/2) type, which exhibited a distinct triad of features. They include: Deep bite, retroclined maxillary incisors and a posteriorly positioned mandibular dental arch. Characteristics of the II/2 malocclusion are well-documented. They can be summarized as follows: skeletal components include a hypo-divergent pattern, decreased lower face height, low mandibular plane angle, decreased gonial angle, and commonly, adequate mandibular body length and width in comparison to the Class II Division 1 (II/1) type. Dental components include retroclination of the maxillary central incisors, minimal overjet and deep bite [2-4].

Angle characterized the Class II/1 malocclusion as having a narrowing of the maxillary arch with protrusive incisors accompanied by abnormal function of the lips and some form of nasal obstruction and mouth breathing. The Class II/2 malocclusion is characterized by less narrowing of the maxillary arch, and lingual inclination of the maxillary incisors. A malocclusion is further classified as a subdivision when the malocclusion exists on one side of the arches but is normal on the other. The offending side determines the namesake of the subdivision [1].

Although the Angle classification system has shortcomings it remains the predominant classification system to describe the anteroposterior occlusal relationship. Most clinicians oversimplify the Class II/2 definition by focusing only on

CHAPTER 6

Recognizing and correcting Class II malocclusions

SECTION I: The development, phenotypic characteristics, and etiology of Class II malocclusion

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6.1 Introduction

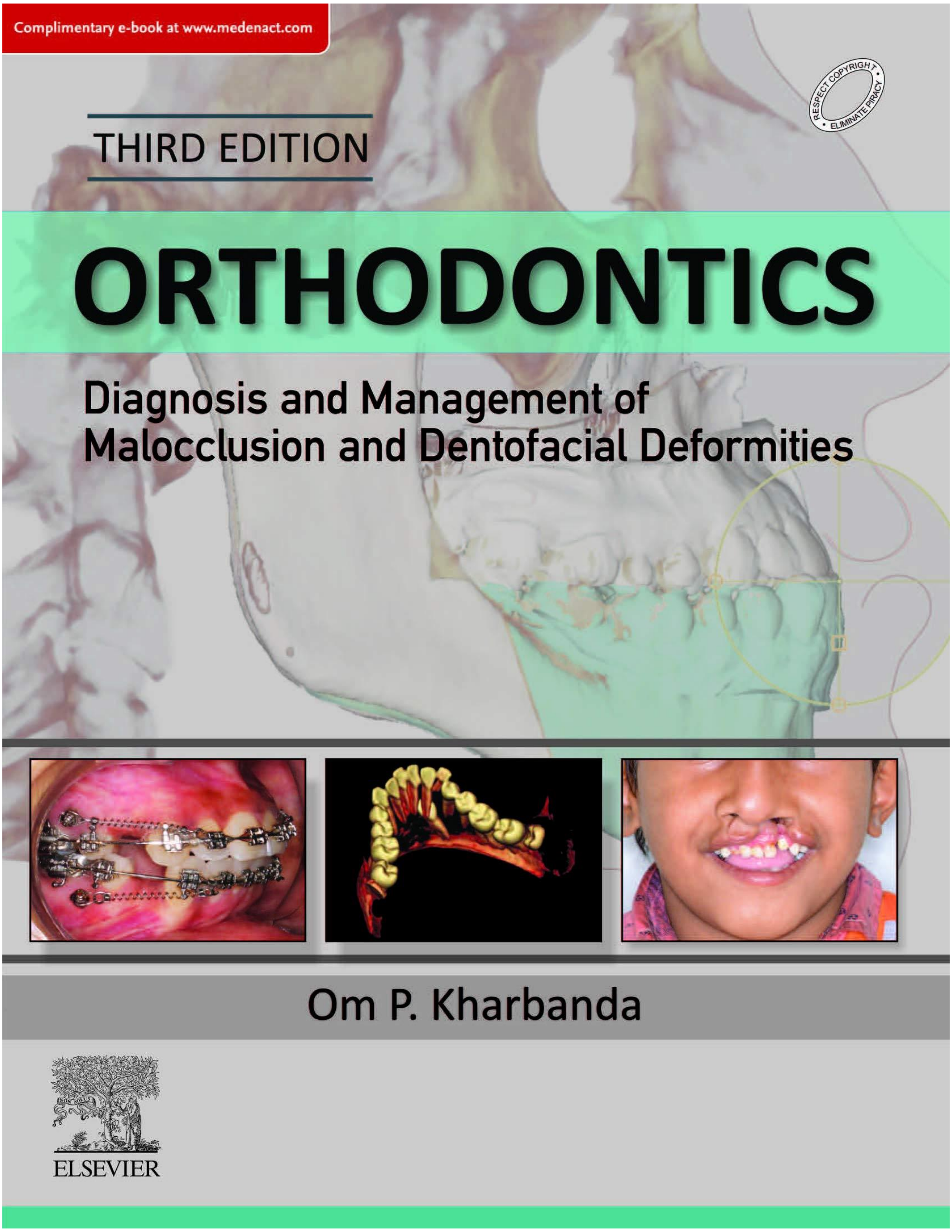
It is important to distinguish between the various types of Class II malocclusions, in order to understand the growth changes that occur. The most important distinction is between Class II, division 1 and Class II, division 2 (Figure 6.1). Angle distinguished between the two by noting that Class II division 2 subjects have ". . . distal occlusion of the teeth in both lateral halves of the lower dentition, indicated by the mesio-distal relations of the first permanent molars, but with retrusion instead of protrusion of the upper incisors." [1]. From a skeletal perspective, Ricketts characterized Class II division 2 subjects as having "brachyfacial patterns with resulting strong musculature. The lower facial height and mandibular arc are below the normal range, therefore the teeth are deep in the basal bone" [2].

To understand a patient's growth potential, the traditional anteroposterior (AP) categories that have been used to classify Class II patients are insufficient. Both the vertical and AP skeletal relationships must be considered. While subjects with Class II division 1 malocclusion are usually retrognathic, their vertical characteristics are, on average, similar to those of Class Is. From a treatment view, it is vitally important to distinguish between the Class II division 1 subjects who are hypodivergent, and those who are hyperdivergent (Figure 6.2). Subjects with Class II, division 2 malocclusion are usually orthognathic and more hypodivergent even than Class Is.

Class IIs typically present with functional deficits (Figure 6.3). Their masticatory performance (i.e. ability to break down foods) has been reported to be only 60% of normal [3]. Chewed particle sizes of untreated Class IIs are approximately 15% larger than those of subjects with normal occlusion [4]. Their inability to break down foods has been directly related to the decreased areas of interdental contact and near contact associated with Class II malocclusion [5]. Reduced areas of contact and near contact are important because they are also related to reduced bite forces and changes in jaw kinematic patterns [6]. This explains why Class IIs apply less energy during mastication than Class Is [7], and why Class IIs often experience problems chewing foods [4]. The functional deficiencies are most pronounced in hyperdivergent Class IIs, who have smaller masticatory muscles and weaker bite forces than hypodivergent Class IIs [8–10].

Class IIs also require treatment in order to correct their aesthetic concerns. The convex profiles and retrusive chins that characterize Class IIs are among the least favored among dental professionals [11]. In fact, excessively convex profiles have been consistently shown to be aesthetically less pleasing than straight profiles [12,13]. Both dental professionals and lay people believe that changing a patient's profile to be straighter,

Recognizing and Correcting Developing Malocclusions: A Problem-oriented Approach to Orthodontics, First Edition.
Edited by Eustáquio Araújo and Peter H. Buschang.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Review

J Clin Med Res. 2014;6(6):399-408

Skeletal Malocclusion: A Developmental Disorder With a Life-Long Morbidity

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Abstract

The likelihood of birth defects in orofacial tissues is high due to the structural and developmental complexity of the face and the susceptibility to intrinsic and extrinsic perturbations. Skeletal malocclusion is caused by the distortion of the proper mandibular and/or maxillary growth during fetal development. Patients with skeletal malocclusion may suffer from dental deformities, bruxism, teeth crowding, trismus, mastication difficulties, breathing obstruction and digestion disturbance if the problem is left untreated. In this review, we focused on skeletal malocclusion that affects 27.9% of the US population with different severity levels. We summarized the prevalence of class I, II and III of malocclusion in different ethnic groups and discussed the most frequent medical disorders associated with skeletal malocclusion. Dental anomalies that lead to malocclusion such as tooth agenesis, crowding, missing teeth and abnormal tooth size are not addressed in this review. We propose a modified version of malocclusion classification for research purposes to exhibit a clear distinction between skeletal vs. dental malocclusion in comparison to Angle's classification. In addition, we performed a cross-sectional analysis on orthodontic (malocclusion) data through the BigMouth Dental Data Repository to calculate potential association between malocclusion with other medical conditions. In conclusion, this review emphasizes the need to identify genetic and environmental factors that cause or contribute risk to skeletal malocclusion and the possible association with other medical conditions to improve assessment, prognosis and therapeutic approaches.

Manuscript accepted for publication July 7, 2014

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doi: http://dx.doi.org/10.14740/jocmr1905w

Keyword: Skeletal malocclusion; Micrognathia; Retrognathia; Prognathia; Late-onset diseases

Introduction

Disorders of the head and face are very common birth defects in all racial populations, and can appear as isolated phenotype or as part of a syndrome. The prevalence of craniofacial anomalies varies among different ethnicities based on genetic background, geography, socio-economical status and environmental factors. Because of the structural complexity of the craniofacial region, variations in genetic and environmental factors may have a profound effect on development, and could lead to congenital birth defects. Cleft lip and palate is one of the most common birth defects with the highest prevalence of 1 in 500 live births in Asian population [1]. Skeletal malocclusion is another common birth defect that occurs due to the distortion of the maxillary and/or mandibular development that will have a huge impact on the positioning, alignment and health of the primary and permanent teeth. Micrognathia, a small mandible or maxilla, is the most common cause of skeletal malocclusion with a prevalence of 1/1,500 live births [2], and is frequently associated with other skeletal abnormalities, cleft palate and tongue deformaties (glossoptosis). Micrognathia occurs as an isolated form or as part of 468 syndromic disorders according to Online Mendelian Inheritance in Man (OMIM) database. It has been reported that all patients with micrognathia are also affected with retrognathia (abnormal posterior positioning of the mandible or maxilla relative to the facial structure) due to the small size and growth pattern [3]. On the other hand, macrognathia is characterized by the overgrowth of the mandible or maxilla above the normal values where the manifestation becomes more prominent at the peak of jaw growth around the age of 12.2 years in females and 14 years in males [4].

Sonographic detection used for prenatal diagnosis of isolated micrognathia (manifestation of class II malocclusion) is normally disparate from the actual natal outcome in the large majority of cases. More than 90% of fetuses diagnosed with isolated micrognathia by 3D ultrasound repre-

Treatment of skeletal class II division 1 malocclusion with mandibular deficiency using myofunctional appliances in growing individuals

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Access this article online

Quick Response Code:	Website: www.jisppd.com
	DOI: 10.4103/0970-4388.95584

Abstract

Class II division 1 malocclusion is the most common malocclusion seen in day-to-day practice. The majority of the patients with class II division 1 malocclusions have the presence of underlying skeletal discrepancy between maxilla and mandible. The treatment of skeletal class II division 1 depends upon the age of the patient, growth potential, severity of malocclusion, and compliance of patient with treatment. Myofunctional appliance can be successfully used to treat growing patients with class II division 1 malocclusion having retrusive mandible. This article presents a discussion on treatment of class II division 1 due to mandibular deficiency with growth modification approach using myofunctional appliances and a series of three case reports of treatment of skeletal class II division 1 malocclusion using myofunctional appliance followed by fixed mechanotherapy.

Key words

Class II malocclusion, growth modification, myofunctional appliance

Introduction

Among the various types of malocclusion found in human population, class II division 1 is one of the most common. According to Dr. James McNamara,[1] mandibular retrusion is the most common feature of class II division 1 malocclusion in growing children. Class II malocclusion is found in 15% of population in the world. Class II division 1 malocclusion is often complicated by the presence of underlying skeletal discrepancy between maxilla and mandible. It can be due to protrusive maxilla, retrusive mandible, or a combination of both. The treatment of class II division 1 depends upon the age of the patient, growth potential, severity of malocclusion, and compliance of patient for treatment.[1,2] In growing individuals, growth modification procedures can be carried out to correct the skeletal class II malocclusion, during mixed or early permanent dentition before the cessation of active growth. In patients who are at the end of prepubertal growth spurt or who are uncooperative, fixed functional appliances like Herbst, Forsus-FRD or Jasper Jumper can be used. In patients with mild to moderate skeletal class II, where active growth is completed, it is not possible to undertake growth modification procedures. In such condition, underlying skeletal discrepancy can be camouflaged by orthodontic tooth movement with extraction or without extraction (depending upon the severity of malocclusion). In adult patients where the discrepancy is very severe, the best treatment approach is combined orthodontic and orthognathic surgery.[3-6]

Yin et al. Progress in Orthodontics (2019) 20:24
https://doi.org/10.1186/s40510-019-0280-2

Progress in Orthodontics

RESEARCH Open Access

Evaluating the treatment effectiveness and efficiency of Carriere Distalizer: a cephalometric and study model comparison of Class II appliances

Kaifeng Yin[1,2*†], Eugene Han[1†], Jing Guo[3], Toshihiko Yasumura[1,4], Dan Grauer[1] and Glenn Sameshima[1]

Abstract

Background: The purpose of this study was to evaluate the treatment effectiveness of Carriere Distalizer in comparison to Class II intermaxillary elastics and Forsus.

Methods: Three groups of patients treated with Class II intermaxillary elastics ($n = 18$), Carriere Distalizer ($n = 18$), and Forsus appliance ($n = 18$) were collected from three private orthodontic practices. Inclusion criteria were as follows: (1) 10–14 years old of start age with permanent dentition, (2) no history of previous orthodontic treatment, (3) complete pre- and post-treatment records, (4) dental Class II division 1 (end-to-end or more), (5) no pre-treatment transverse discrepancy, (6) non-extraction treatment plan, and (7) Class I post-treatment occlusal relationship. The data consisted of cephalometric and study model measurements from pre- and post-treatment records and treatment time. Two-tail Student *t* test was used to analyze the differences in cephalometric changes and dental corrections between Carriere Distalizer group and Class II elastics/Forsus group.

Results: All three groups of patients showed no differences in the age of treatment initiation, pre-treatment cephalometric measurements and discrepancy index (DI). The time of Class II correction for Carriere Distalizer was significantly shorter than that for Class II elastics; there was no difference in the length of Class II correction between Carriere Distalizer and Forsus groups. The amount of Class II correction (canine/molar relationship) was significantly lower for Carriere Distalizer when compared with Forsus appliance. Carriere Distalizer, similarly to Class II elastics, did not induce any statistically significant correction in skeletal component (ANB and Wits appraisal).

Conclusions: There is no clinically significant skeletal correction induced by Carriere Distalizer in growing patients. Carriere Distalizer can be applied to treatment of mild to moderate Class II dental malocclusion over 6 months on average, although the total treatment time may be prolonged due to various side effects. Overall, the Carriere Distalizer appears to be no more effective or efficient than alternatives in the treatment of Class II malocclusion.

Keywords: Class II malocclusion, Carriere Distalizer, Forsus, Class II elastics, Retrospective study

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ORIGINAL ARTICLE

Radiographic Assessment of Skeletal Maturation Stages for Orthodontic Patients: Hand-wrist Bones or Cervical Vertebrae?

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Background/Purpose: The skeletal maturation status of a growing patient can influence the selection of orthodontic treatment procedures. Either lateral cephalometric or hand-wrist radiography can be used to assess skeletal development. In this study, we examined the correlation between the maturation stages of cervical vertebrae and hand-wrist bones in Taiwanese individuals.

Methods: The study group consisted of 330 male and 379 female subjects ranging in age from 8 to 18 years. A total of 709 hand-wrist and 709 lateral cephalometric radiographs were analyzed. Hand-wrist maturation stages were assessed using National Taiwan University Hospital Skeletal Maturation Index (NTUH-SMI). Cervical vertebral maturation stages were determined by the latest Cervical Vertebral Maturation Stage (CVMS) Index. Spearman's rank correlation was used to correlate the respective maturation stages assessed from the hand-wrist bones and the cervical vertebrae.

Results: The values of Spearman's rank correlation were 0.910 for males and 0.937 for females, respectively. These data confirmed a strong and significant correlation between CVMS and NTUH-SMI systems ($p < 0.001$). After comparison of the mean ages of subjects in different stages of CVMS and NTU-SMI systems, we found that CVMS I corresponded to NTUH-SMI stages 1 and 2, CVMS II to NTUH-SMI stage 3, CVMS III to NTUH-SMI stage 4, CVMS IV to NTUH-SMI stage 5, CVMS V to NTUH-SMI stages 6, 7 and 8, and CVMS VI to NTUH-SMI stage 9.

Conclusion: Our results indicate that cervical vertebral maturation stages can be used to replace hand-wrist bone maturation stages for evaluation of skeletal maturity in Taiwanese individuals. [*J Formos Med Assoc* 2008;107(4):316–325]

Key Words: cervical vertebrae, hand-wrist radiography, lateral cephalometric radiography, skeletal maturation

In orthodontics and dentofacial orthopedics, the skeletal maturation status of a growing patient influences the selection and execution of treatment procedures. Favorable orthopedic effects for patients with mandibular retrognathism only occur when the treatment begins at his or her optimal maturation stage. Whereas, it is recommended that the best time for correction of mandibular prognathism is after the completion of mandibular growth.

Considerable variations in the development among individuals of the same chronological age have led to the concept of assessing biological or physiological maturity. Several biological indicators

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ELSEVIER

Received: November 13, 2007
Revised: December 7, 2007
Accepted: January 15, 2008

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The Cervical Vertebral Maturation (CVM) Method for the Assessment of Optimal Treatment Timing in Dentofacial Orthopedics

Tiziano Baccetti,*,† Lorenzo Franchi,*,† and James A. McNamara, Jr.†,‡,§

The present study introduces a further modified version of the Cervical Vertebral Maturation (CVM) method for the detection of the peak in mandibular growth, based on the analysis of the second through fourth cervical vertebrae in a single cephalogram. The morphology of the bodies of the second (C2 –odontoid process), third (C3), and fourth (C4) cervical vertebrae were analyzed in 6 consecutive cephalometric observations (T_1 through T_6) of 30 orthodontically untreated subjects. Observations for each subject consisted of two consecutive cephalograms comprising the interval of maximum mandibular growth (as assessed by means of the maximum increment in total mandibular length, Condylion –Gnathion: Co-Gn), together with two earlier consecutive cephalograms and two later consecutive cephalograms. The analysis consisted of both visual and cephalometric appraisals of morphological characteristics of the three cervical vertebrae. The construction of this new modified version of the CVM method was based on the results of both ANOVA for repeated measures with post hoc Scheffé's test ($P < 0.05$) and discriminant analysis. The new clinically improved CVM method is comprised of six maturational stages (cervical stage 1 through cervical stage 6, ie, CS1 through CS6). CS1 and CS2 are prepeak stages; the peak in mandibular growth occurs between CS3 and CS4. CS6 is recorded at least 2 years after the peak. The use of the CVM method enables the clinician to identify optimal timing for the treatment of a series of dentoskeletal disharmonies in all three planes of space.
Semin Orthod 11:119–129

In the organization, differentiation, development, and growth of any somatic structure, time plays a crucial role in determining the final morphological and dimensional result. In orthodontics and dentofacial orthopedics, it is becoming increasingly evident that the timing of the treatment onset may be as critical as the selection of the specific treatment protocol, as will be discussed below. By beginning a protocol at the individual patient's optimal maturational stage, the most favorable response with the least potential morbidity can be anticipated.

The issue of optimal timing for dentofacial orthopedics is linked intimately to the identification of periods of accelerated growth that can contribute significantly to the correction of skeletal imbalances in the individual patient. Cephalometric investigations on longitudinal samples have identified a pubertal spurt in mandibular growth that is characterized by wide individual variations in onset, duration, and rate.[1-6] Individual skeletal maturity can be assessed by means of several biologic indicators: increase in body height[1-3]; skeletal maturation of the hand and wrist[7-10]; dental development and eruption[8,11,12]; menarche or voice changes[9,13,14]; and cervical vertebral maturation.[15,16] The biologic indicators of skeletal maturity refer mainly to somatic changes at puberty, thus emphasizing the strict interactions between the development of the craniofacial region and the modifications in other body regions.

The reliability and efficiency of a biologic indicator of skeletal maturity can be evaluated with respect to several fundamental requisites.[17] An "ideal" biologic indicator of individual mandibular skeletal maturity should be characterized by at least five features.

1. Efficacy in detecting the peak in mandibular growth. The method should present with a definite stage or

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1073-8746/05/$-see front matter
doi:10.1053/j.sodo.2005.04.005

Skeletal maturation evaluation using cervical vertebrae

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Lateral cephalometric and left hand-wrist radiographs from the Bolton-Brush Growth Center at Case Western Reserve University were reviewed a posteriori to develop a cervical vertebrae maturation index (CVMI). By using the lateral profiles of the second, third and fourth cervical vertebrae, it was possible to develop a reliable ranking of patients according to the potential for future adolescent growth potential. (AM J ORTHOD DENTOFAC ORTHOP 1995;107:58-66.)

Sexual maturation characteristics, chronologic age, dental development, height, weight, and skeletal development are some of the more common means that have been used to identify stages of growth. Determination of maturation and subsequent evaluation of growth potential during preadolescence or adolescence is extremely important. With many orthodontic patients, pubertal growth needs to be factored into the diagnostic equation.

One important diagnostic tool currently used in determining whether the pubertal growth has started, is occurring, or has finished is the hand-wrist radiographic evaluation. Biologic age, skeletal age, bone age, and skeletal maturation are nearly synonymous terms used to describe the stages of maturation of a person. Because of individual variations on timing, duration and velocity of growth, skeletal age assessment is essential in formulating viable orthodontic treatment plans.

The primary objective of this study was to create a method of evaluating the skeletal maturation of the orthodontic patient with the cephalometric radiograph that is routinely taken with pretreatment records. Correlations were made between cervical vertebrae maturation and the skeletal maturation of the hand-wrist.

BACKGROUND

Skeletal maturation refers to the degree of development of ossification in bone. Size and maturation can vary independently of each other. Skeletal maturation is more closely related to sexual maturity than to stature.[1-5]

During growth, every bone goes through a series of changes that can be seen radiologically. The sequence of changes is relatively consistent for a given bone in every person. The timing of the changes varies because each person has his or her own biologic clock. There are some exceptions, but generally speaking, the events are reproducible enough to provide a basis for comparison between different persons.[6-9]

Many authors have shown that significant correlation exists between facial and statural growth. Statural growth acceleration generally precedes facial growth acceleration by 6 to 12 months.[10-20]

Hand-wrist radiographic evaluation

After Roentgen demonstrated his new radiographic discovery in 1895, Roland, in 1896, introduced the idea of using the comparative size and shape of the radiographic shadows of growing bones as indicators of rate of growth and maturity.[21]

In the early 1900s, Pryor,[22] Rotch,[23] and Crampton[24] began tabulating indicators of maturity on sequential radiographs of the growing hand and wrist. Hellman published his observations on the ossification of epiphysial cartilages of the hand in 1928.[25]

Todd[26] compiled hand-wrist data that was further elaborated on by Greulich and Pyle in atlas form.[5] Flory, in 1936, indicated that the beginning of calcification of the carpal sesamoid (adductor sesamoid) was a good guide to determining the period immediately before puberty.[27] The appearance of the adductor sesamoid has been highly correlated to peak height velocity and the start of the adolescent growth spurt.[11-13,28-34] Most authors agree that peak height velocity follows adductor sesamoid appearance by approximately 1 year.

Fishman developed a system of hand-wrist skel-

The views expressed herein by the authors are not necessarily those of the Department of Defense or the U.S. Government.

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Case Report

Skeletal Class II Malocclusion in Growing Patients: A Simplified Nonextraction Approach

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To cite: Singh DP, Kaur R. Skeletal Class II Malocclusion in Growing Patients: A Simplified Non-extraction Approach.Journal of Contemporary Orthodontics. February 2018, Vol 2, Issue 1, (page 46-53)

Received on: 23\11\2017

Accepted on: 18\02\2018

Source of Support: Nil

Conflict of Interest: None

ABSTRACT

In contemporary orthodontics, the complex and multifactorial etiology of class II malocclusion has always presented a clinical challenge to the orthodontists. Management of class II malocclusion requires a thorough evaluation as the treatment options available vary widely from growth modification using dentofacial orthopedics with functional appliances, dental camouflage using extraction or non-extraction approaches or even orthognathic surgery. Selection of treatment modality for class II patient is based on the age, growth potential, location of skeletal component, the severity of malocclusion and the compliance of the patient. Correction of skeletal class II malocclusion due to retrognathic mandible can be done with non-compliance appliances such as fixed functional appliances. Fixed functional appliances are emerging as viable and successful treatment option for class II patients owing to the refinement in their designs and mechanics to advance the retrognathic mandible. A wide variety of non-compliance fixed functional appliances are available that can be used with comprehensive fixed mechanotherapy. Forsus fatigue resistant device and Powerscope are two such fixed functional appliances used for class II correction. These appliances can be assembled chair-side and installed easily intraorally. This case report substantiates the efficacy of these appliances in the two types of Class II malocclusion growing patients presenting with a chief complaint of forwardly placed upper jaw and a mean age of 14 years (age range of 13–15 years).

Keywords: Class II malocclusion, Fixed functional appliance, Growth modification.

INTRODUCTION

About one-third of the population presents with class II malocclusion which is one the most common saggital malocclusion encountered in day-to-day practice.[1] Most common single characteristic of class II malocclusion is skeletal mandibular retrusion.[2] Forward mandible posture can be achieved by using various functional appliances, that include both myofunctional appliances and fixed functional appliances. Numerous functional jaw orthopedic appliances used for treatment of mandibular skeletal retrusion are available. Twin Block, Frankel Functional Regulator FR-2, the Herbst appliance and bionator being the most common.[2] Mandibular advancement using functional appliances has been advocated for correction of skeletal retrusion in class II patients.[3-5]

Fixed functional appliances are being widely used as a non-extraction treatment approach in non-compliant patients presenting with mandibular skeletal retrusion. Newer appliances are available nowadays that can be assembled chair side, does not require lab work, are easy to install and are patient friendly. But at the same they are rigid enough to bring about the desired skeletal and dental correction. Refinement of fixed functional appliances offers greater freedom of functional mandibular movements thereby enhancing patient comfort.[6]

This case report illustrates the efficacy of two such appliances used in the two types of class II malocclusion in growing. The appliances studied are Forsus fatigue resistant device and Powerscope.

Case Report

Access this article online
Quick Response Code:
Website:
www.jorthodsci.org
DOI:
10.4103/jos.JOS_59_17

Severe skeletal Class II Division 1 malocclusion in postpubertal girl treated using Forsus with miniplate anchorage

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Abstract:

This case report outlines the treatment of a 17-year-old female with Class II Division 1 malocclusion with mandibular retrusion, deep bite, and convex facial profile. The Forsus fatigue resistance device with miniplate was used for this patient and it was very affecting tool in correcting both skeletal and dental parameters. The total active treatment time was 19 months. This method can serve as an alternate choice of treatment, especially those who refuse orthognathic surgery. Hence, Forsus with miniplate might be useful in both growing and postpubertal patients.

Keywords:

Class II correctors, fixed functional appliance, miniplate

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Introduction

Among all malocclusion, Class II malocclusion presents a constant challenge to the orthodontist.[1] The treatment options for the correction of Class II malocclusion in growing age include early phase of functional appliance with growth modification and later the fixed orthodontic treatment. Unlike removable functional appliances, fixed functional devices have the advantage of not requiring patient compliance, and they can also be used concurrently with brackets.[2] Fixed functional appliances are considered to be noncompliant Class II correctors; these are herbst, jusper jumper, twin force bite corrector, Forsus, etc. Among all Class II correctors, the Forsus™ has proven to be most comfortable to a patient, right from installation itself. The Forsus corrector, not being as forceful as Herbst, allows gradual overpowering of the patient's oral musculature.[3,4] The Forsus™ fatigue resistance device (FFRD)* is a three-piece, telescoping system, which incorporates a super-elastic nickel-titanium coil spring. The FRD attaches at the maxillary first molar and on the mandibular archwire, distal to either the canine or first premolar bracket. As the coil is compressed, continuous opposing forces are transmitted to the sites of attachment without the possibility of fatigue, thereby correcting Class II malocclusions. Although previously performed studies have proved the efficiency of Forsus, the protrusion of the mandibular incisor was the most common problem which further limits the skeletal effect of the functional appliance.[4-6] Aslan *et al.*[7] used a FFRD appliance combined with a miniscrew, it was concluded that the mandibular incisor protruded significantly. The overjet and molar corrections were dentoalveolar and no skeletal improvement was concluded. Recently, Celikoglu *et al.*[8] successfully treated a case of pubertal phase girl having skeletal Class II malocclusion

How to cite this article: Patil HA, Kerudi VV, Rudagi BM, Sharan JS, Tekale PD. Severe skeletal Class II Division 1 malocclusion in postpubertal girl treated using Forsus with miniplate anchorage. J Orthodont Sci 2017;6:147-51.

Case Report

Early Intervention in Skeletal Class II and dental Class II division I malocclusion

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Abstract

A Class II malocclusion may occur as a result of mandibular deficiency, maxillary excess, or a combination of both. However, the most common finding is mandibular skeletal retrusion. The use of functional jaw orthopedics, at the right time during growth, can ultimately result in malocclusion patients achieving an excellent functional occlusion, a broad beautiful smile, a full face with a beautiful jaw line, and profile. Functional jaw orthopedic (FJO) appliances are designed to encourage adaptive skeletal growth by maintaining the mandible in a corrected forward position. The activator developed by Andresen is one of the most widely used for this purpose. A 12-year-old boy with skeletal Class II malocclusion and dental Class II div I malocclusion, a low mandibular plane angle was treated with growth modulation using an activator followed by molar distalization using fixed orthodontics for detailing of the occlusion. The major effects of the activator treatment in this case have been due to increase in condylar growth and also an increase in mandibular base length. Further, non-extraction fixed orthodontic treatment for proper interdigitation of the dentition also helped to maintain the stability of the satisfactory results achieved.

Key words: Activator, class II malocclusion, functional jaw orthopedics, molar distalization

INTRODUCTION

No one would deny that good occlusion in the first dentition with the jaws in a class I relation and the face well-developed is a favorable precursor to the same desirable condition in the permanent dentition. It is also true that some temporary disharmonies of the early mixed dentition are self-correcting or correctable by simple means if properly timed. The class II and class III malocclusions, however, do not correct themselves and it is these cases that are of concern to parents and pediatricians. They question why, if other deformities are more easily corrected at an early age, the same should not hold true for the face. The early correction of occlusion is the greatest aid to the promotion of the health of the denture through development of normal masticatory and facial habits as well as the beauty of the face.

There is a lack of consensus regarding the degree of success of different treatment modalities applied during the early to late mixed dentition stages.[1-3] The concept of "early treatment" is controversial. Some define it as removable or fixed appliance intervention in the primary, early mixed (permanent first molars and incisors present), or mid-mixed (inter-transitional period, before the emergence of first premolars and permanent mandibular canines). Others define early treatment as late-mixed dentition stage treatment (before the emergence of second premolars and permanent maxillary canines).[4] Clinical research has focused on two prominent strategies for the timing of treatment for Class II malocclusion.[5,6] The first intervention is considered during the pre-adolescent years (ages 8-11 years)[7] and includes correction of the molar distocclusion, incisor alignment, improvement of the overjet/overbite relationships,

Access this article online	
Quick Response Code:	Website: www.apospublications.com
	DOI: 10.4103/2321-1407.117380

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The European Journal of Orthodontics Advance Access published December 22, 2014

European Journal of Orthodontics, 2014, 1–17
doi:10.1093/ejo/cju071

Systematic Review

Treatment effects of removable functional appliances in patients with Class II malocclusion: a systematic review and meta-analysis

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Summary

Objective: To assess the treatment effects of removable functional appliances (RFAs) in treated versus untreated patients with Class II malocclusion by means of lateral cephalometric radiographs.
Search methods: Unrestricted electronic search of 18 databases and manual searches up to October 2013.
Selection criteria: Prospective randomized and non-randomized controlled trials reporting on cephalometric angular measurements of Class II patients treated with RFAs and their matched controls.
Data collection and analysis: Skeletal, dental, and soft tissue changes were annualized and stratified to short- and long-term effects. Methodological limitations were evaluated with the Cochrane Risk of Bias tool and the Downs and Black checklist. Mean differences (MDs) with their 95% confidence intervals (CIs) were calculated from random-effects meta-analyses. Patient- or appliance-related subgroup analyses and sensitivity analyses were performed with mixed-effects models.
Results: Seventeen studies were included (1031 patients; mean age: 10.6 years), with most of them originating from university clinics and reporting short-term effects (directly after the removal of RFAs). Treatment was associated with minimal reduction of SNA angle (11 studies, MD = −0.28 degree/year, 95% CI: −0.44 to −0.12 degree/year), minimal increase of SNB angle (11 studies, MD = 0.62 degree/year, 95% CI: 0.36–0.88 degree/year), and small decrease of ANB angle (10 studies, MD = −1.14 degree/year, 95% CI: −1.52 to −0.77 degree/year) compared to untreated Class II patients. RFAs caused significant dentoalveolar changes (predominantly retroclination of the upper incisors) and significant soft tissue changes. Skeletal changes were more pronounced with the Twin Block appliance. Various patient- or appliance-related factors influenced the results of the subgroup analyses, while the sensitivity analyses indicated robustness. Existing evidence was inadequate to assess the long-term effectiveness of RFAs.
Conclusions: The short-term evidence indicates that RFAs are effective in improving Class II malocclusion, although their effects are mainly dentoalveolar, rather than skeletal.

IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 18, Issue 5 Ser. 4 (May. 2019), PP 65-68
www.iosrjournals.org

Functional Appliances: Origins, the Present & the Future

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Abstract
Orthodontic treatment to correct malocclusion had been to a large extent taken to mean correcting the dentition in all three planes using a fully strapped fixed appliance. The realization that sagital correction of dentition alone, over a skeleton that has a sagital discrepancy, is ineffective led to the focus shifting to correcting the skeletal bases. Two modalities were identified viz: surgical and functional. Functional jaw orthopaedics has seen widespread use in correcting skeletal malocclusion in the growing age. Various appliances have been advocated with some being used by a large section while others not being in vogue. However there is still ambiguity in literature as to the effectiveness of functional appliances and whether it is a sound practice to pull the mandible out of the fossa. This article reviews the concept of functional jaw orthopaedics and presents the current best evidence.

Key Words-*Functional appliances, Growth modification, Supplementary mandibular growth, Current evidence.*
Word count- 2321 words.

Date of Submission: 29-04-2019 Date of acceptance: 13-05-2019

I. Introduction

Functional appliances represent a wide range of appliances that primarily alter the position of the mandible, both sagittally and vertically, to stimulate an increased condylar cartilage growth resulting in supplementary lengthening of the mandible [1-2]. They find application in the correction of skeletal class II malocclusions with mandibular retrusion. Though a skeletal Class II malocclusion can also be due to a prognathic maxilla, mandibular retrusion has been shown as the major contributing factor [3]. The advantage, according to the proponents of functional appliances, of early treatment in the mixed dentition is that the orofacial environment is improved to receive the permanent dentition. By lengthening the mandible during the active growth period the need for complex intervention involving extractions or surgical correction is minimized [4]. However current evidence points out that mandibular lengthening achieved by functional appliances is clinically insignificant[5] and there is no advantage of early two phased treatment, over a single phase treatment started at a later age[6].

II. History

Wilhelm Roux's (Fig 1) work on tail fins of Dolphins in the year 1883 sowed the seed for the concept of function influencing form. He described functional stimuli as capable of building, molding, remolding and preserving tissue. Robin and Andresen at different periods applied Roux's hypothesis. In 1885 Julius Wolff (Fig 2) published his book "Law of the transformation of bone" in which he stated that function brought about changes in form [7]. Much later Karl Hauple used Roux's hypothesis to explain how functional appliances bring about change through the activity of orofacial muscles [8]. Though functional appliance is identified as a European treatment philosophy, it was Norman W.Kingsley (Fig 3) who first advanced the mandible forward in the treatment of malocclusion [9]. The predominant use of removable functional appliances in Europe was more out of necessity brought about by the Second World War (1939-1945), while across the globe, in the United States, fully banded fixed appliance was the orthodontic treatment mainstay. Edward Angle used Wolff's hypotheses to his own end as reinforcement for his conviction that expanding arches brought about new bone formation. In the year 1933, when Oppenheim published his work on the potentially damaging effects of heavy orthodontic forces [10] as used in fixed fully strapped up appliances, it turned out to be an impetus to the advocacy of functional appliances.

ORIGINAL ARTICLE CE AJO-DO

Dentoskeletal changes induced by the Jasper jumper and the activator-headgear combination appliances followed by fixed orthodontic treatment

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Introduction: The aim of this study was to compare the dentoskeletal changes of patients with Class II Division 1 malocclusion treated with either the Jasper jumper appliance or the activator-headgear combination, both associated with fixed appliances. **Methods:** The sample comprised 72 subjects with Class II Division 1 malocclusion divided into 3 groups: group 1 included 25 subjects treated with fixed appliances and the force modules of the Jasper jumper at an initial mean age of 12.72 years, group 2 included 25 subjects treated with the activator-headgear combination followed by fixed appliances at an initial mean age of 11.07 years, and group 3 included 22 untreated subjects at an initial mean age of 12.67 years. Initial cephalometric characteristics and dentoskeletal changes were compared with analysis of variance. **Results:** Both experimental groups had similar dentoskeletal changes: restrictive effect on the maxilla, clockwise mandibular rotation and a slight increase in anterior face height, retrusion of the maxillary incisors, distalization of the maxillary molars, protrusion of the mandibular incisors, extrusion of the mandibular molars, and significant improvements of the maxillomandibular relationship, overjet, overbite, and the molar relationship. **Conclusions:** The effects of the Jasper jumper and the activator-headgear combination followed by fixed orthodontic appliances were similar in Class II malocclusion treatment. (Am J Orthod Dentofacial Orthop 2013;143:684-94)

A common strategy in the treatment of Class II Division 1 malocclusions in growing patients is a 2-step approach. In the first phase of treatment, the sagittal jaw relationship is normalized. The Class II malocclusion is transformed to a Class I malocclusion. In the second phase of treatment, tooth positions are adjusted, usually with fixed appliances. Correction of the sagittal jaw relationship can be achieved in several ways. Removable functional appliances, such as the activator, change a Class II relationship by the transmission of soft-tissue tension to the dentition. This is achieved by positioning the mandible anteriorly with the appliance. In Jasper jumper therapy, fixed appliances with flexible intraoral force modules are used in the first phase of treatment.[1]

Only 2 studies in the English literature have compared the initial dentoskeletal effects between the Jasper jumper and the activator-headgear combination in Class II malocclusion treatment.[1,2] However, 1 study had no control group.[1] Sari et al[2] concluded that the activator-headgear appliance was more effective on the mandible, whereas the jumper appliance was mainly active on the maxilla. Weiland et al[1] studied 72 Class II patients treated with either the Herren activator associated with headgear or the Jasper jumper appliance. Corrections of overjet and molar relationship were more evident in patients treated with the Jasper jumper compared with the activator.[1]

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The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.
Based on research by the first author in partial fulfillment of the requirements for a PhD degree at Bauru Dental School, University of São Paulo, Bauru, São Paulo, Brazil.
Reprint requests to: Guilherme Janson, Department of Orthodontics, Bauru Dental School, University of São Paulo, Alameda Octávio Pinheiro Brisolla 9-75, Bauru, São Paulo 17012-901, Brazil; e-mail, jansong@travelnet.com.br.
Submitted, August 2012; revised and accepted, January 2013.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2013.01.009

Activator : An Andresen Innovation

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Abstract

Functional orthodontic treatment has been proved to be one of the most effective and successful treatment modality in orthodontics. Functional appliances can only be applied in growing young patients. In the treatment of angle class II malocclusions the activator is often the appliance of choice. The activator might have an influence on the skeletal structures of the face as well as on the growth and position of mandibular arch.

Key Words: Class II Malocclusion, Mandibular retrognathism, Functional jaw orthopaedics, Activator.

Introduction

Myofunctional appliances influence the facial skeleton of growing child and exert orthodontic effect on dentoalveolar area and best time for using it in growing phase in which the distobuccal cusp of the upper first permanent molar occlude in the mesiobuccal groove of the lower first permanent molar. Class II division I is probably one of the most disfiguring types of malocclusion causing early apprehension.[1,2] Growth timing in early stage of treatment, gives a greater chance to the effect of orthopedic force to aid in redirecting the growth pattern into more favorable correction of skeletal malrelation and improving the facial esthetic, in addition to the decision of the most effective technique to use in treatment of growing patients with skeletal and / or dental Class II malocclusion. This could be achieved through either extra oral force (maxillary head-gear) in cases diagnosed as maxillary excess or repositioning and encouraging the forward growth of the mandible by orthopedic myofunctional appliances.[3,4]

Functional appliances are commonly used for the treatment of Class II malocclusions with mandibular deficiency. The treatment goals are to reduce the large overjet and correct the sagittal skeletal discrepancy[7]. The success of treatment with a functional appliance relies on the patient's cooperation and favourable mandibular growth. Treatment with a functional appliance usually lasts for 9 to 12 months and requires a proper retention time to ensure complete musculoskeletal adaptation. A second stage of treatment with a full-fixed appliance is often required to achieve proper alignment and good interdigitation of the dentition[8]. Basically there are two categories of functional appliances, removable and fixed. Activator, Frankel and Twin block are examples of removable one and, on the other hand, the Herbst appliance represents an example of fixed functional appliance.[3,4] The activator and its successors provide a greater contact area with the mandibular teeth and lingual mucosa, and thus are more effective in stimulating the patient to position the mandible forward constantly.

Indications [3,4]

1. Class II division 1 malocclusion with sufficient overjet.
2. Class II caused by mandibular over closure that results in functional retrusion.
3. Class II division 1 malocclusion with posterior position of the mandible caused by growth deficiency but with likelihood of a future horizontal growth pattern.
4. Prevention and correction of oral habit, including thumb/ lip sucking, mouth breathing and oral functional aberrations.

Contraindication[5]

1. Class II skeletal by maxillary prognathism
2. Vertical directed growers
3. Crowding
4. Labial tipping of lower incisors

Discussion

Functional appliances are effective in treating skeletal class II malocclusion, particularly in cases with retrognathic mandible functional appliances are of greatest clinical benefit in actively growing patients with good compliance. These appliances position the mandible forward, promoting a new mandibular postural position. The reactive forces from the stretch of the muscles and soft tissues are transmitted to the maxillary dentition and through that, to the maxilla.

The acrylic body of the Andresen activator covers part of the palate and the lingual aspect of the mandibular alveolar ridge. A labial bow fits anterior to the maxillary incisors and carries U-loops for adjustment. On the palatal aspects of the maxillary incisors, the acrylic is relieved to allow their retraction. A main feature of the appliance is the faceting of the acrylic on palatal and lingual aspects of the maxillary and mandibular posterior teeth, respectively, designed to direct their eruption. On the palatal aspect of the maxillary posterior teeth the facets are cut so as to allow occlusal, distal and buccal movement of these teeth. This movement is achieved by keeping the acrylic in contact with only the mesiopalatal surfaces of the premolars and molars. On the lingual aspect of the mandibular posterior teeth the facets only permit occlusal and mesial movement, with the acrylic contacting the distolingual surface of these teeth. The activator also had an influence on dentition. By inhibiting the maxillary dentoalveolar vertical growth and encouraging the mandibular dentoalveolar mesial and vertical development, the activator resolved the class II malocclusion to class I malocclusion.[5,7,8]

Conclusion

Functional appliances can be used successfully to treat skeletal class II malocclusions in growing patients. The ideal case for such treatment are Class II division I malocclusion with retrognathic mandible, Low to average mandibular plane angle and Upright or lingually tipped lower incisors. The activator can solve many problems that become more severe if left untreated. The Activator cannot create a large mandible from a small one, but it can help the patient achieve the optimal size consistent with morphogenetic pattern. The restoration of the normal function is a major contribution to improvement in the morphofunctional interrelationship.

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Taiwanese Journal
of Orthodontics

Volume 29 | Issue 3 Article 2

2020

Is Early Treatment with Functional Appliances Worth the Effort? A Discussion of the Pros and Cons of Early Interceptive Treatment

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Recommended Citation
Nielsen, Ib Leth (2020) "Is Early Treatment with Functional Appliances Worth the Effort? A Discussion of the Pros and Cons of Early Interceptive Treatment," *Taiwanese Journal of Orthodontics*: Vol. 29 : Iss. 3 , Article 2.
DOI: 10.30036/TJO.201709_29(3).0002
Available at: https://j.tjo.org.tw/tjo/vol29/iss3/2

RESEARCH ARTICLE

Long-term effects of functional appliances in treated versus untreated patients with Class II malocclusion: A systematic review and meta-analysis

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Citation: Cacciatore G, Ugolini A, Sforza C, Gbinigie O, Plüddemann A (2019) Long-term effects of functional appliances in treated versus untreated patients with Class II malocclusion: A systematic review and meta-analysis. PLoS ONE 14(9): e0221624. https://doi.org/10.1371/journal.pone.0221624

Editor: Mani Alikhani, Harvard School of Dental Medicine, UNITED STATES

Received: April 19, 2019

Accepted: August 12, 2019

Published: September 6, 2019

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Funding: The authors received no specific funding for this work.

Competing interests: The authors have declared that no competing interests exist.

Abstract

Objective

To assess the cephalometric skeletal and soft-tissue of functional appliances in treated versus untreated Class II subjects in the long-term (primarily at the end of growth, secondarily at least 3 years after retention).

Search methods

Unrestricted electronic search of 24 databases and additional manual searches up to March 2018.

Selection criteria

Randomised and non-randomised controlled trials reporting on cephalometric skeletal and soft-tissue measurements of Class II patients (aged 16 years or under) treated with functional appliances, worn alone or in combination with multi-bracket therapy, compared to untreated Class II subjects.

Data collection and analysis

Mean differences (MDs) and 95% confidence intervals (95% CIs) were calculated with the random-effects model. Data were analysed at 2 primary time points (above 18 years of age, at the end of growth according to the Cervical Vertebral Maturation method) and a secondary time point (at least 3 years after retention). The risk of bias and quality of evidence were assessed according to the ROBINS tool and GRADE system, respectively.

 DOI: 10.18231/2348-7240.2017.0003

Role of Activator and Bionator in class II malocclusion correction- A review

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Abstract
Functional appliances are passive appliances, which make use of the natural forces generated by the orofacial & masticatory muscles and the forces of occlusion to bring about changes in dento alveolar & craniofacial structures. These appliances alter neuromuscular environment of orofacial region to improve occlusal development and craniofacial skeletal growth. In this article we will discuss effects of two functional appliances that are activator and bionator.

Keywords: Activator, Bionator, Maxillary protrusion.

Introduction
Class II malocclusion is one of the most common orthodontic problem and it occurs in about one third of population.(1-3) Class II malocclusion can result from many contributing factors, both dental and skeletal. Although both maxillary protrusion and mandibular retrusion are causative factors, it has been reported that the most common component in a class II sample population is mandibular retrusion.(4) For Class II patients in whom the mandible is retrognathic, the ideal treatment is alteration of amount and direction of growth of mandible. The primary treatment for this is functional appliance therapy.(5) Functional appliances include removable and fixed devices that are designed to alter the position of the mandible, both sagitally and vertically and to induce supplementary lengthening of the mandible by stimulating growth of condylar cartilage.(6,7)

Functional appliances have been used since 1930s. Despite this long history, there is much controversy regarding their use, method of action, and effectiveness.(7)

Bjork(8) and Pancherz(9) demonstrated only small changes in mandibular growth with functional appliance therapy. Butmany other researchers reported that functional appliances significantly affect mandibular growth.(10,11,12)

Activator
The original monobloc designed by Robin in 1902 and it was a one-piece removable appliance.(13) This appliance positioned the mandible forward in patients with severe mandibular retrognathism. Viggow Andresen in 1908 developed a mobile, loose fitting appliance that transferred functioning muscle stimuli to the jaws, teeth, and supporting tissues and this appliance was called biomechanic working retainer. Later, Andersen and Haupal called their appliance activator because of its ability to activate the muscle force.

According to Andersen and Haupal, the activator makes use of the interrelationship between function and changes in internal bone structure for malocclusion correction. Activator induces musculoskeletal adaptation by introducing a new pattern of mandibular closure and these adaptations in functional pattern caused by activator also affect condyles. Condylar adaptations include growth in an upward and backward direction to maintain the integrity of temporomandibular joint structures.(14) The appliance advances the mandible and generate a biomechanical force as the muscles attempt to return the mandible to its normal position.(15)

Skeletal effects of activator
Activator inhibits the horizontal growth of the maxilla,(9,16) also results in increased growth of the mandible and causes anterior relocation of the glenoid fossa.(17) Barbel Kahl-Nieke(18) found that activator appliance therapy in hemifacial microsomia patients showed improvement of function, occlusion and facial asymmetry was also reduced. Construction bite in such cases is taken by keeping mandible in slightly forward and overcompensated position that changes muscle activity which can lead to enhanced bone apposition and optimal growth of the condyle. Horizontal activator results in increase in SNB angle, mandibular plane angle, reduction in SNA angle, ANB angle, and increase in mandibular length.(19,20)Mehta and patel(21) reported activator corrects class II malocclusion by increasing condylar growth and mandibular base length. According to Luder's Hypothesis, a great interocclusal height of an activator would lead to improvement in mandibular retrognathism, no change in maxillary prognathism, clockwise rotation of occlusal plane and low construction bite results in reduction in maxillary prognathism, clockwise mandibular rotation, anterior tipping of mandibular anterior teeth. Some clinical studies found no significant increase in mandibular length with the use of this device(9) but other authors

Original Article

Long-term skeletal and dental effects and treatment timing for functional appliances in Class II malocclusion

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ABSTRACT

Objective: To analyze the long-term skeletal and dentoalveolar effects and to evaluate treatment timing of Class II treatment with functional appliances followed by fixed appliances.

Materials and Methods: A group of 40 patients (22 females and 18 males) with Class II malocclusion consecutively treated either with a Bionator or an Activator followed by fixed appliances was compared with a control group of 20 subjects (9 females and 11 males) with untreated Class II malocclusion. Lateral cephalograms were available at the start of treatment (mean age 10 years), end of treatment with functional appliances (mean age 12 years), and long-term observation (mean age 18.6 years). The treated sample also was divided into two groups according to skeletal maturity. The early-treatment group was composed of 20 subjects (12 females and 8 males) treated before puberty, while the late-treatment group included 20 subjects (10 females and 10 males) treated at puberty. Statistical comparisons were performed with analysis of variance followed by Tukey's post hoc tests.

Results: Significant long-term mandibular changes (Co-Gn) in the treated group (3.6 mm over the controls) were associated with improvements in the skeletal sagittal intermaxillary relationship, overjet, and molar relationship (~3.0–3.5 mm). Treatment during the pubertal peak was able to produce significantly greater increases in total mandibular length (4.3 mm) and mandibular ramus height (3.1 mm) associated with a significant advancement of the bony chin (3.9 mm) when compared with treatment before puberty.

Conclusion: Treatment of Class II malocclusion with functional appliances appears to be more effective at puberty. (*Angle Orthod.* 2013;83:334–340.)

KEY WORDS: Functional jaw orthopedics; Class II malocclusion; Cervical vertebral maturation; Cephalometrics; Puberty

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Accepted: July 2012. Submitted: May 2012.
Published Online: August 29, 2012

INTRODUCTION

Functional jaw orthopedics (FJO) is a specific type of treatment for Class II dentoskeletal disharmonies associated with mandibular retrusion. Despite controversies on the effectiveness of FJO, it has been shown that in the short term, FJO produces different dentoskeletal results based on timing of treatment.[1–9] A significant supplementary elongation of the mandible can be achieved only when FJO is performed at pubertal or immediately postpubertal periods of skeletal development.[2–6] Recently, it has been suggested that FJO at the pubertal spurt followed by fixed appliances is a viable therapeutic option in patients with unfavorable Class II malocclusions.[10]

As for the long-term outcomes of FJO, data available in the literature are much more scarce.[4,6,11–15] While Freeman et al.[14] and Malta et al.[15] have described a long-term statistically significant increase in mandibular length in patients treated with FJO over untreated Class

DOI: 10.2319/052912-450.1

Hindawi Publishing Corporation
BioMed Research International
Volume 2017, Article ID 4861924, 9 pages
http://dx.doi.org/10.1155/2017/4861924

Research Article

Comparison of Activator-Headgear and Twin Block Treatment Approaches in Class II Division 1 Malocclusion

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Received 1 November 2016; Accepted 4 January 2017; Published 22 January 2017

Academic Editor: Simona Tecco

The purpose was to compare the treatment effects of functional appliances activator-headgear (AH) and Twin Block (TB) on skeletal, dental, and soft-tissue structures in class II division 1 malocclusion with normal growth changes in untreated subjects. The sample included 50 subjects (56% females) aged 8–13 years with class II division 1 malocclusion treated with either AH (n = 25) or TB (n = 25) appliances. Pre- and posttreatment lateral cephalograms were evaluated and compared to 50 untreated class II division 1 cases matched by age, gender, ANB angle, and skeletal maturity. A paired sample, independent samples tests and discriminant analysis were performed for intra- and intergroup analysis. Treatment with both appliances resulted in significant reduction of skeletal and soft-tissue facial convexity, the overjet, and the prominence of the upper lip in comparison to untreated individuals ($p < 0.001$). Retroclination of maxillary incisors and proclination of mandibular incisors were seen, the latter being significantly more evident in the TB group ($p < 0.05$). Increase of effective mandibular length was more pronounced in the TB group. In conclusion, both AH and TB appliances contributed successfully to the correction of class II division 1 malocclusion when compared to the untreated subjects with predominantly dentoalveolar changes.

1. Introduction

Early treatment of class II malocclusion aims to correct the sagittal relationship, modify the pattern of facial growth, and improve both hard- and soft-tissue profile [1–4]. The majority of the clinical studies recognize the useful effect of functional appliances in sagittal correction of the malocclusion but agree that the treatment is mainly restricted to dentoalveolar changes [5]. Favorable skeletal changes which can modify the growth pattern can also occur depending on individual growth potential [1, 6].

A class II malocclusion may result from mandibular deficiency, maxillary excess, or combination of both [7, 8]. Several varieties of functional appliances are currently in use aiming to correct the skeletal imbalances. The combination of an activator with headgear (AH) is used to provide greater cumulative skeletal changes than either appliance would provide alone [9]. They affect maxilla by decreasing forward and downward growth of the maxillary complex, while allowing the forward growth of the mandible to continue, thus influencing the profile more favorably [9, 10]. Twin Block (TB) appliance as well as most of other functional appliances is designed to encourage adaptive skeletal growth by maintaining the mandible in a corrected forward position for a sufficient period of time [1, 4, 11].

Many studies have investigated the effect of AH and TB appliance on the dental and skeletal variables. However, no studies have provided a direct comparison of the treatment changes between them. One study compared the effects of both appliances [3], but the evaluation was limited to the soft-tissue profile changes.

Therefore, the aims of this study were to explore skeletal and dentoalveolar changes in class II division 1 patients treated with TB and AH and to compare their treatment effect with normal growth changes of untreated controls (CTRL) with the same malocclusion. The hypotheses were as follows:

Santamaría-Villegas et al. BMC Oral Health (2017) 17:52
DOI 10.1186/s12903-017-0339-8

BMC Oral Health

RESEARCH ARTICLE Open Access

Effect of removable functional appliances on mandibular length in patients with class II with retrognathism: systematic review and meta-analysis

Adriana Santamaría-Villegas[1], Rubén Manrique-Hernandez[2], Emery Alvarez-Varela[2] and Claudia Restrepo-Serna[1*]

Abstract

Background: Orthopedic functional devices, are used to improve mandibular length in skeletal class II patients. However, the orthopedic functional device with the best effect to increasing the mandibular length, has not been identified before. Thus, the aim of the present investigation was to evaluate Randomized Controlled Trials (RCT), to determine the best functional appliance improving mandibular length in subjects with retrognathism.

Methods: A systematic review and meta-analysis was performed, including studies published and indexed in databases between 1966 and 2016. RCTs evaluating functional appliances' effects on mandibular length (Condilion-Gnation (Co-Gn) and Condilion-Pogonion (Co-Po)), were included. Reports' structure was evaluated according to 2010 CONSORT guide. The outcome measure was distance between Co-Gn and/or Co-Po after treatment. Data were analyzed with Cochran Q Test and random effects model.

Results: Five studies were included in the meta-analysis. The overall difference in mandibular length was 1.53 mm (Confidence Interval (CI) 95% 1.15–1.92) in comparison to non-treated group. The Sander Bite Jumping reported the greatest increase in mandibular length (3.40 mm; CI 95% 1.69–5.11), followed by Twin Block, Bionator, Harvold Activator and Frankel devices.

Conclusions: All removable functional appliances, aiming to increase mandibular length, are useful. Sander Bite Jumping was observed to be the most effective device to improve the mandibular length.

Keywords: Malocclusion, Angle class II, Retrognathia, Meta-analysis, Orthodontics appliances, Functional

Background

The main reason for using functional removable appliances is to establish muscular balance, eliminate oral dysfunction, and allow a proper length of both the maxilla and the mandible [1]. Several studies have been performed in order to evaluate with different methods, the morphogenic mandibular changes, associated with the use of functional appliances to propulse forward the mandible. Frankel [2, 3], Bionator [4], Bass appliance [5], Herbst [6], Sander Bite Jumping [7], among others; could be found in the literature for this purpose. Individually, many studies have found changes in mandibular length and position, both in the sagittal and vertical plane [2–7]. However, when studies are grouped and analyzed together in systematic reviews and meta-analysis, controversies appear. Some reviews have found no statistically or clinically significant differences between groups treated with functional appliances and controls [8], while other authors have observed those differences to be statistically significant [9]. Additionally, studies have found other results for the treatment with functional appliances, such as secondary statistically significant mandibular elongation [10] and changes in the facial profile, due to incisal inclination [11].

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Bionator di Balters and Frankel in the treatment of class II malocclusions: a literature review

Author(s): Da Mommio L, Vompi C, Carreri C, Germano F, Musone L

Abstract

Functional devices in class II malocclusions can optimize mandibular growth in order to obtain a first-class skeletal relationship, normalising neuromuscular activity and achieving harmonious anatomical relations. The aim of this review is to compare the dentoalveolar and skeletal effects produced by the Frankel II (FR-2) and Bionator appliances in patients with Class II malocclusion. A research was conducted online on the following databases: Pubmed, Google scholar and Scopus until 2019. A combination of key words like *frankel II, bionator II, functional appliance, dentoskeletal effects* was used. According to inlclusion and exclusion criteria, 18 articles have been selected. As results, the major effects of the bionator and the FR-2 appliances were dentoalveolar as labial tipping, linear protrusion of the lower incisors and a lingual inclination, retrusion of the upper incisors, increase in mandibular posterior dentoalveolar height. Smaller, but significant, skeletal effect as significant increases in mandibular growth and in the degree of mandibular protrusion can be also observed.

Background

Some studies have shown that the class II malocclusion can be categorized into 4 main groups: anterior position of the maxilla, anterior position of the maxillary dentition, mandibular skeletal retrusion in absolute size or relative position and excessive or deficient vertical development (1,2). McNamarastated that most Class II patients present a deficiency in the anteroposterior position of the jaw (3). This type of malocclusion can be treated in growing patients with the use of functional appliances. Frankel and Bionator are two functional devices used in the treatment of malocclusion from mandibular deficit. Functional jaw orthopedics (FJO) at the pubertal spurt followed by fixed appliances is a viable therapeutic option in patients with Class II malocclusion associated with mandibular retrusion (4). Several functional devices have been designed to treat second class malucclusion by mandibular deficit. The goal of these functional appliances is to optimize mandibular growth in order to obtain a first-class skeletal relationship. Such modification also aims at dentoalveolar change of the maxillary and mandibular anterior teeth, normalising neuromuscular activity, and achieving harmonious anatomical relations. The aim of this review is to compare the dentoalveolar and skeletal effects produced by the Frankel II (FR-2) and Bionator appliances in patients with Class II malocclusion.

Bionator

Bionator appliance, which was developed by Balter in 1964 [Graber and Neumann, 1984], is a passive appliance. The acrylic components consist of a lower horse shoe shaped acrylic lingual plate from distal of last erupted molar of one side to other side; an upper arch with a lingual extention that cover molar and premolar region. A vestibular arch that extends with handles buccinatoris and a palatal bar orients the tongue and mandible anteriorly by stimulating its dorsal surface. The buccinator bends moves cheeks laterally in order to favour expansion and transverse development of dentition (5-7).

Frankel

The frankel 2 regulator (Fr2), conceived by Rolf Frankel in 1956, is a passive activator that is the only tissue retention device and has the function of keeping the jaw in an active protruded position by a nociceptive stimulus on the mucosa, as opposed to the traditional activators in which the passive protrusion is bound by the presence of planes to slide in contact with the teeth. consists of acrylic components and wire components. Acrylic components are composed by buccal shield or premolar and tuberosity shield, extended well into the sulcus; lower lip pads in the labial sulcus of the anterior region; lingual shield extended towards premolar region. Wire components are upper labial bow, lower lip pad support wire, lower lingual support wire, maxillary lingual stabilizing bow, palatal bow, lower lingual springs, canin loops, canine extension, occlusal rest. The fr2 allows minor and projected 2mm mandibular movements, the bite of the construction should be taken in a protruded position of two mm unlike other functional appliances where the construction bite is head to head (8-12).

Materials and Methods

Twin Block, Bionator and Frankel II: comparative study

Author(s): Rodi G, Emanuele F, Elisa L, Martina Maria D, Gabriella P

Abstract

Many appliances are described in the literature in the second molars class where you want to obtain a mandibular advancement . The aims of this study is to compared, with a literature review using PubMed from 1998 to 2016, dental and skeletal effects of Twin Block, the Bionator and Frankel II. The final results found in our research is that the Twin block appliances determines a greater positive torque of the lower incisors togheter with the benefit of significant mandibular growth. Still today there are different opinions about the mandibular growth, some works in literature said that they are due with the advancement get by the use of these functional device, other says that the mandibular growth is link with the differential growth of the two jaws. However we have to remember that these devices are dependent on compliance and is difficult to compare dental and skeletal effects that have in individual patients.

Introduction

Frankel II, Twin Block and Bionator are functional devices used in order to correct the second skeletal malocclusion class.

The second skeletal class is not a disease but there is a possible link with the instability of the stomatognathic equilibrium. Functional and structural problems (in the three planes of space) should be investigated in order to have a correct diagnostic process.

The diagnosis of second skeletal class is done with cephalometric in lateral view, where the measurement of the ANB angle and Ao-Bo are greater than 2° and 2mm respectively.

The second skeletal class can be a mandibular component, maxillary or mixed. The patient's age is critical to the treatment plan. A patient at the end of growth that has a 9° of ANB for example, to resolve the problems sagittal skeletal is forced to orthognathic surgery.

A patient with the same value of ANB of 11 years through mandibular advancement devices and retrusion of the maxilla can solve the problem through skeletal functional orthodontic appliances. So it's very important selection a treatment plan that is specific for patient and the time sequence of therapeutic strategies for the resolution of the patient's problems. So the diagnostic process at first had to do a problem list, and then plans the treatment that best meets the patient's needs.

The timing for the functional equipment described in the literature is between 9 and 15 years in males and between 8 and 14 in femmes . Each patient has a skeletal age that is not always in line with the anamnestic data, so a radiographic evaluation is critical to monitor the patient's growth.

Twin block determines a greater mandibular advancement compared to Franke II and Bionator and is therefore used in cases of a skeletal overjet.

Frankel II and Bionator are usually used in mixed dentition or even at the peak of growth to advance slightly the jaw and re-educate the musculature or as a restraint of a mandibular advancement already achieved.

The jaw expresses maximum growth in the shortest possible time at the peak of pubertal growth. Thus we need to put the mandibular advancement devices at the beginning of this peak. For aesthetic requirements, functional and to avoid trauma of upper incisor.

Besides Herbst and Twin Block that are fixed appliances, the other are all removable appliances which requires the patient's compliance. The patient should dress the device 24 hours a day and the results are related with the cooperation of the patient. In fact the failures described in the literature of removable equipment are mainly due to lack of cooperation of paziente. This should be aevaluetd by the orthodontic clinician first to began a treatment, we know that here are patients who can not put a removable appliance because they are not followed, in this case clinician should reach with controls, motivation and education constant in time an optimal level of cooperation.

Frankel II

FRANKEL, is a functional device , based on functional orthopedics principles and, in union with muscle gymnastics, creates maxillary morphological changes, restoring the malocculsion. Moss study shown how with a modification of function there is a myofunctional re-education in a growing patient that can lead to a

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Evaluation of long-term effects in patients treated with Fränkel-2 appliance

ABSTRACT

Aim *To evaluate the dentoskeletal effects produced by Fränkel-2 (FR-2) appliance during the treatment of patients with Class II malocclusion by mandibular retrusion and to verify the long-term stability of these changes.*

Materials and methods *Pre-treatment, post-treatment and long-term serial cephalograms (at least 10 years after the end of treatment) of patients treated with FR-2 were compared with data obtained from untreated controls. To be included in the study, patients and controls had to exhibit Class II malocclusion caused by short mandibular body. Lateral cephalograms were analysed with a specific tracing regimen in both groups. Summary measures for the initial cephalometric values and increments of changes between visits were calculated.*

Results *Compared to controls, the FR-2 treatment produced a significant decrease in the ANB angle that improved the skeletal intermaxillary and occlusal relationship. At long-term follow-up, the FR-2 group showed further improvements of skeletal intermaxillary and occlusal relationship, therefore the changes observed during treatment showed no compensatory decline or "rebound".*

Conclusion *FR-2 treatment, in conjunction with a period of post-functional fixed appliance therapy designed to perfect the occlusion, can produce a long-lasting improvement of the skeletal Class II malocclusions with little skeletal correction and significant incisor compensation.*

Keywords: *Fränkel-2 appliance; Class II malocclusion.*

Introduction

Class II malocclusions can result from many dental and skeletal derangements. The most common component is mandibular retrusion [McNamara, 1981].

The functional approach seems to be the treatment of choice in Class II cases lacking mandibular growth [Chen et al., 2002; Cozza et al., 2006]. One of the most popular functional appliances used today is the Fränkel-2 (FR-2) appliance, different studies evaluated its dentoskeletal effects of the FR-2 in patients with skeletal Class II malocclusions with controversial outcomes. Some authors [Falck and Fränkel, 1989; Perillo et al., 1996; Toth and McNamara, 1999; De Almeida et al., 2002] suggested that mandibular growth could increase, whereas others [Hamilton et al., 1987; Nelson et al., 1993; Chadwick et al., 2001; Janson et al., 2003] believed that the most significant treatment effects are restricted to dentoalveolar changes. A recent metanalysis [Perillo et al., 2011] reported that the FR-2 appliance has a statistically significant impact on the dimensions of the mandible in treated patients versus untreated controls, but it can be considered to have a modest clinical effect. However, the studies included in this metanalysis presented some limitations: they were heterogeneous, mostly non randomized and retrospective, of low to medium quality, and almost all lacked initial differential diagnosis in order to identify the type of mandibular retrusion associated with the Class II malocclusion. Moreover, there are few studies on long-term effects in FR-2 patients. Difficulties arise in recruiting patients to evaluate the dentoskeletal changes that may occur during the treatment, post-treatment, and post-retention periods. It is even more difficult to obtain control data from untreated children with same initial dentofacial pattern. Long-term data, however, seem to be the only way to test the efficacy of competing therapies.

To date, Falck and Fränkel [1989], Perillo et al. [1996] and more recently Berger et al. [2005] and Freeman et al. [2009] reported long-term data on FR-2 treated patients and, in particular, only Freeman et al. evaluated the long-term effects 10 years after treatment. These studies concluded that the mandible continued to grow in a favourable direction even after discontinuing the functional appliance [Berger et al., 2005] without compensatory decline or "rebound" [Perillo et al., 1996], so the correction of Class II malocclusion with FR-2 maintains favourable over the long-term with both skeletal and dentoalveolar changes [Freeman et al., 2009].

Therefore, the aim of the present investigation was to evaluate the dentoskeletal effects of FR-2 treatment in patients with Class II malocclusion associated with mandibular retrusion by mandibular short body versus an untreated control group with the same initial characteristics and to verify the long-term stability of these changes.

Materials and methods

FR-2 sample

The sample was selected from patients treated with the FR-2 appliance at the Second University of Naples from 1984 to 1998. Each subject had two high quality lateral cephalograms, taken before and after FR-2 treatment. The

European Journal of Orthodontics 36 (2014) 192–199
doi:10.1093/ejo/cjt026
Advance Access publication 4 June 2013

Long-term treatment effects of the FR-2 appliance: a prospective evalution 7 years post-treatment

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SUMMARY

AIM To examine the long-term effects induced by treatment with the function regulator (FR-2) appliance 7 years post-treatment compared with untreated class II subjects.

SUBJECTS AND METHODS The FR-2 sample was collected prospectively and comprised 17 subjects (10 boys and 7 girls, mean age 10.8 years) who were treated with the FR-2 appliance for 1.7 years and re-evaluated 7.1 years after treatment. The step-by-step mandibular advancement was performed gradually (increments up to 3–4 mm), until a 'super class I' molar relationship was obtained. The control group consisted of 17 class II subjects (9 boys and 8 girls, mean age 11.3 years) with class II malocclusion, excessive overjet, and class II molar relationship, matched to the treated group as to ages at all times, gender distribution, and stages of skeletal maturity (evaluated by the cervical vertebral maturation method). The lateral cephalograms were analysed at T1 (initial), T2 (final), and T3 (7.1 years post-treatment). The compatibility between the groups and the comparisons of their changes at T1–T2, T2–T3, and T1–T3 intervals were examined by independent sample *t*-tests ($P < 0.05$).

RESULTS FR-2 treatment provided a significant improvement in the maxillomandibular relationship due to an increase in mandibular length compared with controls, which remained stable over time. Also overjet, overbite, and molar relationship corrections demonstrated stability. Among dentoalveolar changes, only the increased mesial movement of the mandibular molars in the FR-2 group demonstrated stability.

CONCLUSIONS Correction of class II malocclusion remained stable 7 years after FR-2 treatment mainly due to the stability of the skeletal changes.

Introduction

Class II malocclusion has been studied frequently in orthodontics because it is found in one-third of the population (Proffit *et al.*, 2013). Mandibular retrognathism has been associated with skeletal class II malocclusion (McNamara, 1981). For these patients, a therapy for stimulating mandibular growth by means of forward positioning of the mandible provided by functional appliances often is indicated (McNamara and Brudon, 2001).

Functional appliances were introduced in the early 1900s and since then have gained popularity worldwide. One of these appliances is the function regulator (FR-2), proposed in the 1960s by Fränkel (1966, 1969a,b). The FR-2 appliance was designed by Fränkel as an exercise device used to correct the function of the circumoral musculature. According to Fränkel (1966, 1969a,b), a normal pattern of muscular behaviour promotes normal skeletal and dental development, maintaining the new mandibular position.

There is consensus in the literature that FR-2 treatment corrects class II malocclusion. However, some studies have shown that class II correction was achieved due to an increase in mandibular growth in comparison with untreated subjects (McNamara *et al.*, 1985; Falck and Fränkel, 1989; Perillo *et al.*, 1996; Toth and McNamara, 1999; Almeida *et al.*, 2002a,b; Cevidanes *et al.*, 2003; Cevidanes *et al.*, 2005); others also report restriction of maxillary growth (Creekmore and Radney, 1983; Nielsen, 1984). On the other hand, some investigations observed only dentoalveolar effects (Robertson, 1983; Remmer *et al.*, 1985).

Nevertheless, the stability of the changes promoted by FR-2 treatment over time is of great clinical significance. There are only four long-term studies (Falck, 1991; Perillo *et al.*, 1996; Freeman *et al.*, 2009; Perillo *et al.*, 2011) of FR-2 treatment. Fixed and removable appliances were utilized in the post-treatment period in two studies (Perillo *et al.*, 1996; Perillo *et al.*, 2011); for the two other studies (Falck, 1991;

The use of functional appliances in contemporary orthodontic practice

A. T. DiBiase,*[1] M. T. Cobourne[2] and R. T. Lee[3]

IN BRIEF

- Describes the different types of functional appliance.
- Explains the different ways in which functional appliances work.
- Explores the evidence behind claims that functional appliances affect skeletal growth.
- Outlines how functional appliances are used in orthodontic practice and their limitations.

PRACTICE

Functional appliances have been used for over 100 years in orthodontics to correct Class II malocclusion. During this time numerous different systems have been developed often accompanied by claims of modification and enhancement of growth. Recent clinical evidence has questioned whether they really have a lasting influence on facial growth, their skeletal effects appearing to be short term. However, despite these findings, the clinical effectiveness of these appliances is acknowledged and they can be very useful in the correction of sagittal arch discrepancies. This article will discuss the clinical use of functional appliances, the underlying evidence for their use and their limitations.

INTRODUCTION

The term functional appliance refers to a large and diverse family of orthodontic appliances designed mainly to correct Class II malocclusion. They were developed primarily in Europe but have been adopted by orthodontists in many countries. They all work by posturing the lower jaw forward, the stretched musculature and soft tissues creating a force, which is transmitted to the dentition. In addition, the soft tissue envelope surrounding the teeth is changed. This results in tooth movement, establishment of a new occlusal relationship and reduction of the overjet. The efficiency of these appliances in the correction of sagittal discrepancies in growing patients has intrigued orthodontists for many years, particularly the question of whether they significantly affect skeletal growth. There has been a lot of mystery and misinformation associated with their use, often supported by quasi-scientific theories of growth. Many of the claims made in association with these appliances are in the form of case reports, or retrospective studies, using unreliable and over-complicated cephalometric analyses, with all the inherent bias associated with these types of study.[1] More recently, the results of several large prospective clinical trials have provided the best evidence of what these appliances can do and equally importantly, what they do not do.

The development and use of functional appliances was pioneered in Europe early in the twentieth century, at the same time that fixed appliances were being developed in the USA. A simple monobloc appliance was described by Pierre Robin in 1902[2] for use in mandibular retrognathia and functional jaw expansion, it was the precursor of the appliance used for the treatment of Class II malocclusions described by Viggo Andresen while working at the dental school in Oslo. The story goes that following fixed appliance therapy on his daughter he fitted her with a modified upper Hawley type retainer with a lower lingual flange that guided the mandible forward into an ideal inter-arch relationship. The appliance was fitted as a retainer during her three month summer holidays to be worn at night, and it corrected her Class II relationship. Andresen refined the technique and appliance, with the assistance of Karl Häupl, and coined the phrase 'functional jaw orthopedics' to encapsulate their philosophy of how the appliances worked. A detailed history on functional appliances and the personalities involved has been published by Levrini and Favero.[3]

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Refereed Paper
Accepted 12 November 2014
DOI: 10.1038/sj.bdj.2015.44
©British Dental Journal 2015; 218: 123-128

TYPES OF FUNCTIONAL APPLIANCES

Functional appliances can either be removable or fixed. Numerous different types and designs have been described usually bearing the name of their inventor and incorporating components reflecting their philosophy. Functional appliances all have a postural effect on the mandible, although how this is achieved and the auxiliary components they incorporate vary between different systems.

Fig. 1 Modified Andresen activator. The original design did not have lower incisor capping or Adams cribs, which have both been added for retention

Removable functional appliances

Activators

The original Andresen-Häupl activator was constructed from a single block (or monobloc) of Vulcanite, which was later replaced by acrylic (Fig. 1). The postural element of the appliance is achieved by a lingual extension of the bloc in the lower arch. It was deliberately made loose to encourage activation of the protractor and elevator muscles to keep it in place. Apart from this postural effect it is designed to be a passive appliance, although guided eruption of the buccal dentition can be achieved by facets cut into the bloc. Numerous variations of the activator have been developed. Increased

European Journal of Orthodontics 36 (2014) 164–172
doi:10.1093/ejo/cjt013
Advance Access publication 24 April 2013

Dentoskeletal effects of Twin Block and Herbst appliances in patients with Class II division 1 mandibular retrognathy

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SUMMARY

OBJECTIVE: The aim of this study is to evaluate dentoskeletal effects of Herbst and Twin Block (TB) appliance therapies in Skeletal Class II malocclusion.

SUBJECTS AND METHODS: Herbst group consisted of 11 girls and 9 boys (mean age = 12.74 ± 1.43 years), TB group comprised of 10 girls and 10 boys (mean age = 13.0 ± 1.32 years), and control group included 9 girls and 11 boys (mean age = 12.17 ± 1.47 years). Mean treatment/observation times were 15.81 ± 5.96 months for Herbst, 16.20 ± 7.54 months for TB, and 15.58 ± 3.13 months for control group. Pre-treatment (T0) and post-treatment (T1) lateral cephalograms were traced using a modified Pancherz's cephalometric analysis. Inter-group differences were evaluated with one-way analysis of variance, and intra-group differences were assessed with paired samples *t*-test at the $P < 0.05$ level.

RESULTS: In control group, all sagittal and vertical skeletal measurements increased as a result of continuing growth. However, skeletal discrepancy and overjet remained unchanged. After functional appliance therapy, greater increases were recorded in TB group for all mandibular skeletal measurements compared with those in control group. Upper dental arch distalization and lower incisor protrusion were significant in Herbst group, compared with control. All face height measurements increased after functional appliance therapy.

IMPLICATIONS AND CONCLUSIONS: In TB group, the treatment effects were mainly due to mandibular skeletal changes. Both skeletal and dental changes contribute to Class II correction with Herbst appliance therapy. Herbst appliance may be especially useful in Skeletal Class II patients with maxillary dentoalveolar protrusion and mandibular dentoalveolar retrusion, whereas TB appliance may be preferred for skeletal mandibular retrognathy patients.

Introduction

Patient cooperation is one of the most important factors for successful functional appliance treatment. Need for cooperation is reduced with the use of fixed functional appliances. The Herbst appliance has gained widespread acceptance and is suggested to be the most effective appliance in correcting Class II malocclusions (Pancherz, 1997).

Although fixed functional appliances reduce the need for patient cooperation, they are tooth-borne appliances. On the other hand, removable functional appliances are more tissue borne and they are more likely to produce skeletal changes (Mills and McCulloch, 1998).

Twin Block (TB) can be worn for 24 hours and takes the advantage of all functional forces applied to dentition (Clark, 1982, 2002). Because of its small size, patients adopt it easily and speech disturbance is minimized (Mills and McCulloch, 1998).

The cast splint design is one of the most recent designs of Herbst appliance (Pancherz, 2003). Treatment effects of cast splint Herbst appliance (Ruf and Pancherz, 1998; Hägg *et al.*, 2002; Weschler and Pancherz, 2005; Martin and Pancherz, 2009) and TB appliance (Illing *et al.*, 1998; Lund and Sandler, 1998; Toth and Mcnamara, 1999; Bacetti *et al.*, 2000; Mills and McCulloch, 2000; Trenouth, 2000) were evaluated in adolescents.

Schaefer *et al.* (2004) compared the treatment effects of TB and Herbst appliances. They found that molar relationship and sagittal maxillomandibular discrepancy correction were greater for TB appliance. O'Brien *et al.* (2003a) evaluated the efficacy of Herbst and TB appliances and reported similar dental and skeletal effects. Because of high cooperation rates, they suggested that Herbst appliance could be a good treatment alternative for treating adolescents with Class II division 1 malocclusions (O'Brien *et al.*, 2003a). Neither of the studies included a control group to compare the effects of the appliances with an untreated sample.

In the literature, there seems to be a consensus on the effectiveness of both appliances, but the lack of comparable studies leaves questions regarding which appliance is more effective. Thus, the aim of this prospective clinical study is to compare the dentoskeletal effects of TB and Herbst appliances in patients with Class II division 1 mandibular retrognathy. The study also includes an untreated control sample to be compared with treatment groups.

Case Report

Management of severe Class II malocclusion with sequential modified twin block and fixed orthodontic appliances

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Abstract

Functional appliance is an effective way of treating skeletal Class II malocclusion in children and adolescents. A 12 months stepwise mandibular advancement protocol with Herbst appliance has been proved to enhance condylar growth and improve mandibular prognathism. The present case report documents a 12-year-old boy presenting with Angle's Class II, division 1 malocclusion associated with excessive overjet (11 mm), 100% deep bite, and retrognathic mandible. He was treated by a phase I growth modification therapy using twin block appliance with lip pads in a stepwise mandibular advancement protocol followed by a phase II preadjusted Edgewise appliance therapy.

Key words: Angle Class II malocclusion, functional appliances, myofunctional therapy

INTRODUCTION

Based on the incisor relationship, Class II malocclusion is defined as the lower incisor edges lying posterior to the cingulum plateau of the upper incisors resulting in an increase in overjet.[1] The prevalence of having an overjet >10 mm has been reported to be around 0.2% of the population.[2] Large overjet, especially in children and adolescents is associated with an increased risk of traumatic injury to the upper anterior teeth and psychological distress which results in loss of self-esteem and problems with social interaction.

Correction of Class II malocclusion may be approached by growth modification, dental camouflage, and surgical orthodontics.[2] For treating growing Class II patients, functional appliance is often applied in the stage of late mixed dentition or early permanent dentition to reduce excessive overjet by stimulating the growth of the mandible.[3]

The following case report documents a 12-year-old boy with 11 mm overjet treated by a phase I growth modification therapy using twin block appliance with lip pads in a stepwise mandibular advancement protocol[4-6] followed by a phase II preadjusted Edgewise appliance therapy to settle the occlusion and correct the remaining dental discrepancy.

CLINICAL EXAMINATION AND DIAGNOSIS

A 12-year-old boy reported to the clinic complaining of forwardly placed upper front teeth. Extraorally, the patient had no apparent facial asymmetry. He had mesoprosopic

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	DOI: 10.4103/2321-1407.177966

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How to cite this article: Chowdhary S. Management of severe Class II malocclusion with sequential modified twin block and fixed orthodontic appliances. APOS Trends Orthod 2016;6:113-8.

Twenty-year clinical experience with fixed functional appliances

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DOI: *https://doi.org/10.1590/2177-6709.23.2.087-109.sar*

Introduction: Considering the large number of fixed functional appliances, choosing the best device for your patient is not an easy task. **Objective:** To describe the development of fixed functional appliances as well as our 20-year experience working with them. **Methods:** Fixed functional appliances are grouped into flexible, rigid and hybrid. They are different appliances, whose action is described here. Four clinical cases will be reported with a view to illustrating the different appliances. **Conclusions:** Rigid fixed functional appliances provide better skeletal results than flexible and hybrid ones. Flexible and hybrid appliances have similar effects to those produced by Class II elastics. They ultimately correct Class II with dentoalveolar changes. From a biomechanical standpoint, fixed functional appliances are more recommended to treat Class II in dolichofacial patients, in comparison to Class II elastics.

Keywords: Orthodontics. Class II malocclusion. Fixed functional appliance.

Introdução: considerando-se o grande número de aparelhos propulsores mandibulares, não é uma tarefa fácil escolher o melhor deles para o seu paciente. **Objetivo:** descrever o desenvolvimento desses aparelhos e a experiência clínica de vinte anos dos autores na sua utilização. **Métodos:** os aparelhos funcionais fixos aqui apresentados foram classificados em flexíveis, rígidos e híbridos, e o modo de ação de cada um deles foi descrito e ilustrado por meio de quatro casos clínicos. **Conclusões:** os aparelhos propulsores rígidos fornecem mais resultados esqueléticos do que os flexíveis e os híbridos. Esses últimos têm efeito semelhante ao uso de elásticos com direção de Classe II e, basicamente, corrigem a má oclusão de Classe II com alterações dentoalveolares. Do ponto de vista biomecânico, os propulsores fixos estão mais indicados para tratar a Classe II em pacientes dolicofaciais do que os elásticos de Classe II.

Palavras-chave: Ortodontia. Má oclusão de Classe II. Propulsor mandibular.

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» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

How to cite: Moro A, Borges SW, Spada PP, Morais ND, Correr GM, Chaves Jr. CM, Cevidanes LHS. Twenty-year clinical experience with fixed functional appliances. Dental Press J Orthod. 2018 Mar-Apr;23(2):87-109. DOI: https://doi.org/10.1590/2177-6709.23.2.087-109.sar

Submitted: January 05, 2018
Revised and accepted: February 23, 2018

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Fixed functional appliances with multibracket appliances have no skeletal effect on the mandible: A systematic review and meta-analysis

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Introduction: Our aim was to assess the skeletal mandibular changes (anteroposterior and vertical) in circumpubertal patients with fixed functional appliances installed on multibracket appliances compared with untreated patients. **Methods:** An open-ended electronic search of 4 databases (PubMed, Embase, Cochrane Library, and Web of Science) up to April 2014 was performed. Additional searches of relevant journals, reference lists of the retrieved articles, systematic reviews, and gray literature were performed. Specific inclusion and exclusion criteria were applied to identify relevant articles. Quality was evaluated using the Cochrane Collaboration risk of bias tool and the Newcastle-Ottawa scale for prospective controlled clinical trials. Meta-analyses were conducted with fixed and random effects models as appropriate. Statistical heterogeneity was also examined. **Results:** Seven articles were included in the qualitative synthesis and 5 in the meta-analysis. The included randomized controlled trials were at high risk of bias, and the methodologic quality of the prospective controlled clinical trials was high. Based on assessment of the fixed functional appliance phase in isolation, no difference in mandibular anteroposterior positional changes (SNB angle) (standard mean difference, 0.11°; 95% CI, −0.28, 0.50) was found between the treated and control groups. The vertical dimension was not influenced by the fixed functional appliance treatment. **Conclusions:** There is little high-quality evidence concerning the relative influence of fixed functional appliances on skeletal and dentoalveolar changes. However, based on the limited evidence, it appears that they have little effect on the skeletal mandibular parameters. (Am J Orthod Dentofacial Orthop 2016;149:612-24)

Skeletal Class II malocclusion is characterized by a sagittal discrepancy caused by mandibular retrusion or maxillary excess. The most common source is mandibular retrusion, which affects about one third of the population.[1] Mandibular retrusion is managed in growing patients with functional appliances (removable and fixed) designed to alter the anteroposterior and vertical positions of the mandible and to induce supplementary mandibular growth and remodeling of the condyle.

Fixed functional appliances (FFA) are compliance-free, tooth-borne appliances. They do not require a second phase of treatment when used with multibracket appliances (MBA). They are classified into 4 groups: rigid, flexible, hybrid, and substitutes for elastics.[2] They may be categorized into 2 major groups according to the timing of the MBA. The Herbst[3] and the mandibular advancement repositioning appliance[4] can be applied before the MBA. The Jasper jumper,[5] Forsus Nitinol Flat Spring,[6] Forsus FatigueResistant Device,[7] Twin Force Bite Corrector,[8] Sabbagh Universal Spring,[9] and integrated Herbst[10] require an alignment and leveling phase with the MBA in preparation for application on a rigid stainless steel archwire attached to the teeth through the MBA.

There is considerable debate as to whether FFAs can stimulate mandibular growth and potentially lead to lasting skeletal changes. Several systematic reviews have focused on the treatment effects of the removable functional appliance (RFA),[11-15] FFA,[16-18] or both.[19] The

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Submitted, January 2015; revised and accepted, November 2015.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2015.11.023

ORIGINAL ARTICLE

AJO-DO

Three-dimensional treatment outcomes in Class II patients treated with the Herbst appliance: A pilot study

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Introduction: The aims of this study were to analyze 3-dimensional skeletal changes in subjects with Class II malocclusion treated with the Herbst appliance and to compare these changes with treated Class II controls using 3-dimensional superimposition techniques. **Methods:** Seven consecutive Herbst patients and 7 Class II controls treated with Class II elastics who met the inclusion criteria had cone-beam computed tomographs taken before treatment, and either after Herbst removal or at posttreatment for the control subjects. Three-dimensional models were generated from the cone-beam computed tomography images, registered on the anterior cranial bases, and analyzed using color maps and point-to-point measurements. **Results:** The Herbst patients demonstrated anterior translation of the glenoid fossae and condyles (right anterior fossa, 1.69 ± 0.62 mm; left anterior fossa, 1.43 ± 0.71 mm; right anterior condyle, 1.20 ± 0.41 mm; left anterior condyle, 1.29 ± 0.57 mm), whereas posterior displacement predominated in the controls (right anterior fossa, −1.51 ± 0.68 mm; left anterior fossa, −1.31 ± 0.61 mm; right anterior condyle, −1.20 ± 0.41 mm; left anterior condyle, −1.29 ± 0.57 mm; $P < 0.001$). There was more anterior projection of B-point in the Herbst patients (2.62 ± 1.08 mm vs 1.49 ± 0.79 mm; $P < 0.05$). Anterior displacement of A-point was more predominant in the controls when compared with the Herbst patients (1.20 ± 0.53 mm vs −1.22 ± 0.43 mm; $P < 0.001$). **Conclusions:** Class II patients treated with the Herbst appliance demonstrated anterior displacement of the condyles and glenoid fossae along with maxillary restraint when compared with the treated Class II controls; this might result in more anterior mandibular projection. (Am J Orthod Dentofacial Orthop 2013;144:818-30)

Treatment of Class II malocclusions is a common challenge for orthodontists in the United States. Approximately one third of all patients have a Class II Division 1 malocclusion.[1,2] Mandibular retrognathism is the primary etiologic factor in most of those patients.[3,4] Functional appliances have been shown to be effective in correcting Class II malocclusions by decreasing overjet and achieving Angle Class I canine and molar relationships.[3-7] Eliminating patient compliance factors and delivering continuous forces give fixed functional appliances a distinct treatment advantage compared with removable appliances. Many studies have reported the greatest anteroposterior improvements in mandibular projection when using fixed Herbst functional appliances.[3,4,7-12]

Functional appliances, such as the Herbst, have been purported to improve mandibular projection, consequently improving the underlying skeletal discrepancies.[7,8,10,13] However, the available data that examine the extent of skeletal vs dentoalveolar adaptation in Class II correction with functional appliances are controversial.[5,6,13,14] The skeletal component of Class II correction has been reported to be from 13% to 85%.[5,11,14-21] Variations in reported skeletal changes are due to a number of factors ranging from physiologic and anatomic inconsistencies in the study subjects to limitations in the study methodologies.

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Submitted, May 2013; revised and accepted, July 2013.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2013.07.014

Original Article

Long-Term Dentoskeletal Changes with the Bionator, Herbst, Twin Block, and MARA Functional Appliances

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ABSTRACT

Objective: To determine if the long-term dentoskeletal changes in patients treated with tooth-borne functional appliances were comparable to each other and to matched controls.

Materials and Methods: The experimental sample consisted of 80 consecutively treated patients who were equally divided into Bionator, Herbst, Twin Block, and mandibular anterior repositioning appliance (MARA) groups. The control group comprised 21 children with untreated skeletal Class II malocclusions. Lateral cephalograms were taken for the treated group at T_1 (initial records), T_2 (completion of functional therapy), and T_3 (completion of fixed appliance therapy). A repeated measure analysis of variance (ANOVA) was used to assess the differences between and within groups. If ANOVA results were significant, Tukey-Kramer tests were used to determine where the significant differences occurred.

Results: (1) Temporary restriction of maxillary growth was found in the MARA group (T_2–T_1). (2) SNB increased more with the Twin Block and Herbst groups when compared with the Bionator and MARA groups. (3) The occlusal plane significantly changed in the Herbst and Twin Block groups. (4) The Twin Block group expressed better control of the vertical dimension. (5) The overbite, overjet, and Wits appraisal decreased significantly with all of the appliances. (6) The Twin Block group had significant flaring of the lower incisors at the end of treatment. (7) Over the long-term, there were no significant soft tissue changes among treated and untreated subjects.

Conclusions: No significant dentoskeletal differences were observed long-term, among the various treatment groups and matched controls. (*Angle Orthod* 2010;80:18–29.)

KEY WORDS: MARA; Long-term changes; Functional appliances

INTRODUCTION

The most common skeletal problem in orthodontics is the Class II malocclusion characterized by mandibular retrognathia.[1–5] In addition, most subjects with this type of malocclusion exhibit narrow maxillary arches.[4,6]

The effects and stability of early Class II treatment with functional appliances has been surrounded by much controversy and uncertainty. It has been shown in histologic studies with laboratory animals that when the mandible is brought forward there is an increase in cellular activity at the condylar head as well as an increase in mandibular length.[7–10] Numerous studies have shown condylar and glenoid fossa remodeling following the use of various types of functional appliances.[11–37] Questions that still remain are: (1) Are these findings substantiated with clinical research in humans; (2) Is the growth of the mandible different with functional treatment than that of similar controls; and (3) Is this treatment stable over the long-term?

There are multiple factors that influence the stability of early Class II treatment including mandibular rotational growth patterns,[38,39] airway obstructions,[40,41] proper manipulation of appliances, treatment timing,[11,12] and retention.[13–16] There are few investigators who have studied the long-term stability with functional appliances, and most have reported favorable findings with prolonged retention.[11,14–16]

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Accepted: April 2009. Submitted: February 2009.

 DOI: 10.2319/020109-11.1

Effects of Class II division 1 malocclusion treatment with three types of fixed functional appliances

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DOI: https://doi.org/10.1590/2177-6709.24.5.030-039.oar

Objective: This study aimed at comparing the dentoskeletal changes in patients with Class II division 1 malocclusion, treated with three types of fixed functional appliances. **Methods:** A sample comprising 95 patients with the same malocclusion, retrospectively selected, and divided into four groups, was used: G1 consisted of 25 patients (mean age 12.77 ± 1.24 years) treated with Jasper Jumper appliance; G2, with 25 patients (mean age 12.58 ± 1.65 years) treated with the Herbst appliance; G3, with 23 patients (mean age 12.37 ± 1.72 years) treated with the Mandibular Protraction Appliance (MPA); and a Control Group (CG) comprised of 22 untreated subjects (mean age 12.66 ± 1.12 years). Intergroup comparison was performed with ANOVA, followed by Tukey test. **Results:** The Jasper Jumper and the Herbst group showed significantly greater maxillary anterior displacement restriction. The Jasper Jumper demonstrated significantly greater increase in the mandibular plane angle, as compared to the control group. The MPA group demonstrated significantly greater palatal inclination of the maxillary incisors. Vertical development of the maxillary molars was significantly greater in the Herbst group. **Conclusions:** Despite some intergroup differences in the amount of dentoskeletal changes, the appliances were effective in correcting the main features of Class II malocclusions.

Keywords: Cephalometry. Orthodontic appliance design. Malocclusion, Angle Class II. Orthodontic appliances, functional.

Objetivo: o objetivo do presente estudo foi comparar as alterações dentoesqueléticas em pacientes com má oclusão de Classe II, divisão 1, tratados com três tipos de aparelhos funcionais fixos. **Métodos:** a amostra compreendeu 95 pacientes, selecionados retrospectivamente e divididos em quatro grupos: G1, composto por 25 pacientes (idade média de 12,77 ± 1,24 anos), tratados com aparelho Jasper Jumper; G2, com 25 pacientes (idade média de 12,58 ± 1,65 anos), tratados com aparelho Herbst; G3, com 23 pacientes (idade média de 12,37 ± 1,72 anos), tratados com o Aparelho de Protração Mandibular (APM); e um Grupo Controle (GC), composto por 22 sujeitos não tratados (idade média de 12,66 ± 1,12 anos) que apresentavam a mesma má oclusão. A comparação intergrupos foi realizada com ANOVA, seguida do teste Tukey. **Resultados:** os grupos Jasper Jumper e Herbst apresentaram significativamente maior restrição de deslocamento anterior da maxila. O Jasper Jumper demonstrou aumento significativamente maior no ângulo do plano mandibular, em comparação ao grupo controle. O grupo APM demonstrou inclinação palatina significativamente maior dos incisivos superiores. O desenvolvimento vertical dos molares superiores foi significativamente maior no grupo Herbst. **Conclusões:** apesar de algumas diferenças intergrupos na quantidade de alterações dentoesqueléticas, os aparelhos foram eficazes na correção das principais características das más oclusões de Classe II.

Palavras-chave: Cefalometria. Designs de aparelhos Ortodônticos. Má oclusão de Classe II. Aparelho ortodôntico funcional.

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» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

How to cite: Brito DBA, Henriques JFC, Fiedler CF, Janson G. Effects of Class II division 1 malocclusion treatment with three types of fixed functional appliances. Dental Press J Orthod. 2019 Sept-Oct;24(5):30-9.
DOI: https://doi.org/10.1590/2177-6709.24.5.030-039.oar

Submitted: March 09, 2018 - **Revised and accepted:** November 25, 2018

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Original Article

Class II correction in orthodontic patients utilizing the Mandibular Anterior Repositioning Appliance (MARA)

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ABSTRACT

Objectives: To evaluate skeletal and dentoalveolar changes produced by the Mandibular Anterior Repostioning Appliance (MARA) in the treatment of Class II malocclusion in adolescent patients.

Materials and Methods: Lateral cephalograms of 24 patients, mean age 12.40 years, with a Class II malocclusion consecutively treated with MARA were compared with a historical control group. Changes were evaluated using the Pancherz superimposition and grid analysis pre- and posttreatment. Independent sample *t*-test, Mann-Whitney *U*-test, and Pearson correlation coefficient analysis were performed.

Results: Significant differences were seen between the treatment and control groups during the 12 month period. Improvement in Class II relationship in the MARA group resulted from skeletal and dentoalveolar changes. There was a 7-mm molar correction and a 4.7-mm overjet reduction. There was also an increase in the mandibular base of 3.3 mm with the lower molar and incisor coming forward 2.6 mm and 2.2 mm, respectively. No significant headgear effect was shown on the maxilla. The maxillary incisor position remained unchanged, whereas the molar distalized 1.8 mm. The anterior lower facial height had an overall increase of 2.2 mm.

Conclusions: The MARA was successful in achieving a Class I molar relationship and reducing the overjet in Class II malocclusions. This was the result of both skeletal and dentoalveolar changes. (*Angle Orthod.* 2019;89:404–410.)

KEY WORDS: Class II malocclusion; MARA; Functional appliance; Class II therapy

INTRODUCTION

Treatment of Class II malocclusion is one of the most frequent challenges facing orthodontists in everyday practice. It has been estimated that about 35% of the US population has a Class II malocclusion based on overjet.[1] Class II malocclusion, unlike what the Angle sagittal dental classification implies, is a multifactorial entity that involves a combination of one or more dental and skeletal factors.[2] Treatment of Class II malocclusions has varied with time and place.[3] The Herbst appliance has been considered the gold standard for a fixed functional appliance over the past half century.[4,5] A more recent fixed functional appliance that is gaining popularity, especially in the United States, is the Mandibular Anterior Repostioning Appliance (MARA) originally developed by Toll.[6,7] Scientific studies on the MARA have been limited. Pangrazio-Kulbersh et al.[8] evaluated the treatment effects of the MARA in a cephalometric study of patients age 9.5 to 15.8 years with a mean treatment time of 10.7 months. Class II correction was achieved by means of both skeletal and dental changes. Proper molar relationship was obtained by 47% skeletal changes and 53% dental changes. Skeletal changes showed an increase in mandibular length and anterior and posterior facial heights but minimal restraint of the maxilla. The dental effects included distalization of maxillary molars, mesialization of molars and incisors, and mild proclination of the lower incisors.[8] Siara-Olds et al.[9] evaluated the long-term dentoskeletal changes in patients treated with Bionator, Herbst, Twin Block, and MARA functional appliances with matched con-

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Accepted: October 2018. Submitted: June 2018.
Published Online: January 2, 2019

 DOI: 10.2319/062618-478.1

Original Article

Treatment effects of the mandibular anterior repositioning appliance in patients with Class II skeletal malocclusions

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ABSTRACT

Objective: To examine the changes produced by the mandibular anterior repositioning appliance (MARA) appliance and compare the treatment effects to an untreated Class II control group.

Materials and Methods: Thirty consecutively treated patients were matched with an untreated control group. Lateral cephalograms were taken at T1, 5 months pre-MARA (CVMS 2.7); T2, immediately after MARA removal and prior to placement of full fixed edgewise appliances (CVMS 4.2); and T3, at least 2 years after MARA removal and completion of edgewise treatment (CVMS 5.4). The mean age of the MARA patients was 11.9 years for boys and 10.8 years for girls. Repeated-measures analysis of variance (ANOVA) was used to assess if the samples were morphologically comparable at the outset and to test if there were significant differences between the groups for the various increments of change. Given a significant ANOVA, the source of the difference was explored via Tukey-Kramer tests.

Results: Restriction of maxillary growth and no significant mandibular growth were observed with the MARA appliance. The Class II correction was obtained mainly by slight maxillary molar distalization and intrusion, in addition to mesial migration of the lower molars and flaring of the lower incisors. No vertical effect was observed with this appliance.

Conclusion: The MARA appliance was effective in the treatment of Class II malocclusions. Restriction of maxillary growth and dentoalveolar changes in the maxillary and mandibular arches were responsible for the correction of the Class II malocclusion. Significant mandibular growth did not contribute to this correction. (*Angle Orthod.* 2012;82:971–977.)

KEY WORDS: MARA; Maxillary growth restriction; Dentoalveolar changes; Molar distalization

INTRODUCTION

Class II malocclusions present a major and common challenge to orthodontists. Based on an overjet greater than 4 mm, the Third National Health and Nutrition Examination Survey (NHANES III) data indicated an 11% prevalence of Class II malocclusion in the US population. It has been reported that this malocclusion accounts for 20% to 30% of all orthodontic patients.[1] Seventy-five percent of the Class II patients exhibit a retrusive chin position.[2,3] Once the skeletal Class II pattern has been established, it remains as such during the growing years and thereafter.[4–6]

The decision as to which is the most effective technique to use in the treatment of growing patients with skeletal and dental Class II malocclusions has long been the source of considerable debate in the orthodontic literature.

Four commonly used methods for Class II correction include (1) selective extraction therapy, (2) orthopedic forces delivered with headgear, (3) functional jaw orthopedics using functional appliances, and, more recently, (4) molar distalization with or without temporary anchorage devices.

The term *functional appliance* refers to a removable or fixed appliance designed to alter the mandibular position both sagittally and vertically, resulting in

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Accepted: January 2012. Submitted: December 2011.
Published Online: March 21, 2012

http://dx.doi.org/10.17159/2519-0105/2019/v74no10a7

The Mandibular Anterior Repositioning Appliance (MARA) - A report of three cases

SADJ November 2019, Vol. 74 No. 10 p561 - p570

JH Weber[1], P Botha[2], SH Dawjee[3]

SUMMARY

Introduction

The MARA (Mandibular Anterior Repositioning Appliance) is a fixed functional appliance used in the treatment of mandibular deficiencies.

Aims and objectives

To demonstrate the clinical capabilities, treatment effects and the expected duration of treatment when using the MARA, therefore creating awareness of the MARA as a treatment alternative to other functional appliances designed for correction of Class II malocclusions.

Methods

A retrospective study exploring the anteroposterior dimensional changes in the maxilla and mandible brought about by the MARA and the associated treatment time. The samples were the first three cases treated by a clinician inexperienced with the clinical application of the MARA and served as an ideal introduction to the treatment technique.

Results

In this study mandibular growth stimulation and temporomandibular joint remodeling may have been the main contributing factors in the resolution/improvement of the Class II malocclusions under treatment.

Conclusion

The MARA is a useful non-compliance appliance that produces exceptional treatment results when applied in combination with full fixed appliances. The changes observed were predominantly of a skeletal nature in the anteroposterior dimension. Maxillary growth restriction may also have played a role in the correction of these treated Class II abnormalities.

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1. **Johann H Weber:** Principal researcher, writing - 65%
2. **Piet Botha:** Treatment, research and writing - 35%
3. **Salahuddien M Dawjee:** Writing and advisor - 10%

Keywords

MARA, Mandibular changes, Maxillary changes, SNA, SNB, ANB, WITS, Y-axis, Tweed angle, Facial angle, Mandibular growth.

INTRODUCTION

The idea of using a fixed functional appliance to stimulate mandibular growth was proposed by Angle and others of his peers many years ago, but the materials to make the concept an actuality in clinical practice were lacking. The development of stronger adhesives overcame this limitatation. The MARA was developed by Dr. D Toll and modified in 1994 by Dr. James E Eckhart to function as a fixed non-compliance appliance to correct Class II malocclusions.[1,2]

The decision as to which is the most effective technique to use in the treatment of growing patients with skeletal and dental Class II malocclusions has long been the source of considerable debate in the orthodontic literature.[3] A scientific orthodontic study yielding insightful and meaningful results must ensure that the individual/samples studied must be of the same clinical and functional characteristics, age and gender.

Some widely utilized treatment techniques in the correction of Class II malocclusions include:

- space creation by performing selective extractions of teeth, especially upper first premolars, in order to camouflage the Class II malocclusion, or a reduction in upper tooth size by enamel stripping, by palatal expansion, utilization of the leeway space, or by orthopedic manipulations of the mandible and maxilla produced by headgear.
- functional appliance therapy together with full fixed appliances.
- temporary anchorage devices (TAD's) used in the distalization of molars.
- orthognathic surgery.[4]

The lack of success with removable functional appliance treatment has been attributed to a lack of patient compliance and the inability to control the amount and direction of mandibular growth.[3]

ORIGINAL ARTICLE

Effects of the jasper jumper appliance in the treatment of Class II malocclusion

Rafael Pinelli Henriques*, Guilherme Janson**, José Fernando Castanha Henriques**, Marcos Roberto de Freitas**, Karina Maria Salvatore de Freitas***

ABSTRACT

Introduction: The Jasper Jumper is a fixed functional appliance which keeps the mandible in a protruded position by applying continuous light forces. Even though previous studies have revealed the clinical outcome of the appliance, there is still some debate about how much correction is achieved by skeletal changes vs. dentoalveolar changes. Objective: The objective of this study was to evaluate the skeletal and dentoalveolar effects of the treatment of Class II malocclusion with the Jasper Jumper appliance associated with fixed orthodontic appliances, compared to an untreated control group. **Material and Methods:** The sample comprised 47 subjects, divided into two groups: Group 1, with 25 patients at a mean initial age of 12.72 years, treated with the Jasper Jumper appliance for a mean period of 2.15 years; and Group 2 (Control), included 22 subjects at a mean initial age of 12.67 years, who were not submitted to any type of orthodontic treatment and presenting Class II malocclusion, observed by a mean period of 2.12 years. Lateral cephalograms before and after orthodontic treatment for group 1 and during the observational period for group 2 were evaluated. Initial and final dentoskeletal cephalometric variables and changes with treatment were compared between the groups by independent t tests. **Results:** When compared to the control group, the Jasper Jumper group presented greater restriction of anterior displacement of the maxilla and a greater maxillary retrusion, improvement of maxillomandibular relationship, reduction of facial convexity, greater protrusion and intrusion of mandibular incisors and a greater extrusion of mandibular molars, besides a greater reduction of overjet and overbite and improvement of molar relationship. **Conclusion:** The correction of the Class II in the group treated with the Jasper Jumper and fixed appliances was mainly due to restriction of maxillary growth, protrusion and intrusion of mandibular incisors and extrusion of mandibular molars.

Key-words: Class II malocclusion. Cephalometrics. Functional Appliance.

INTRODUCTION

When analyzing the prevalence of malocclusion, Class I is present in 55% of the Brazilian population and Class II, in 42%[25]. The latter is characterized by an anteroposterior discrepancy of skeletal bases, negatively influencing esthetics and self-esteem of patients, justifying the percentage of Class II patients who look for orthodontic

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ORIGINAL ARTICLE

AJO-DO

Long-term stability of Class II treatment with the Jasper jumper appliance

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Introduction: Treatment of Class II Division 1 malocclusion with orthopedic devices combined with fixed orthodontic appliances has shown excellent results when used in growing patients. We aimed to evaluate the long-term stability of the cephalometric changes obtained during Class II malocclusion correction with the Jasper jumper associated with fixed appliances. **Methods:** The treatment group comprised 24 patients who were evaluated at 3 stages: pretreatment, posttreatment, and long-term posttreatment. The control group comprised 15 subjects with normal occlusion. Intratreatment group comparisons among the 3 stages were performed with repeated measures analysis of variance, followed by Tukey tests. Intergroup comparisons of posttreatment changes and normal growth changes of the treatment group were performed with *t* tests. **Results:** Apical base relationship, maxillary incisor anteroposterior position, and overjet demonstrated significant relapses in relation to the control group. **Conclusions:** Most dentoalveolar changes obtained with the Jasper jumper followed by fixed appliances during treatment remained stable in the long term. However, apical base relationship, maxillary incisor anteroposterior position, and overjet demonstrated significant relapses in relation to the control group. Therefore, active retention time should be increased in the posttreatment period. (Am J Orthod Dentofacial Orthop 2017;152:663-71)

Class II malocclusions are of great concern to orthodontists, considering the high prevalence of this malocclusion.[1] Class II Division 1 malocclusion affects 12% to 49% of the population[2] and comprises approximately one third of patients seeking orthodontic treatment because of its important esthetic effect; it may be caused by varying combinations of skeletal and dental factors.[3]

Early intervention in patients with active growth using a combination of functional and fixed appliances can generate great outcomes in the treatment of Class II malocclusion.[2] The Jasper jumper appliance, a fixed device composed of a flexible force module, capable of promoting light and continuous force 24 hours a day through mandibular advancement, with freedom in jaw movement including laterality, ensures comfort without relying on patient compliance.[4]

The appliance promotes restrictive effects in forward displacement of the maxilla, dentoalveolar retraction of the maxillary dentition, and dentoalveolar protrusion of the mandibular dentition. Additionally, it features an intrusion force that benefits vertical control in patients with an unfavorable growth pattern and increased overbite during correction of the maxillomandibular discrepancy, demonstrating it to be a successful treatment choice for this malocclusion.[4-6]

As important as achieving malocclusion correction is the long-term stability of the dentoskeletal changes. However, follow-up studies in the literature have evaluated only the period from jumper removal to removal of the fixed appliances,[7] or only during a short observation period of a few months with the use of retention,[8] which does not represent the long-term stability of this treatment approach. Several authors have demonstrated the need for long-term stability studies of treatment with this appliance.[1,6,9]

Noticing the lack of investigations in this area, we aimed to cephalometrically assess, after a minimum of 5 years, the long-term stability of the changes obtained in the correction of Class II Division 1 malocclusion with the Jasper jumper associated with fixed orthodontic appliances.

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
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Submitted, July 2016; revised and accepted, March 2017.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2017.03.029

Clinical and Experimental Health Sciences

Original Article / Özgün Araştırma

Investigation of Dentoskeletal and Soft Tissue Effects of Forsus Fatigue Resistant Device and Jasper Jumper Appliances in Class II Malocclusions

Sınıf II Maloklüzyonlarda Forsus Fatigue Resistant Device ve Jasper Jumper Apareylerinin Dentoiskeleletsel ve Yumuşak Doku Üzerine Etkilerinin İncelenmesi

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Cite this article as: Buyuk S.K., Genc E., Benkli Y.A., Arslan A. Investigation of Dentoskeletal and Soft Tissue Effects of Forsus Fatigue Resistant Device and Jasper Jumper Appliances in Class II Malocclusions. Clin Exp Health Sci 2018; 8: 291-295.

ABSTRACT

Objective: The aim of this study was to investigate skeletal, dental and soft tissue effects of Forsus Fatigue Resistant Device (FRD) and Jasper Jumper appliances in correction of Class II malocclusion.

Methods: 33 patients were divided into two groups as treated with Forsus FRD appliance (18 subjects: 8 females, 10 males-mean age: 15.79 ± 1.50 years) and treated with Jasper Jumper appliance (15 subjects: 9 females, 6 males-mean age: 16.12 ± 1.58 years), randomly. Initial and final lateral cephalometric radiographies were traced and analyzed digitally. The data were analyzed statistically.

Results: In the assessment of the skeletal parameters, both two groups had similar outcomes and there were no statistically significant differences (p>0.05). In both groups ANB, Convexity angles and Wits values decreased and maxillomandibular discrepancy improved on sagittal plan. Maxillary incisors were proclined in Forsus FRD group, and maxillary incisors were retroclined in Jasper Jumper treated group and there was a statistically significant difference between groups (p<0.05). In the assessment of mandibular incisor, proclination occurred in both two groups. In the soft tissue evaluation, facial profile was improved through upper lip retrusion and lower lip protrusion and there were no statistically significant differences between groups in these values (p>0.05).

Conclusion: The skeletal and soft tissue effects of the Forsus FRD and Jasper Jumper appliances were similar while there were some differences in dental effects. Some factors such as skeletal age, cephalometric values should be taken into consideration when making a choice about the fixed functional appliance.

Keywords: Class II malocclusion, fixed functional appliance, Jasper Jumper, Forsus FRD

ÖZ

Amaç: Bu çalışmanın amacı, Sınıf II maloklüzyonu düzeltmede kullanılan Forsus Fatigue Resistant Device (FRD) ve Jasper Jumper apareylerinin iskeletsel, dişsel ve yumuşak doku üzerine etkilerinin incelenmesidir.

Yöntemler: 33 hasta, Forsus FRD apareyi ile tedavi edilenler (18 birey: 8 kız, 10 erkek-ortalama yaş aralığı 15,79 ± 1,50) ve Jasper Jumper apareyi ile tedavi edilenler (15 birey: 9 kız, 6 erkek-ortalama yaş aralığı 16,12±1,58) olmak üzere randomize bir şekilde iki gruba ayrılmışlardır. Başlangıç ve bitiş lateral sefalometrik radyografiler dijital olarak çizilmiştir ve analiz edilmiştir. Veriler istatistiksel olarak analiz edilmiştir.

Bulgular: İskeletsel parametreler değerlendirildiğinde her iki grupta da benzer sonuçlar görülmektedir ve istatistiksel olarak anlamlı farklılıklar bulunmamıştır (p>0,05). Her iki grupta de ANB, Konveksite açıları ve Wits değerleri azalmış ve sagittal yönde maksillomandibular uyumsuzluk düzelmiştir. Forsus FRD apareyi ile tedavi edilen grupta üst keserler prokline olmuşlardır. Jasper Jumper apareyi ile tedavi edilen grupta ise üst keser retroklinasyonu mevcuttur ve gruplar arası karşılaştırmada istatistiksel olarak anlamlı bir farklılık mevcuttur (p<0,05). Alt keser dişler değerlendirildiğinde her iki grupta da proklinasyon meydana gelmiştir. Yumuşak doku değerlendirmesinde üst dudakta retrüzyon, alt dudakta ise protrüzyon ile yüz profilinde düzelme sağlanmıştır ve bu değerlerde gruplar arasında istatistiksel olarak anlamlı bir fark bulunmamıştır (p>0,05).

Sonuç: Forsus FRD ve Jasper Jumper apareylerinin iskeletsel ve yumuşak doku etkileri benzer olmakla birlikte dental etkilerinde bazı farklılıklar bulunmaktadır. Sabit fonksiyonel apareyin seçiminde hastanın iskeletsel yaşı, sefalometrik değerleri gibi faktörler göz önünde bulundurularak karar verilmesi gerekmektedir.

Anahtar Kelimeler: Sınıf II maloklüzyon, sabit fonksiyonel aygıt, Jasper Jumper, Forsus FRD

INTRODUCTION

Skeletal Class II malocclusions are a very common malocclusion type in orthodontic treatment (1). This type of malocclusion is often associated with mandibular skeletal retrusion. Therefore, the main goal of the skeletal Class II treatment protocol is to modify and direct mandibular growth (2). In this way, skeletal compliance and facial soft tissue profiles can be improved (3).

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ORAL SURGERY

Forsus Fatigue Resistant Device a Fixed Functional Appliances: An Update

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ABSTRACT

Objective: **Functional appliances play an important role in achieving an ideal facial profile. Forsus has been assessed by orthodontists extensively to notice significant improvements in dental and skeletal growth pattern. It can control overbite, modify dental eruption and result in a good soft tissue profile of face. The prime objective of our investigation is to update the forsus fatigue resistant device fixed functional appliances.**

Material and methods: **Online publication search engines were extensively searched using keyword combinations. Forest plot were analyzed for statistical analysis.**

Results: **Forsus produces statistically significant changes in antero-posterior relationship of dental arches and can be used as a fixed functional appliance during fixed orthodontic treatment.**

Conclusions: **Forsus is an effective mechanism for Class II correction, especially in patients with retrognathic chins and small mandibles.**

KEY WORDS

forsus, class II treatment, functional appliance, cephalometrics

INTRODUCTION

Around the globe Class II malocclusions affect twenty percent of the population and the Class II division 1 malocclusions are thought to be the most well-known issue experienced in orthodontics. Functional appliances would be the better decision for the growth adjustment and modification, but if the patient report after the pubertal growth spurt or during the late stages of puberty, and it also reduces the need of patient compliance then fixed functional appliance will be the more wise choice of treatment.

Different appliances have been invented to aid in for credible and effective orthodontic treatment. These range from extraoral to intraoral, inter-arch to intra-arch, fixed to removable and a combination of any of the above. Compliance of patients has always been an issue that orthodontics patients during the course of treatment. Literature demonstrated that just 29% of patients wear their elastics full time as per their specialists' guidelines, while 28% utilize them for at least 12 hours). The remaining 42%, however, only wear their elastics at night, rarely or not at all. Currently non-extraction plans and non-compliance therapies have gained popularity.

The Forsus™ FRD* is a three-piece, telescoping system, which incorporates a super-elastic nickel-titanium coil spring. The FRD attaches at the maxillary first molar and on the mandibular archwire, distal to either the canine or first premolar bracket. As the coil is compressed, continuous opposing forces are transmitted to the sites of attachment without the possibility of fatigue, thereby correcting Class II malocclusions. Forsus FRD provides one of the best treatment options for class II correction, especially for non-compliant patients, with stable long-term results achieved by sagittal forward displacement of mandible and remodeling at glenoid fossa. 3M Unitek helped Bill Vogt develop the Forsus Fatigue Resistant Device system. The appliance was later adapted into the Fatigue Resistant Device with a direct push rod with a 0.5 x 3.0 mm spring bar (45% nickel and 55% titanium). The aim of our investigation is to update the forsus fatigue resistant device fixed functional appliances (Forsus™).

MATERIAL AND METHOD

Publications from the PubMed, Medpilot, Medline, Science Direct, Google scholar and Thomson Reuters ISI web of Science electronic databases were searched. The combinations included any article published until May 7, 2015.

Searches were performed under the term "Forsus™." These searches yielded sixty-one articles. These were reviewed for relevance based on inclusion and exclusion criteria. Articles were excluded if they did not measure the effectiveness of Forsus™ treatment or were not written in English. Nine Articles were deemed of relevance with a high-quality study design and were included in this study for evaluation. The current literature suggests that Class II treatment with the Forsus™ appliance is an effective and efficient method to treat Class II malochussions in six months. It produces mainly a restraining effect on maxillary growth, while the Class II molar correction is derived primarily from dentoalveolar changes. Overjet and overbite is reduced through proclination,

Received on June 28, 2015 and accepted on April 7, 2016

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Correction of a Full Cusp Class II Malocclusion and Palatal Impingement with Intermaxillary Elastics

Abstract

A 13yr 5mo old female presented with a bilateral full cusp, Class II malocclusion, large overjet, deep curve of Spee and palatal impingement. A passive self-ligating appliance, with maxillary anterior bite turbos, was used as a platform for the application of an array of intermaxillary elastics. The severe Class II malocclusion, Discrepancy Index (DI) of 25, was conservatively corrected in 18 months to an excellent result, as documented with a Cast Radiograph Evaluation (CRE) of 21 and a Pink & White (P&W) dental esthetics score of 3. (Int J Othod Implantol 2015;38:54-72)

Key words:

large overjet, palatal impingement, bite turbos, early light short elastics, Class II orthodontic mechanics, finishing elastics, residual Class II relationship

History and Etiology

A 13-year-5-month-old female was referred by her dentist for orthodontic consultation (*Fig. 1*) because of difficulty incising food. There was no contributory medical or dental history. A clinical examination revealed protrusive lips, large overjet, deep lower curve of Spee, and palatal impingement (*Figs. 2 and* 3). Intraoral photographs and study casts confirmed a bilateral, full-cusp Class II molar relationship. Careful evaluation of the patient's age, facial profile, and occlusal problems suggested the etiology of the malocclusion was due to a lip trap (*lower incisors posture between the incisors*) and forward (*counterclockwise*) rotation of the mandibular arch.

The patient was treated to a pleasing result as shown in Figs. 4-9. Pre-treatment (*Fig. 7*) and post-treatment (*Fig. 8*) cephalometric and panoramic radiographs document the dental and skeletal relationships. Superimposed cephalometric tracings reveal the treatment achieved (*Fig. 9*). The details for diagnosis and treatment are discussed below.

Diagnosis

Skeletal:

- Skeletal Class II (*SNA 81°, SNB 78°, ANB 3°*)
- Mandibular plane angle (*SN-MP 26°, FMA 21°*)

Dental:

- Bilateral full cusp Class II molar relationship
- Overjet was 7mm (*Fig. 10*)
- Overbite 3.5 mm and the with palatal impingement.
- Curve of Spee was ~5mm.

Facial:

- Moderate convex profile with protrusive lips

SYSTEMATIC REVIEW CE AJO-DO

Correction of Class II malocclusion with Class II elastics: A systematic review

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Introduction: Although Class II elastics have been widely used in the correction of Class II malocclusions, there is still a belief that their side effects override the intended objectives. The aim of this systematic review was to evaluate the true effects of Class II elastics in Class II malocclusion treatment. **Methods:** A search was performed on PubMed, Scopus, Web of Science, Embase, Medline, and Cochrane databases, complemented by a hand search. Study eligibility criteria were the application of Class II elastics in Class II malocclusion treatment and the presentation of dental or skeletal outcomes of treatment. All age groups were included. **Results:** The search indentified 417 articles, of which 11 fulfilled the inclusion criteria. Four studied the isolated effects of Class II elastics, and 7 were comparisons between a single use of elastics and another method for Class II malocclusion correction. Because of the differences in treatment modalities in these articles, a meta-analysis was not possible. **Conclusions:** Based on the current literature, we can state that Class II elastics are effective in correcting Class II malocclusions, and their effects are primarily dentoalveolar. Therefore, they are similar to the effects of fixed functional appliances in the long term, placing these 2 methods close to each other when evaluating treatment effectiveness. Little attention has been given to the effects of Class II elastics on the soft tissues in Class II malocclusion treatment. (Am J Orthod Dentofacial Orthop 2013;143:383-92)

Class II malocclusion is a major reason that patients seek orthodontic treatment. Combinations of dental and skeletal factors ranging from mild to severe provide the multiple characters of this discrepancy.[1,2] Among other factors, the treatment protocols can widely vary according to professional ability, malocclusion severity, and patient compliance.[3-6]

There are a number of orthodontic techniques and appliances to treat Class II malocclusion; among these are Class II elastics.[7] In spite of their popularity,[8] some authors have attributed several side effects to the use of Class II elastics—eg, loss of mandibular anchorage, proclination of mandibular incisors, extrusion of maxillary incisors, and even worsened smile esthetics because of increased gum exposure—thus suggesting minimal use of intermaxillary elastics.[9-12] Also, there is the claim that the occlusal relationships produced might look good on dental casts but be less satisfactory from the perspective of skeletal relationships and facial esthetics. It also has been stated that Class II elastics can extrude the mandibular molars and the maxillary incisors, causing clockwise rotation of the occlusal plane and the mandible.[11,13]

Therefore, the main objectives of this systematic review were to evaluate whether Class II elastics are effective in correcting Class II malocclusions; to determine the true dental, skeletal, and soft-tissue effects when they are used as the primary Class II anteroposterior discrepancy treatment device in the short and long terms; and to compare the results with other Class II treatment modalities.

MATERIAL AND METHODS

With the objective to determine the most frequent uses and the main effects of Class II elastics in Class II malocclusion treatment, a search was performed in PubMed, Scopus, Web of Science, Embase, Medline, and Cochrane databases, complemented by a hand search, with no date limitation (Table I). The keywords were chosen with the help of a senior librarian.

To be accepted in this review, the application of Class II elastics in Class II malocclusion treatment should have been used in the clinical studies and mentioned in the

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The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.
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Submitted, July 2011; revised and accepted, October 2012.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2012.10.015

Available online at www.iponlinejournal.com

Journal homepage: www.innovativepublication.com/journal/ijodr

Case Report

Correction of skeletal class II malocclusion using class II elastics in an adolescent patient

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Abstract

Application of elastics in orthodontics has various outcomes in relation to maxillary arch, mandibular arch, facial pattern and occlusal plane. All these factors can be modified depending upon the response of the individual towards the treatment procedure. Elastics being a dependable mode of changing such parameters have been employed in orthodontics from time to time. In the present case report class II elastics were incorporated with a motive to stimulate growth and change or improve the facial profile as the individual was in a growing phase. With continuous application of elastics and patient cooperation satisfactory occlusion and facial profile was achieved for the patient.

Keywords: Class II malocclusion, Class II elastics, Growth, Profile.

Introduction

Evaluation and prediction of growth is an important prerequisite for assessing the remaining growth of an individual. Orthodontic treatment is mainly sort by the adult class of patients but it is always the best when growth is utilized by intervention during the adolescent phase of patient growth.[1] Response of an individual to growth modification is very subjective because few individuals respond better to treatment as they are early or late growers with considerable variations in the growth spurts respectively.[2] Assessing growth and favourably utilizing it is very difficult as it is important to keep a track on the ossification or growth status in an individual, in other words an operator should be able to diagnose and implicate treatment at the right time as it takes place at different chronological ages. Radiographs that can be put to use are hand wrist radiograph which provides with essentials of anatomy and ossification status, lateral cephalogram provides with information regarding the maturation status in cervical vertebrae and sinuses, OPG may be useful for predicting the growth status as per the level of maturation or calcification in mandibular canine region and overall dental maturation along with intraoral periapical radiograph.[3]

Correction of class II malocclusion with class II elastics is considered as one of the key support along with fixed orthodontic appliance in growing patients. Having been incorporated and stretched between the incisor and canine region in the maxillary arch and the erupted second molar in the mandibular arch (as used in the present case report) among the rigid arch wires is said to decrease the vertical component of force by about 27% to 20% and increases the horizontal component of force in the range which may be favourable for a vertically growing individual. An advice to the patient for wearing on a day to day basis is said to be helpful as both the vertical and horizontal components of force are in equilibrium and preferably in 50-300 grams range.[4] Along with mandibular skeletal advancement other important function that can be achieved with class II elastics are labial buccal tipping of the mandibular incisors, opening of the bite and correction of the midline.[5]

Skeletal changes are bought by judicious use of elastics particularly for a longer period of time on a 24 hour basis and can be used for correction of class II malocclusion without any significant side effects.[6] Hence with such application of elastics a satisfactory correction of class II malocclusion and canine relation with acceptable facial profile was achieved. The main aim and objective of this case report is to substantiate that elastics when used during the growth period can bring about orthopaedic changes.

Diagnosis and treatment plan

A 12 year old male patient came to the department of orthodontics and dentofacial orthopaedics, JSS dental college and hospital, Mysore, India, and desired to get his teeth corrected. After extraoral examination, patient presented with Angle's Class II division 1 malocclusion with incompetent lips, facial form was mesoprosopic, shape of head mesocephalic and convex profile. After intraoral examination, patient presented with crowding and proclination in the upper and lower anterior teeth with class II canine, class II molar relation and presence of symmetrical generalized linear enamel hypoplasia depicting ring like appearance on buccal and lingual surfaces formed as a result of enamel maturation defect(figure 1). Fixed orthodontic treatment was started and after initial levelling and aligning patient was put on rigid archwires and class II elastics were employed. Total duration of treatment was 2 years and one month, out of which initial levelling and aligning was performed for about eight-month time. Class II elastics were employed for a total of seventeen months after

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http://doi.org/10.18231/j.ijodr.2019.021

ORIGINAL ARTICLE CE AJO-DO

Root resorption in Class II malocclusion treatment with Class II elastics

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Introduction: The objective of this investigation was to compare the amount of apical root resorption in nonextraction treatment of Class II malocclusions with and without Class II elastics. **Methods:** A sample of 54 patients with Class II Division 1 malocclusion, retrospectively selected, was divided into 2 groups. The elastic group consisted of 27 patients who were exclusively treated with fixed appliances associated with elastics, and the headgear group consisted of 27 patients treated with fixed appliances and extraoral headgear. The groups were matched regarding initial age, treatment time, amount of overjet, initial malocclusion severity, final occlusal status, and severity of Class II molar relationship. Posttreatment periapical radiographs of the maxillary and mandibular central and lateral incisors were used to evaluate root resorption. The amounts of resorption in the groups were compared with Mann-Whitney U tests. **Results:** There was no statistically significant difference in the amounts of root resorption between the elastic and the headgear groups. **Conclusion:** Nonextraction treatment of Class II malocclusions with Class II elastics associated with fixed appliances causes similar root resorption as treatment with extraoral headgear and fixed appliances. Apical root resorption was predominantly mild and similar in the 2 groups. (Am J Orthod Dentofacial Orthop 2016;150:585-91)

A Class II malocclusion is a major reason that patients seek orthodontic treatment,[1] and it requires different types of treatment when severity of the anteroposterior discrepancy, age, and patient compliance are considered.[2] There are a number of orthodontic appliances and accessories to treat a Class II malocclusion and Class II elastics are among them.

Tucker was one of the first to use rubber in his appliances, such as rubber bands or tubes for tooth movement.[3] The use of intermaxillary elastics has been a standard procedure in the correction of Class II malocclusions since the early days of orthodontic treatment, when their use was pioneered by Calvin S. Case of Chicago and Henry A. Baker of Boston in the 1890s.[4,5]

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
Based on research by Ana Niederberger in partial fulfillment of the requirements for the degree of MSc at Bauru Dental School, University of São Paulo, Brazil.
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Submitted, August 2015; revised and accepted, February 2016.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2016.02.031

It is well documented in the literature that although intermaxillary elastics are effective in correcting the anteroposterior relationship of the dentition, undesirable side effects may occur.[5,6] Many authors have noted adverse results caused by the vertical force vector that is inherent with intermaxillary elastics.[4] It has been stated that this vertical force may extrude the maxillary incisors and mandibular molars, causing clockwise rotation of the occlusal plane and the mandible when Class II elastics are used.[2,4,5,7]

There are no evidence-based studies that definitively establish the optimum force for Class II elastics. Some studies have suggested that the long-term jiggling force caused by the intermittent use of elastics might increase the prevalence of incisor root resorption,[8-10] and indicated that Class II elastics are a significant risk factor.[10,11]

Root resorption, particularly in the anterior teeth, is frequently reported in orthodontic treatment and has been recognized by clinical investigators in daily practice since Ketcham[12] first reported it in 1927.

The association of root resorption with orthodontic therapy is complex, and several treatment risk factors were reported, alone or in combination. Amount of apical displacement,[8,11,13,14] type of malocclusion,[9,11] orthodontic movement type,[15] and treatment duration are directly associated with root resorption. When mechanical factors are mentioned, the type and the amount

Case Report

iMedPub Journals
http://journals.imedpub.com

Journal of Orthodontics & Endodontics
ISSN 2469-2980

2017
Vol. 3 No. 4: 12

DOI: 10.21767/2469-2980.100046

Correction of Class II Malocclusions in Growing Patients by Using the Invisalign® Technique: Rational Bases and Treatment Staging

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Received: June 30, 2017; **Accepted:** September 13, 2017; **Published:** September 20, 2017

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Citation: Giancotti A, Pirelli P, Mampieri G (2017) Correction of Class II Malocclusions in Growing Patients by Using the Invisalign® Technique: Rational Bases and Treatment Staging. J Orthod Endod. Vol. 3 No. 4:12

Keywords: Class II; Clear aligners; Invisalign; Biomechanics

Introduction

Over the past two decades, several articles have demonstrated that the prevalent skeletal feature in Class II patients consists of mandibular retrusion [1-7]. For such reason, an effective universally accepted treatment strategy is based on promoting a mesial repositioning of the mandible to correct the Class II relationship. Moreover, from a dental analysis, it has been shown that up to 85% of Class II patients' present mesial rotation of their maxillary 1st and 2nd molars. One cause for displacement of molars is the mesial movement into the leeway space left during transition from mixed to permanent dentition [8,9]. This creates a loss of arch length and results in mesial rotation of the remaining dentition anteriorly, creating a Class II cuspid relationship and increased overjet. In Class II div. 2, there is a palatal version of the central upper incisors with reduced overjet and limited mandibular advancement. Hence, any appliance that demonstrates the ability to significantly stimulate mandibular growth would be an important asset to a clinician's armamentarium [10-13]. More recently, clear aligner technology has evolved over the past 10 years with such appliances continuously being modified to broaden the range of tooth movements they can achieve [14]. Nowadays, it is possible to correct every type of malocclusion by using aligners: deep bite, open bite, cross bites, severe crowding, Class II and Class III malocclusions [15-17]. In literature, a number of scientific articles including case reports show proper correction of Class II malocclusions by using aligners. However, treatment protocols are not so clearly evidenced at times so as to allow for a standardization and simplification of such orthodontic treatments, which would implement success rate [18-22]. The aim of this work is to show how it is possible to treat Class II malocclusions by means of aligners according to suggested treatment protocols herein.

Rational Approach to Class II Correction

When clinicians decide to treat a Class II malocclusion by means of fixed appliances, they conventionally follow the biomechanical steps below:

1. Correct any mesial rotation of upper 1st molars;
2. Expand the maxillary archform;
3. Coordinate the upper and lower archforms;
4. Overcorrect the maxillary incisor lingual torque;
5. Use Class II elastics.

In our experience with aligners, orthodontic correction of mild to moderate Class II malocclusions may be managed both predictably and efficiently by complying to the same biomechanical requirements as in conventional orthodontics. Furthermore, aligners can provide an additional advantage allowing greater freedom of movement of the mandible and, thus, facilitating a mandibular mesial repositioning. Obviously, it is important to carefully evaluate the etiology of Class II relationships. If one determines that the malocclusion does not depend on a real skeletal discrepancy but rather on dental-skeletal problems, it is possible to plan the strategic biomechanical steps to correct it by using aligners. The treatment protocol for Class II malocclusion treatment with aligners includes the same 5 steps mentioned above:

1. Correct any mesial rotation of upper 1st and 2nd molars. The correction of mesial rotations may open up to 2 mm of space per side for subsequent distalization of bicuspids and canines. Request the buccal surfaces of the upper molars

ORIGINAL ARTICLE

AJO-DO

Class II malocclusion correction with Invisalign: Is it possible?

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Introduction: This research aimed to determine whether Class II malocclusion can be treated with clear aligners after completing treatment with the initial set of aligners. **Methods:** A sample of 80 adult patients were divided into Group 1 with Class I molar malocclusions ($n = 40$ [11 men and 29 women]; 38.70 ± 15.90 years) and Group 2 with Class II molar malocclusions ($n = 40$ [11 men and 29 women]; 35.25 ± 15.21 years). All patients had finished treatment with the initial set of Invisalign aligners (Align Technology, Santa Jose, Calif) without known centric occlusion–centric relation discrepancies, issues of compliance, or overcorrection. The 7 measurements using the American Board of Orthodontics (ABO) Model Grading System and millimetric measurements for anteroposterior (AP) and vertical dimensions were assessed and compared between the 2 groups at pretreatment, posttreatment ClinCheck (Align Technology) prediction, and posttreatment. **Results:** No improvements were observed in the AP correction. The amount of AP correction in patients with Class II malocclusion was 6.8% of the predicted amount. The amount of overbite correction achieved was 28.8% and 38.9% of the predicted amounts in patients with Class I and Class II malocclusion, respectively. Significant improvements in alignment and interproximal contact scores were observed, with only slight improvements in total ABO scores. An increase in mean occlusal contacts score was observed after treatment. No patient with Class II malocclusions would meet the ABO standards after Invisalign treatment. **Conclusions:** The Invisalign system successfully achieves certain tooth movements but fails to achieve other movements predictably. No significant Class II correction or overjet reduction was observed with elastics for an average of 7-month duration in the adult population. Additional refinements may be necessary to address problems created during treatment, as evidenced by a posterior open bite incidence. (Am J Orthod Dentofacial Orthop 2021;159:e41-e48)

As early as 1945, orthodontists used aligners to correct minor tooth movements; however, comprehensive orthodontic treatment was deemed impractical because of the number of impressions and laboratory time required to fabricate each aligner.[1] Invisalign (Align Technology, San Jose, Calif) clear aligners originated in 1997, when Stanford student Zia Chishti, an orthodontic patient turned entrepreneur, received a clear retainer from his orthodontist for retention. Using the design software in a computer laboratory at the university, Chishti and his partners learned how to simulate a solid object with a computer-aided design model and then recreate that object using 3-dimensional printing technology. Through this technology and sequential staging of tooth movements capable of generating orthodontic forces, the Invisalign system was developed under the company name Align Technology.[2,3] Currently, more than 7.5 million Invisalign cases have shipped worldwide with yearly net revenues exceeding $2.3 billion.[4] Most recently, Align has released the first U.S. Food and Drug Administration–approved clear aligner treatment for Class II malocclusion, termed Invisalign with mandibular advancement.

With the improvements in aligner materials, attachment design, and 3-dimensional software,[5] the scientific community has responded with research measuring the success or failure of these technological progressions by measuring achieved individual tooth movements and comparing them with their predicted models. Some of the most notable conclusions in comparison with fixed appliances include the following: aligner cases demonstrated significantly poorer root control during extraction space closure,[6-9] shorter treatment duration by 5.7 months on average, and higher Peer Assessment

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Submitted, June 2019; revised, July 2020; accepted, August 2020.
0889-5406/$36.00

https://doi.org/10.1016/j.ajodo.2020.08.016

Class II Correction with the Invisalign System

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JULIA HAUBRICH, DDS
IRIS NEUMANN, DDS

The Invisalign* system has long been used to treat mild to moderate crowding, spacing, and tipped teeth.[1-5] Recently, it has been used successfully in more complex cases, such as those involving extractions, open bite, and Class II malocclusion.[6-10]

This article describes treatment of a unilateral Class II malocclusion with Invisalign and elastics, as well as a second Class II case treated with the Carrière Distalizer** followed by Invisalign appliances.

Case 1

A 14-year-old female presented with a Class I relationship on the right side and a Class II relationship on the left (Fig. 1). The treatment plan included Invisalign treatment with direct-bonded attachments on the maxillary right canine, the mandibular left canine and premolars, and the mandibular right canine and premolars. Elastic hooks were also bonded to the maxillary left canine and mandibular left first molar (Fig. 2). We planned to align both arches using interproximal reduction (IPR), to distalize the upper left segment into a full Class I relationship, and to intrude the lower anterior teeth to reduce the overbite (Fig. 3).

In the first phase of treatment, the maxillary left buccal segment was distalized into a full Class I relationship, as was the maxillary right canine. For better anchorage, the patient wore Class II

*Registered trademark of Align Technology, Inc., 881 Martin Ave., Santa Clara, CA 95050; www.aligntech.com.

**Registered trademark of ClassOne Orthodontics, 5064 50th St., Lubbock, TX 79414; www.classoneortho.com.

Fig. 1 Case 1. 14-year-old female with Class II occlusion on left, Class I occlusion on right, crowding in both arches, midline deviation, and deep bite before treatment.

A STUDY OF SHORT-TERM SKELETAL, DENTAL, AND SOFT TISSUE EFFECTS OF CLASS II MALOCCLUSIONS TREATED WITH INVISALIGN® WITH MANDIBULAR ADVANCEMENT FEATURE OR TWIN BLOCK APPLIANCE COMPARED WITH HISTORICAL CONTROLS

by

Spencer Sonntag Blackham

D.M.D., Southern Illinois University, 2017

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in

THE FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

(Craniofacial Science)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

July 2020

Different approaches to the treatment of skeletal Class II malocclusion during growth: Bionator versus extraoral appliance

Renato Barcellos **Rédua**[1]

DOI: *https://doi.org/10.1590/2177-6709.25.2.069-085.bbo*

Introduction: Class II malocclusion, which has a significant incidence in the population, may compromise facial esthetics and the smile, as well as the masticatory and respiratory functions. Often associated with skeletal abnormalities, it severely affects and compromises quality of life. An accurate diagnosis is fundamental to prepare a treatment plan to correct dental and skeletal anomalies. **Objectives:** This study discusses treatment alternatives to the correction of Class II division 1 and 2 malocclusion in growing patients, using a Bionator and an extraoral appliance.

Keywords: Activating appliances. Extraoral traction appliances. Angle Class II malocclusion.

Introdução: A má oclusão de Classe II apresenta uma incidência significativa na população, podendo comprometer a estética facial, o sorriso e as funções mastigatória e respiratória. Frequentemente está associada à alteração esquelética, o que aumenta a repercussão desse comprometimento, interferindo ainda mais na qualidade de vida das pessoas afetadas. O correto diagnóstico dessa condição é fundamental para a elaboração de um plano de tratamento que permita a correção dentária e esquelética. **Objetivos:** O objetivo do presente artigo é discutir as alternativas terapêuticas para correção da Classe II divisão 1 e 2 em pacientes em fase de crescimento, utilizando-se o Bionator de Balters ou o aparelho extrabucal.

Palavras-chave: Aparelhos ativadores. Aparelhos de tração extrabucal. Má oclusão Classe II de Angle.

INTRODUCTION

Class II malocclusion, the distal relationship between mandibular and maxillary molars[1], is very frequent in the population. It affects 22.6% of the American children aged 8 to 11 years[2], 28% of the Dutch population[3], 23% of the Colombian children 5 to 17 years old[4], 19% of the Lebanese[5], and 38% of the Brazilian children 7 to 12 years old[6], with no sex predilection.

Class II malocclusion may be associated with skeletal abnormalities in about 75% of the patients[7], who usually present with characteristic mandibular retrognathism resulting from a shortened mandible[8] and maxillary protrusion.

Dental and skeletal Class II malocclusion carries a greater risk of dental trauma[10], a more negative perception of facial[11] and dental[12] esthetics, a negative impact on quality of life and self-esteem[13], a greater predisposition to periodontal diseases[14] and tooth wear[15,16], and a reduction of oropharyngeal space and greater incidence of sleep disorders[17].

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» The author reports no commercial, proprietary or financial interest in the products or companies described in this article.

» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

How to cite: Rédua RB. Different approaches to the treatment of skeletal Class II malocclusion during growth: Bionator versus extraoral appliance. Dental Press J Orthod. 2020 Mar-Apr;25(2):69-85.
DOI: https://doi.org/10.1590/2177-6709.25.2.069-085.bbo

Submitted: January 28, 2019 - **Revised and accepted**: February 06, 2019

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Orthod Fr 2019;90:13–27
© EDP Sciences, SFODF, 2019
https://doi.org/10.1051/orthodfr/2019003

Disponible en ligne sur :
www.orthodfr.org

Article original

Traitement des classes II pour les patients au cours de la croissance par gouttières thermoformées : quel protocole ?

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(Reçu le 7 janvier 2019, accepté le 1er février 2019)

MOTS CLÉS :
Aligneurs /
Classe II /
Croissance /
Vertèbres cervicales /
Protocole de traitement des classes II /
Potentiel auxologique

RÉSUMÉ – **Introduction :** Les classes II squelettiques, fréquemment associées à une rétromandibulie et un surplomb supérieur à 2 mm, entraînent un préjudice fonctionnel et esthétique que le traitement orthodontique se doit de corriger. L'objectif de cet article est de décrire un protocole de traitement par aligneurs, chez le patient en cours de croissance, en fonction de l'importance de la classe II et du stade de maturité de ses vertèbres cervicales. **Matériels et méthodes :** Au travers de cas cliniques, cet article va présenter trois approches thérapeutiques différentes en fonction du stade de croissance. **Résultats :** L'étude du potentiel auxologique et la détermination de l'âge osseux (analyse radiologique de la maturation des vertèbres cervicales) vont permettre de déterminer le moment le plus opportun pour traiter la classe II et l'attitude thérapeutique la plus appropriée en fonction du stade de croissance. **Discussion :** Ce prérequis avant traitement est donc essentiel afin d'adapter un protocole clinique individualisé à chaque patient. En ce sens, les aligneurs sont des dispositifs qui répondent bien à cet impératif, car ils sont personnalisables au vu de la thérapeutique et du plan de traitement envisagés par le praticien. Toutefois, il faut garder à l'esprit qu'une bonne observance est indispensable, quelle que soit la thérapeutique envisagée.

KEYWORDS:
Aligners /
Class II /
Growing patient /
Cervical vertebrae /
Best protocol /
Auxologic potential

ABSTRACT – ***Treatment of class II for growing patients by clear aligners: which protocol?*** **Introduction:** *Skeletal class II, frequently associated with retromandibular and overjet > 2 mm, lead to functional and aesthetic damage, that orthodontic treatment has to correct. The aim of this article is to describe a treatment protocol by aligners for class II growing patients according to the value of the class II and the maturity state of cervical vertebrae.* **Materials and methods:** *Through clinical cases, this article will present three different therapeutic approaches depending on the growth state.* **Results:** *The study of the auxologic potential and determination of the bone age (radiological analysis of the maturation of the cervical vertebrae) will allow to determine the best moment to treat class II and the most appropriate therapeutic attitude according to growing state.* **Discussion:** *This study before treatment is essential to adapt an individualized clinical protocol to each patient. In this way, aligners are devices that respond well to this imperative because they are customizable in view of the strategy and the treatment plan considered by the practitioner. We must keep in mind, however, that with any therapy, it is essential to ensure good patient compliance.*

Clinique et varia

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Temporary Skeletal Anchorage Techniques

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KEYWORDS

• TADs • Skeletal anchorage • Miniscrews • Miniplates • BAMP • MARPE

KEY POINTS

- Basics of biomechanics of temporary skeletal anchorage.
- Types of temporary skeletal anchorage devices.
- Indications and surgical application of miniplates and miniscrews.
- Skeletal anchorage for orthopedic growth modification.

THE INTRODUCTION OF TEMPORARY SKELETAL ANCHORAGE DEVICES

The term orthodontic anchorage was first introduced by Edward Angle and can be explained as resistance to unwanted movement. The goal is to maximize desired tooth movements and minimize the unwanted ones.[1] As orthodontic treatment advanced in complexity and in frequency, more recent techniques, using temporary skeletal anchorage, were developed to help correct more severe discrepancies. These techniques allowed the orthodontist to move teeth against a rigid fixation, allowing for more focused movements of teeth. This type of rigid fixation allowed for greater interaction between the orthodontist and the oral and maxillofacial surgeon and vastly enhanced the treatment planning for the orthodontist.[2]

Although only recently used in mainstream orthodontic treatment planning, the idea of temporary skeletal anchorage dates back to 1945, when Gainsforth and Higley[3] unsuccessfully used vitalium screws and stainless steel wires in dogs as appliances for traction. Thereafter, in 1970, Linkow[4] used blade implants for class II elastic forces and throughout the 1970s and into the 1990s, many investigators used dental implants[5,6] as skeletal anchorage. In 1995, Block and Hoffman[7] used an implant in the palate as an orthodontic anchor device. In 1998, Costa and associates[8] used titanium miniscrews for oral and maxillofacial surgery plating fixation systems as skeletal anchorage. Then, in 1999, a rigid fixation plate traditionally used for fixation of fractures was modified by Umemori and coworkers.[9] This began a quick trajectory of the development of many more temporary skeletal anchorage techniques that allow the orthodontist to create movements in all 3 spatial planes[10] with absolute anchorage. In 2010, only 5.9% of published articles in 6 major orthodontic journals were associated with skeletal anchorage, and in 2015 and 2016, the number of articles nearly doubled at 10.4% and 10.5% of all published articles, respectively.[11]

BIOMECHANICS OF TEMPORARY SKELETAL ANCHORAGE DEVICES

Being skeletally anchored and not bearing force on existing dentition, the orthodontic force is applied in a much more continuous manner and creates less undesired movement of the adjacent dentition. The forces from the skeletal anchorage can

Disclosure Statement: The authors have nothing to disclose.
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Oral Maxillofacial Surg Clin N Am 32 (2020) 27–37
https://doi.org/10.1016/j.coms.2019.08.003
1042-3699/20/Published by Elsevier Inc.

Settling the Score with Class IIs Using Miniscrews

4

S. Jay Bowman

Abstract

Class IIs have been one of the most prevalent malocclusions treated in orthodontic practice. Throughout the history of the specialty, all manner of methods and devices have been employed to resolve these bad bites. Yet, after decades, there is still no consensus on the best technique or approach. In fact, we seemingly cannot even agree on the etiology nor the correct jaw to address with our mechanics. It does appear that we might find common ground regarding the most common issues with any of our treatment approaches, namely, that we are constrained by two major limitations: the requirements of patient compliance and anchorage control. It is this interminable battle for compliance and anchorage that has led us to employ skeletal anchorage for the management of Class IIs.

4.1 How Are Class IIs Corrected?

Despite the fact that Class IIs have presumably been the second most common malocclusion sign that patients present with to orthodontic practices, there has been no consensus over the past century as to when and how to correct them. In fact, there is still misunderstanding in regard to how the correction actually occurs. As a result, the multitude of philosophies and associated devices for the resolution of Class IIs remain staggering, even though substantial amounts of research have been published on the effects and effectiveness of nearly all approaches.

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From an examination of the wide range of different types of investigations of Class II treatments, there seem to be little demonstrable differences among the results produced by the menagerie of methods [1–8]. Whether addressing maxilla or mandible [2], early or late treatment timing [8], results are virtually the same. This is especially true in terms of the magnitude of mandibular growth contributing to the overall correction: it's also nearly identical [2].

Although some Class II mechanisms are intended to modify skeletal growth (i.e., orthopedics) or move teeth (i.e., orthodontics) or even both, the actual effects are, on average, mostly found in the midface and not so much in the mandible [1–8]. Moreover, it seems that the key to Class II correction in the growing patient is primarily due to the interruption of dentoalveolar compensation—no matter the treatment method chosen [3, 9].

K.B. Kim (ed.), *Temporary Skeletal Anchorage Devices*,
DOI 10.1007/978-3-642-55052-2_4, © Springer-Verlag Berlin Heidelberg 2014

Kaohsiung Journal of Medical Sciences (2014) 30, 111–115

Available online at www.sciencedirect.com

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REVIEW ARTICLE

Miniscrew implant applications in contemporary orthodontics

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Received 2 May 2013; accepted 31 May 2013
Available online 8 December 2013

KEYWORDS
Miniscrew implants;
Orthodontic anchorage;
Risk factors

Abstract The need for orthodontic treatment modalities that provide maximal anchorage control but with minimal patient compliance requirements has led to the development of implant-assisted orthodontics and dentofacial orthopedics. Skeletal anchorage with miniscrew implants has no patient compliance requirements and has been widely incorporated in orthodontic practice. Miniscrew implants are now routinely used as anchorage devices in orthodontic treatment. This review summarizes recent data regarding the interpretation of bone data (i.e., bone quantity and quality) obtained by preoperative diagnostic computed tomography (CT) or by cone-beam computed tomography (CBCT) prior to miniscrew implant placement. Such data are essential when selecting appropriate sites for miniscrew implant placement. Bone characteristics that are indications and contraindications for treatment with miniscrew implants are discussed. Additionally, bicortical orthodontic skeletal anchorage, risks associated with miniscrew implant failure, and miniscrew implants for nonsurgical correction of occlusal cant or vertical excess are reviewed. Finally, implant stability is compared between titanium alloy and stainless steel miniscrew implants.

Conflicts of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this paper.

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1607-551X/$36
http://dx.doi.org/10.1016/j.kjms.2013.11.002

Infra-Zygomatic Crest and Buccal Shelf - Orthodontic Bone Screws: A Leap Ahead of Micro-Implants – Clinical Perspectives

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Abstract

Absolute anchorage systems have stormed the world of orthodontics over the past two decades with its ability to produce skeletal anchorage, converting borderline surgical cases into non-surgical and extraction cases into non-extraction or even bringing about the esthetic impact which was difficult to achieve by conventional mechanics. Among the skeletal anchorage systems, the most popular being – mini-implants or micro-screws which have an intra-radicular site of placement. Their greatest advantage being the ease and minimally invasive methods of placement and the commonest disadvantage being early loosening during the course of treatment. A more rigid alternative was then introduced called as the SAS -Skeletal Anchorage Systems (I-plate, Y-plate etc) with its extra-radicular site of placement, which did overcome the high failure rates of a regular mini-implant but then their placement required raising of flaps and extensive surgical intervention. More recently an apt balance was achieved with the advent of the -Orthodontic Bone Screws (OBS) which not only had an extra-radicular site of placement in the infra-zygomatic crest of the maxilla and the buccal shelf area of the mandible, with significantly less failure rates than regular mini-implants but also doesn't require extensive surgical intervention for their placement. This article is aimed at providing an overview - to the recently introduced OBS system, their technical, bio material and bio-mechanical differences with the commonly used mini-implant system, the case selection criteria, advantages, disadvantages and an in-depth to the cases treated with them.

Keywords: *Biomechanics of bone screws, biomechanics of micro-implants, BSS, buccal shelf area, full arch distalization, infra-zygomatic crest, IZC, micro-implants, orthodontic bone screws*

Received: 14-11-2018
Accepted: 14-11-2018

Introduction

Orthodontics in its century of existence have had a lot of landmarks in its evolution, but very few can match the clinical impact made by micro-implants and the recently introduced infra-zygomatic crest (IZC) and buccal shelf (BS) orthodontic bone screws. Micro-implants and extra-radicular bone screws have brought about a renaissance to the field of orthodontics with its concept of absolute anchorage in the past decade. It is an added armamentarium in the hands of an experienced clinician to overcome new clinical challenges and convert even borderline surgical cases to nonsurgical without compromising with the results achieved. However, the choice of cases still remains the key to clinical success.

They have not only been able to solve the problems related to anchorage but also microimplant-mediated segmental distalization or full arch distalization with extra-radicular bone screws have been able to treat cases the non-extraction way or even retreat cases with anchorage loss.

Orthodontic retreatment being so common these days – courtesy poor mechanics, it is the need of the

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Quick Response Code:

Website: www.jios.in

DOI: 10.4103/jios.jios_229_18

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How to cite this article: Ghosh A. Infra-zygomatic crest and buccal shelf - Orthodontic bone screws: A leap ahead of micro-implants – Clinical perspectives. J Indian Orthod Soc 2018;52:S127-41.

ORIGINAL ARTICLE CE AJO-DO

Anatomic assessment of the mandibular buccal shelf for miniscrew insertion in white patients

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Introduction: Cortical bone thickness, bone width, insertion depth, and proximity to nerves are important factors when planning and placing orthodontic miniscrews. The objective of this study was to anatomically assess the mandibular buccal shelf in a white patient population as the insertion site for orthodontic miniscrews by investigating these 4 variables. **Methods:** Measurements were made on cone-beam computed tomography scans of 30 white patients (18 girls, 12 boys; mean age, 14.5 ± 2 years). All measurements were taken adjacent to the distobuccal cusp of the first molar, and the mesiobuccal and distobuccal cusps of the second molar. Additionally, bone depth was measured at 2 height levels, 4 and 8 mm from the cementoenamel junction. Stereolithographic models of patients were superimposed on the cone-beam computed tomography volumes to virtually create an outline of the soft tissue on the cone-beam computed tomography image to allow identification of the purchase point height (mucogingival junction). The inferior alveolar nerve was digitally traced. Miniscrews (1.6 × 10 mm) were virtually placed at the buccal shelf, and their insertion depths and relationships to the nerve were assessed. Analysis of variance with post hoc analysis was used for data analysis. **Results:** Insertion sites and measurement levels had significant impacts on both cortical bone thickness and bone width. Cortical bone thickness was typically greatest at the distobuccal cusp of the second molar. Bone width was also greatest at the distobuccal cusp of the second molar 8 mm from the cementoenamel junction. The greatest insertion depth was found again at the distobuccal cusp to the second molar, whereas the miniscrews had the greatest proximity to the nerve at this site also. **Conclusions:** The distobuccal cusp level of the mandibular second molar is the most appropriate site for miniscrew insertion at the buccal shelf in white patients. (Am J Orthod Dentofacial Orthop 2018;153:505-11)

One of the most important factors when placing orthodontic miniscrews is the presence of sufficient bone at the insertion site.[1] Miniscrews are placed in many anatomic sites depending on the biomechanics used.[2-4] The most popular anatomic sites appear to be the palate, lingual aspect of the maxillary alveolar process, retromolar area, and maxillary and mandibular buccal alveolar processes.[2-6] Several studies have used cone-beam computed tomography (CBCT) to assess cortical bone thickness and overall bone depth to determine the most favorable anatomic insertion sites and to evaluate the structures at risk at various sites.[1,7]

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
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Submitted, February 2017; revised and accepted, August 2017.
0889-5406/$36.00

https://doi.org/10.1016/j.ajodo.2017.08.014

Recently, the mandibular buccal shelf has been used as an insertion site for orthodontic miniscrews. Indications for the buccal shelf as the insertion site are plentiful, but this site seems to be most useful for the correction of Class III malocclusions.[8-10] However, despite reports of numerous treated patients, there was inconsistency in selecting the exact placement site in the mandibular buccal shelf; recommendations included adjacent to the first molar, between the first and second molars, and adjacent to the second molar.[10,11] This wide range of recommendations may be due to strong local anatomic variations at the buccal shelf or the lack of studies that investigated the local anatomy. The purposes of this study were to remedy this lack of anatomic information by evaluating cortical bone thickness and bone width of the mandibular buccal shelf at different potential insertion sites and to assess the relationship between the miniscrews and the inferior alveolar nerve as the only sensitive anatomic structure in this area.