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Review Article

Fixed Functional Appliances in Orthodontics- A Literature Review

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Abstract

Class II malocclusion is one of the frequently discussed malocclusion in Orthodontic literature. However, its correction becomes crucial part of treatment planning depending upon the etiology of malocclusion, age of the patient and also patient cooperation. Fixed functional appliances has been widely used in orthodontic practice for correction of Class II malocclusion. In spite of wide popularity, fixed functional appliances has its own advantages and disadvantages. Current literature review provides detailed information about fixed functional appliances and its use in orthodontics.

Keywords: Fixed Functional Appliance; Review; Class II Malocclusion; Mandibular Retrognathia

Introduction

Altering patient's facial profile has been a challenge for Orthodontists in clinical practice. Every clinician is periodically confronted with malocclusions that do not respond favourably to only tooth moving mechanotherapies because of the disharmony actually existing in the basal jaw bone itself. The challenging task is to correctly position the jaws anterio-posteriorly and vertically with correct overbite, overjet and centric relation.

In order to treat full spectrum of malocclusions effectively clinician must recognize and assess any skeletal disharmony at an early age and plan for growth modification, because if conservative orthodontic therapy can not provided at proper time, then such skeletal disharmony may have to be treated surgically.

Class II malocclusion is one of the most common orthodontic problems and it occurs in about one third of the population [1,2]. The most consistent feature observed in Class II malocclusion is mandibular skeletal retrusion. A therapy able to enhance mandibular growth is indicated in such patients. A wide range of functional appliances used to stimulate mandibular growth by forward posturing of the mandible is available to correct class II skeletal and occlusal disharmony. Although many animal studies have demonstrated that skeletal mandibular changes can be produced by posturing mandible forward, the effects on humans are more equivocal and controversial. Many treatment protocols, sample sizes and research approaches have led to disparate outcomes in studies on human subjects [3].

The term "functional appliance" refers to a variety of removable or fixed appliances, designed to alter the arrangement of various muscle groups that influence the function and position of the mandible in order to transmit forces to the dentition and the basal bone. Typically, these muscular forces are generated by altering the mandibular position sagittally and vertically, which brings about Orthodontic and Orthopedic changes. Functional appliances have been used since the 1930s. Despite this relatively long history, there continues to be much confusion relating to their use, method of action, and effectiveness [4].

Functional appliances can be broadly classified into two types; Removable functional appliances and fixed functional appliances, based on use in the patient's mouth. Fixed functional appliances are those that are fixed to the maxillary or mandibular arches and these appliances cannot be removed by patient on his or her own will. On the other hand, removable functional orthodontic appliances have been used for nearly 85 years in an attempt to guide mandibular growth by changing muscle function and condylar-glenoid fossa relationships. This type of therapy has provided opportunities, both clinical and experimental, to test bone and muscle relationships in a setting of intermittently altered condylar position. In contrast to removable functional appliances, fixed functional appliances (Herbst) maintain a continuous alteration in condylar relationship [5].

Fixed functional appliances 1st appeared in 1900s when "Emil Herbst" presented his system at "Berlin International Dental Congress" (1909), which was reintroduced by "HANS PANCHERZ" of Malmo, Sweden in 1979 who brought the subject back into the discussion with the publication of several articles on the Herbst, who actually used this appliance to stimulate mandibular growth[5]. It was only in the eighties several systems derived from Herbst's work have appeared and gained popularity in recent years to achieve better results in non-compliant patients [6].

From tubes and plunger telescopic mechanism as in Herbst appliance, to Hybrid Fixed Functional Appliances (Forsus), Fixed Functional Appliances has undergone a massive transformation, despite that it's skeletal, dental and soft tissue effects are still an enigma. Present literature review provides an insight into fixed functional appliances in orthodontics.

Mode of action

Functional appliance therapy has become a generally accepted method to treat severe and moderate discrepancy of sagittal jaw relationship. However, no unanimity exists over the mechanism of correction of structural imbalance by the functional appliances. Opinion varies among the researchers. A variety of different functional appliances are available.

Each proponent of different functional appliances has conceived more or less his own concept and working hypothesis like Andresen and Haupl and petric, Herren and Harvold for the activator; Balter for the Bionator; Frankel for the functional regulator; Stockfish for the Kinetor and Bimler for the Gebissformer.

The mechanism of fixed functional appliance for mandibular adaptation to the forward posturing by is the same as that observed in removable functional appliance. The appliance is tooth-borne and exerts its effects via teeth to the underlying bone by transmitting the forces developed due to continuous forward posturing of the lower jaw.

The theoretical basis of functional treatment in general is the principle that a "new pattern of function" dictated by the appliance, leads to the development of a correspondingly "new morphologic pattern." The "new pattern of function" can refer to different functional components of the orofacial system i.e. the tongue, the lips, the facial and masticatory muscles, the ligaments as well as the periosteum.

The "new morphologic pattern" includes a different arrangement of the teeth within the jaws, improvement of the occlusion, and an altered relation of the jaws. It also includes changes in the amount and direction of growth of the jaws and differences in the facial size and proportions [7].

A new functional concept has been prepared by Carels and van der Linden. The hypothesis proposed by many clinicians that during first phase of functional treatment, reflexes in jaw muscles are transiently brought into a state of imbalance. The phase of imbalance could act as a trigger for the mandible to attain a new functional position, subsequently leading to morphologic changes. Usually the neuromuscular changes occur first and subsequently after an interval of 2 weeks' morphologic changes are seen [8].

The effects of functional appliance therapy in correcting skeletal Class II discrepancies have been extensively studied, although controversy still exists as to whether mandibular growth can be enhanced above the levels that exist during normal growth. Clinically Ruf and Pancherz, using magnetic resonance imaging, have shown bone remodeling in the condyle and the glenoid fossa after Herbst therapy, while many studies with rats and monkeys have shown conclusively that new bone formation occurs at the condyle and the glenoid fossa in response to mandibular advancement. Such newly formed bone could be the result of bone remodeling/osteogenesis. An important factor that influences bone growth is the number of osteoblasts which are involved in the Synthesis of the bone matrix. The number of these secretory osteoblasts is directly proportional to the number of committed mesenchymal osteoprogenitor cells. Thus, the number of mesenchymal cells in a given locus determine its osteogenic potential. Therefore, one way to determine whether the response of the temporomandibular joint (TMJ) to functional appliances is merely an adaptive response or actual growth is to quantify the proliferative cells during functional appliance therapy and to follow and compare their temporal pattern of proliferation to that occurring throughout the somatic growth period [9].

The pioneering autoradiographic work of Petrovic., *et al*. on rats showed an increase in the mitotic activity of mesenchymal cells in the condyle in response to mandibular advancement with increase in the thickness of prechondroblastic and chondroblastic zones. In the condyle and the glenoid fossa, as more cells differentiate, this can affect the population of mesenchymal cells. The glenoid fossa forms by intramembranous ossification therefore, mesenchymal cells directly differentiate into osteoblasts before ultimately forming bone. The Condyle, on the other hand, develops by endochondral ossification, so that mesenchymal cells must first undergo a transitory stage of cartilage formation before being replaced by bone after vascular invasion. In the condyle, these cells are located in the proliferative layer whereas in the glenoid fossa; they can be seen as a row of cells beneath the articular layer. The bone marrow and the perivascular connective tissue that surrounds invading osteogenic vessels, are also repository sites of mesenchymal cells.

Rabie., *et al*. found that mandibular advancement elicited an increase in bone formation in the glenoid fossa that could be related to the change in the population size of mesenchymal cells. The forward mandibular positioning produced cellular response in both the condyle and the glenoid fossa. The posterior regions of both showed a significant increase in the number of replicating mesenchymal cells as a response to forward mandibular positioning. Similarly, forward mandibular positioning caused a significant increase in the amount of newly formed bone in the posterior regions of both glenoid fossa and the condyle. These results again support and demonstrate that the number of replicating mesenchymal cells in a given Site is directly proportional to the bone formation at that site. During natural growth of the mandible, the amount of replicating cells in the posterior region of the condyle was observed to be significantly higher compared with the middle and anterior regions. Interestingly, the amount of newly formed bone in the posterior part of the condyle during natural growth was significantly higher than in the anterior and middle regions, again showing a direct correlation between the number of replicating mesenchymal cells and bone formation. The resident mesenchymal cells in the condyle contributed to bone formation in a response to forward mandibular positioning, whereas resident mesenchymal cells in the glenoid fossa contributed less to growth modification. The number of replicating resident mesenchymal cells in the posterior region of the condyle during natural growth was 2 to 3 times more than in the posterior region of the glenoid fossa during the same period. In response to forward mandibular positioning whereas resident mesenchymal cells in the glenoid fossa contributed less to growth modification. The number of replicating mesenchymal cells, which is genetically controlled, influences the growth potential of the condyle and the glenoid fossa. Mandibular protraction leads to an increase in the number of replicating cells in the TMJ. This increase is maintained at higher levels or at levels equal to those of natural growth but not at lower levels. Such a close correlation between mesenchymal cell numbers, which are genetically controlled, and growth could be detrimental to a patient's response to growth modification therapy [10].

During natural growth, the highest level of Vascular Endothelial Growth Factor (VEGF) expression was mostly found in the posterior region when compared with the middle and anterior regions. Forward mandibular positioning led to constant increase in the expression of VEGF. The temporal pattern of expression of VEGF showed that the maximal levels were reached on day 14 of advancement, whereas the maximal level of bone formation was reached at day 21 of advancement.

Mandibular advancement caused a significant increase in neovascularisation and osteogenesis in the glenoid fossa during the earlier stages of advancement followed by a gradual decrease to levels that were insignificantly different from those of the late stages observed during natural growth. The temporal pattern of neovascularisation and new bone formation showed a gradual decrease depending upon age and growth status of an individual.

The mechanical strain caused by forward mandibular positioning stimulated the cells of the chondroid layer to secrete VEGF. VEGF promotes neovascularization and the perivascular connective tissues which surround the new blood vessels are repository sites of mesenchymal cells. These cells could in turn replenish the population size of osteoprogenitor Mesenchymal cells. VEGF also stimulates the vascular endothelial cells to secrete growth factors and cytokines which influence the differentiation of mesenchymal cells to enter the osteogenic pathway and engage in osteogenesis [11].

A limited restraining effect on the downward as well as forward growth on the maxilla was demonstrated. The entire mandible displaced in the forward and inferior directions, with the parasymphyseal and mid symphyseal regions showing a more pronounced displacement than the rest of the mandible. In the nasomaxillary complex, point A and anterior nasal spine (ANS) were displaced anterosuperiorly, but those representing the pterygoid plate were displaced in the posterosuperior direction. The clockwise rotation of the mandible was accompanied by anteroinferior displacement of the entire lower dentition. This side effect was most prominent in the incisor region. The maxillary dentition was displaced in the postero-superior direction. The retrusion and extrusion of maxillary incisors and the distalization and intrusion of the maxillary molars are also observed. In addition, they have reported downward tipping of the occlusal plane in the anterior region. Proclination of the mandibular incisors was the major dental side effect reported.

In summary, fixed functional appliances cause forward and downward displacement of the mandible. They also cause a postero-superior displacement of the maxillary dentition and pterygoid plate and hence contributing to the correction of a Class II malocclusion. Mandibular incisor proclination is the most pronounced side effect during fixed functional treatment. This is a matter of concern in many patients, as it increases relapse tendency and also limits skeletal and soft tissue correction. This could be prevented by cinching the mandibular archwire and laceback in the mandibular arch and by incorporating progressive lingual crown torque in the mandibular anterior segment. Inclusion of the second molars during treatment could enhance anchorage and prevent unwanted proclination of anterior teeth. In high-angle patients, fixed functional appliances should be avoided, as this may increase the vertical dimension owing to clockwise rotation of the mandible [12].

Indications

It is a known fact that for treatment, Patient compliance is an important factor for successful completion of functional appliance. The fixed functional appliance, being fixed to the teeth is a most important weapon against non-compliance patients.

They are indicated in:

1. Young growing individual with skeletal class II pattern with mandibular retrognathia.
2. Low mandibular plane angle cases indicating an anterior growth direction of the mandible.
3. Normal or reduced lower facial height.
4. In cases with mandibular midline deviation.
5. Class II dental arch relationship with increased over jet and normal or increased over bite.
6. Well aligned maxillary and mandibular teeth and the two dental arches fitting each other in normal A-P position.
7. Making use of the residual growth left in neglected post-adolescent patients who have passed the maximal pubertal growth and are too old for removable functional appliances.

Contraindications

1. Fixed functional appliances are contraindicated in nongrowing individuals. Skeletal alterations will be minimal and the treatment effects will be confined to the dentoalveolar area. their use in nongrowing individuals may lead to TMJ disorder.
2. Hyperdivergent facial pattern.
3. The fixed functional appliance is contraindicated in autistic children and in patients with severe bruxism (Rogers).
4. A patient with negative VTO (visual treatment objective).

Advantages

1. Success of removable functional appliance therapy depends on the patient's compliance. In contrast, fixed functional appliances being fixed to the dentition is independent of uncooperative patients for its success. removable functional appliance therapy depends on the compliance of the patient. In contrast, fixed functional appliances being fixed to the dentition is independent of uncooperative patients for its success.
2. Many removable functional appliances ex. activator are meant for night time wear. It may fail to achieve the best possible results. But the action is continuous for 24 hours of the day for fixed functional appliances.
3. Treatment duration required in removable functional appliance is around 2 - 3 years, whereas fixed functional appliances achieve the result in around 6 - 8 months.
4. It can be used successfully in post adolescent patients in whom little growth is remaining to work with.
5. Advantageous in mouth breathers who are unable to adapt to removable appliances.
6. Does not interfere in speech or mastication.
7. Procedures such as rapid maxillary expansion and other can be carried out simultaneously.

8. Last but not the least removable functional cases require ultimate finishing of the case with the help of second stage multiattachment therapy; which can be simultaneously achieved with fixed functional appliances [13].

Disadvantages

1. Though treatment can be achieved within 6 - 8 months, retention of the result has to be maintained using removable functional appliance.
2. Risk of development of dual bite with attendant risk of TMJ dysfunction if treated inadequately.
3. Masticatory efficiency is reduced even after patient gets used to the appliance.
4. High incidence of breakage and loosening of the appliance.
5. Some of the rigid appliances ex: Herbst appliances may restrict the lateral mandibular movements.
6. Most of the work requires the effort of an orthodontist; as precision is required. Hence it is time consuming.
7. Most of the appliances are expensive or may require good laboratory support [14].

Classification [15,16]

A. **Rigid fixed functional appliances (RFFA):**
    1. The herbst appliance and its modifications [6].
    2. The mandibular protraction appliance (MPA) [17-19]
    3. The mandibular anterior repositioning appliance (MARA) [20]
    4. The ritto appliance [15]
    5. The IST-appliance
    6. The biopedic appliance.

B. **Flexible fixed functional appliances (FFFA):**
    1. The jasper jumper [21]
    2. The adjustable bite corrector [22]
    3. The churro jumper [23].
    4. The amoric torsion coils.
    5. The scandee tubular jumper
    6. The klapper super spring
    7. The bite fixer.

C. **Hybrid fixed functional appliances (HFFA):**
    1. Eureka spring [24]
    2. FORSUS-fatigue resistant device [25,26]
    3. The twin force bite corrector [27,28].
    4. Alpern class II closers
    5. The calibrated force module.

(Individual appliance description is not included. Readers are requested to read the respective article for appliance designs).

Conclusion

Removable functional appliances are effective but rely heavily at the mercy of patient cooperation for achieving predictable results in a reasonable time frame. Also, even if patient is cooperative there are, for e.g. Mastication, when the appliance cannot be worn. This can make a significant difference between success and failure. Besides this there are many difficulties faced during other functions like speech with these appliances.

To eliminate these drawbacks, fixed bite jumping appliances were have been developed. With patient cooperation is no longer a stumbling block, the fixed functional appliance have rapidly endeared themselves to the clinician in achieving result. However, fixed bite jumping appliances have definite indications and contraindications, which should not be neglected. Indiscriminate use in any skeletal disorder without proper diagnosis can make a difference between success and failure.

On the basis of available evidence as examined by this literature search following conclusions can be drawn:

1. Both fixed and removable functional appliances are effective in reducing overjet and attaining a Class I molar relationship.
2. The changes produced by the fixed functional appliances are mainly dentoalveolar and less skeletal as compared to removable functional appliances.
3. Fixed functional appliances have more restraining effect on the maxilla in relation to the removable functional appliances.
4. As a result of the dentoalveolar changes in the fixed functional appliances, the occlusal and palatal plane rotated significantly in a clockwise direction.

The level of evidence available in the literature in determining the effectiveness of fixed functional appliances over removable functional appliances is very low. Hence, further well-designed randomized clinical trials to assess the efficacy of fixed functional appliances over removable functional appliances in terms of skeletal changes are required.

Bibliography

1. Maged Sultan. "Global distribution of malocclusion traits: a systematic review". *Dental Press Journal of Orthodontics* 24.3 (2019): 113.

2. Richard Emrich. "Prevalence of Class I, Class II and Class III malocclusions (Angle) in an urban population an epidemiological study". *Journal of Dental Research* (1965).

3. Cozza P and Baccetti T. "Mandibular changes produced by functional appliances in Class II malocclusion: A systematic review". *American Journal of Orthodontics and Dentofacial Orthopedic* 129.5 (2006): 599.

4. Bishara SE and Ziaja RR. "Functional appliances: A review". *American Journal of Orthodontics and Dentofacial Orthopedic* 95.3 (1989): 250-258.

5. Woodside DG., *et al.* "The influence of functional appliance therapy on glenoid fossa remodeling". *American Journal of Orthodontics and Dentofacial Orthopedic* 92.3 (1987): 181-198.

6. Pancherz H. "The Herbst appliance– Its biologic effects and clinical use". *American Journal of Orthodontics* 87.1 (1985): 1-20.

7. Carine Carels. "Concepts on functional appliances mode of action". *American Journal of Orthodontics and Dentofacial Orthopedics* 92 (1987): 162-128.

8. Pancherz H. "The Herbst appliance-Its biologic effects and clinical use". *American Journal of Orthodontics* 87.1 (1985): 1-20.

9. Pancherz H. "Treatment of Class II malocclusions by jumping the bite with the Herbst appliance". *American Journal of Orthodontics* 76.4 (1979): 423-442.

10. Rabie AB., *et al.* "VEGF and bone formation in the glenoid fossa during forward mandibular positioning". *American Journal of Orthodontics and Dentofacial Orthopedics* 122 (2002): 202-209.

11. Rabie AB., *et al.* "Replicating mesenchymal cells in the condyle and the glenoid fossa during mandibular forward positioning". *American Journal of Orthodontics and Dentofacial Orthopedics* 123 (2003): 49-57.

12. Panigrahi P and Vineeth V. "Biomechanical Effects of Fixed Functional Appliance on Craniofacial Structures". *The Angle Orthodontist* 79 (2009): 668-675.

13. Woodside DG., *et al.* "The influence of functional appliance therapy on glenoid fossa remodeling". *American Journal of Orthodontics and Dentofacial Orthopedics* 92.3 (1987): 181-198.

14. Almeida., *et al.* "Soft tissue changes produced by a banded-type Herbst appliance in late mixed dentition patients". *World Journal of Orthodontics* 9.2 (2008): 121-131.

15. Ritto AK. "Fixed Functional Appliances - A Classification". *The Functional Orthodontist* 17.2 (2000): 12-30.

16. Moschos A. "Papadopoulos. Orthodontic treatment of the class II noncompliant patient". *Current Principles and Techniques*.

17. Coelho Filho CM. "Mandibular Protraction Appliances for Class II Treatment". *Journal of Clinical Orthodontics* 29.5 (1995): 319-336.

18. Coelho Filho CM. "The Mandibular Protraction Appliance No. 3". *Journal of Clinical Orthodontics* 32.6 (1998): 379-384.

19. Coelho Filho CM. "Mandibular Protraction Appliance IV". *Journal of Clinical Orthodontics* 35.1 (2001): 18-24.

20. Chiqueto K and Henriques JF. "Angle Class II correction with MARA appliance". *Dental Press Journal of Orthodontics* 18.1 (2013): 35-44.

21. Jasper JJ and McNamara. "The correction of interarch malocclusions using a fixed force module". *American Journal of Orthodontics and Dentofacial Orthopedics* 108.6 (1995): 641-650.

22. West RP. "The Adjustable Bite Corrector". *Journal of Clinical Orthodontics* 29.10 (1995): 650-657.

23. Castañon R., *et al.* "Clinical Use of the Churro Jumper". *Journal of Clinical Orthodontics* 32.12 (1998): 731-745.

24. DeVincenzo J. "The Eureka Spring: A New Interarch Force Delivery System". *Journal of Clinical Orthodontics* 31.7 (1997): 454-467.

25. Vogt W. "The Forsus Fatigue Resistant Device". *Journal of Clinical Orthodontics* 40.6 (2006): 368-377.

26. Sood S. "The Forsus Fatigue Resistant Device as a Fixed Functional Appliance". *Journal of Clinical Orthodontics* 45.8 (2011): 463-466.

27. Rothenberg J., *et al.* "Class II Correction with the Twin Force Bite Corrector". *Journal of Clinical Orthodontics* 38.4 (2004): 232-240.

28. A Chhibber., *et al.* "Long-Term Stability of Class II Correction with the Twin Force Bite Corrector". *Journal of Clinical Orthodontics* 44.6 (2010): 363-376.