Fixed Functional Appliances

Nandalal Girijalal Toshniwal¹, Pooja Changdev Katkade², Shubhangi Amit Mani³, Nilesh Mote⁴

^{1, 2, 3, 4} Department of Orthodontics and Dentofacial Orthopaedics,
Rural Dental College, Ahmednagar, Maharashtra, India.

ABSTRACT

Considering the large number of fixed functional appliances, choosing the best device for your patient is not an easy task. To describe the development of fixed functional appliances as well as our 20-year experience working with them. 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 in illustrating the different appliances. 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. The electromyographic (EMG) activity of masticatory muscles was monitored longitudinally with chronically implanted EMG electrodes to determine whether functional appliances produce a change in postural EMG activity of the muscles. Pre-appliance and post-appliance EMG levels in four experiments that had been fitted with functional appliances were compared against the background of EMG levels in controls without appliances.

The insertion of two types of functional appliance to induce mandibular protrusion was associated with a decrease in postural EMG activity of the superior and inferior heads of the lateral pterygoid, superficial masseter, and anterior digastric muscles; the decrease in the first three muscles was statistically significant. This decreased postural EMG activity persisted for approximately 6 weeks, with a gradual return towards pre-appliance levels during a subsequent 6-week period of observation. Progressive mandibular advancement of 1.5 to 2 mm every 10 to 15 days did not prevent the decrease in postural EMG activity.

KEY WORDS

Orthodontics, Class II Malocclusion, Fixed Functional Appliance.

Corresponding Author:

*Dr. Pooja Changdev Katkade,
Bet Kopargaon, Kopargaon,
Maharashtra, India.*

E-mail: drpoojakatkadego@gmail.com

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BACKGROUND

Fixed functional appliances are normally described as "Noncompliance Class II correctors". The mechanism of correcting the defect consists of forwarding the mandible to a forced anterior front class I position to stimulate growth and thus harmonize skeletal defects and also by eliciting the correction of dentoalveolar effects. They also improve the soft tissue profile. Fixed functional appliance was introduced first in dentistry by Dr. Emil Herbst of Germany.

Fixed functional appliances can be rigid appliances, flexible appliances, or combination of both – Hybrid appliances. While there are various ways of treating class II cases like the headgear, elastics, and many other appliances, many don't correct the malocclusion hand in hand while advancing the mandible, thus saving a lot of treatment duration. The Advan Sync 2 Class II Molar to Molar appliance¹ makes it possible to combine two treatment phases by achieving skeletal and dental corrections at the same time. Functional appliances which are well known for correction of typical class II malocclusions can modify and alter the neuromuscular anatomy and function as well as its entire environment of the dentition and bones linked and attached to it. The fixed functional appliances help in modifying morphologic adaptations which help in altering the muscle tonicity and thus bringing about a change in the direction of the traction, which is exerted by the masticatory muscles of jaw, thus ensuring skeletal changes. But the entire neuromuscular adaptation mechanism is a complex mechanism because of bone and muscle interaction, Andresen and Häupl stated that a myostatic reflex is produced which leads to isometric contractions because of the activity of the jaw which include closing muscles, which thus stimulates the protractor muscles and inhibits the mandibular retractor muscles.

CLASSIFICATION OF FIXED FUNCTIONAL APPLIANCES

By Ritto A. Korrodi² (2001), fixed functional appliances are classified into four categories, depending upon the features of force system used to advance the mandible:

- Rigid fixed functional appliances.
 - Flexible fixed functional appliances.
 - Hybrid appliances.
 - Appliances acting as substitute for elastics.
- A. Rigid fixed functional appliances³ (RFFA) include the following -
- Herbst appliance.
 - The mandibular protraction appliance (MPA)
 - The mandibular anterior repositioning appliance (MARA)
 - Biopedic appliance.
 - Ritto appliance.
 - The IST appliance
- B. Flexible fixed functional appliances⁴ (FFFA) include the following -
- Jasper jumper
 - The adjustable bite corrector

- The churro jumper
- Scandee tubular jumper.
- Amoric torsion coils.
- Adjustable bite corrector.
- Bite fixer.
- Klapper super spring II.

C. Hybrid fixed functional appliances⁵ (HFFA) include the following -

- Eureka spring.
- FORSUS - Fatigue resistant device
- Twin force bite corrector.
- Alpern class II closers
- The calibrated force module

Flexible Fixed Functional Appliances

Flexible fixed functional appliances are described as appliances which consist of intermaxillary coil spring or a fixed spring to incorporate flexibility in the appliances.⁶ Elasticity and flexibility are two typical features of these appliances. They provide and allow satisfactory free mandibular movements and help in ease of performing lateral guidance. The appliance can be totally controlled by the clinician. Thus, the amount of force can vary according to the clinician. The biggest disadvantage of the appliance is system fractures in both the appliance and supporting part, especially in the mandible. Even though the advantage of the appliance is its flexibility but it also produces fatigue in the springs. Since system fracture is the major drawback, it is always advantageous and important to advise and instruct patients to avoid opening their mouths too widely. The appliance in the mouth seems to be unaesthetic. If there is increased spring curvature, it protrudes and appears in patient's cheeks. Examples of flexible appliances include Jasper jumper and Jasper vector.

Rigid Fixed Functional Appliances

Rigid fixed functional appliances are completely different from flexible appliances in two aspects -

1. They don't fracture easily, because they are not elastic nor flexible; after the appliance is placed or engaged in the mouth, they are fitted and activated, which doesn't allow the patient to bite in its maximum intercuspation because the appliance forces the mandible to be in its forward / required position for 24 x 7 hours. This means it prevents and avoids the stimulus to drop there by providing more stimulus for growth. Thus, helping in great success of mandibular protraction.⁷
2. Rigid appliances always work in the mechanism which is based on telescopic mechanism. Therefore stimulating and forcing forward and anterior repositioning of the mandible while the patient tries to bites in occlusion. Skeletal correction and successful effects produced by these appliances are more when compared to those produced by flexible appliances. Examples of rigid appliances include: Herbst, AdvanSync 2 and MARA.

Hybrid Fixed Functional Appliances

Hybrid fixed functional appliances are a combination of both, flexible and rigid fixed functional appliances. They are rigid appliances but with spring / flexible systems. The main agenda and property of these appliances is to push the mandible teeth forward by continuously applying elastic and flexible forces for continuous 24 hours a day to stimulate growth every second. Therefore, it imitates the action of conventional class II elastics. Using of open spring to generate force is a typical property of hybrid fixed functional appliance. Force generated and produced is from 150 to 260 g.

The main purpose of hybrid appliances is not like the typical rigid or flexible appliances to reposition the mandible in anterior position. It is easy to claim that flexible and hybrid appliances produce more tooth movement during treatment, in comparison to rigid ones. This is because it does not move the condyle from its mandibular fossa.

Examples of hybrid appliances include: Forsus, Twin force bite corrector, Sabbagh universal spring (SUS) and power scope. The following characteristics explain the typical features of this new generation appliances: Spring or coil springs are inserted and present into the telescopes, therefore acting as a cushion for soft tissues and thus avoid hurting patient's cheek. It also prevents plaque and calculus formation because it avoids food lodgement or food accumulation while eating or chewing food during meals. Past appliances were very bulky therefore creating discomfort. Therefore, hybrid appliances were made in its reduced size, to provide more comfort and thus achieving comfort and patient's adaptation.

INDICATIONS FOR FIXED FUNCTIONAL APPLIANCE USE⁸

- For correction of class II malocclusions by imitating class II mechanics.
- For correction of cases of class II with mandibular retrognathism or retroposition, rigid appliances are indicated.
- For correction of cases of class II with protrusion in maxillary arch.
- For correction of the residual class II malocclusion correction after treatment with extractions of teeth for camouflage.
- Correction of class II, subdivision cases, where extraction of teeth was not needed.
- After the distalisation of maxillary molars, anchorage is critical to maintain it, therefore fixed functional appliance can act as an anchorage system for the distalised molars.
- After extractions are done, the molars tend to mesialise. Thus, loss of anchorage. Therefore, these appliances help in maintain the anchorage after extractions.
- When there are cases with mandibular second premolar agenesis, anchorage becomes critical, therefore these appliances can act as anchorage system to prevent mesialisation of posterior teeth during space closure.
- When second mandibular molars are extracted, fixed functional appliances act as anchorage
- In patients with mandibular deficiencies, functional appliances can treat as a compensatory treatment for adult patients.

CONTRAINDICATIONS FOR FIXED FUNCTIONAL APPLIANCE USE

There are some clinical situations in which the clinician needs to avoid the use of mandibular protraction appliances namely

- Periodontally compromised patients.
- Patients with gingival overgrowth in anterior region of mandibular teeth.
- Patients with mandibular teeth proclination or excessively tipped.
- Patients with excessive gingival display or overgrowth.
- Patients with skeletal or dental base towards an open bite.
- Efficacy of fixed functional appliances (FFA) in class II correction
- Functional orthopaedic treatment seeks to correct malocclusions and harmonize the shape of the dental arch and orofacial functions.

Removable functional appliances are normally very large in size, have unstable fixation, cause discomfort, lack tactile sensibility, exert pressure on the mucous (encouraging gingivitis), reduce space for the tongue, cause difficulty in deglutition and speech and very often affect aesthetic appearance. The alteration in the mandibular posture creates added difficulties. These adverse effects make the adaptation and acceptance of these appliances more difficult.

Fixed functional appliances (FFA) first appeared in 1900 when Emil Herbst presented his system at the Berlin International Dental Congress. Since then and up to the ninety seventies, very little was published on this appliance. It was at that time that Hans Pancherz brought the subject back into discussion with the publication of several articles on the Herbst. A number of fixed appliances have gained popularity in recent years to help achieve better results in non-compliant patients, so they are normally known as "non-complained class II correctors" as no co-operation of the patient is needed as in removable appliance. Fixed functional systems have some advantages over removable systems. They are designed to be used 24 hours a day, which means that there is a continuous stimulus for mandibular growth. They are smaller in size permitting better adaptation to functions such as a mastication, swallowing, speech and breathing. As these appliance demands minimal patient co-operation, they are able to treat class II malocclusions successfully, thus reducing overall treatment time. It is possible to treat this type of malocclusion with minimal effort. Just as the name implies, what distinguishes them from removable appliances is that it is impossible for the patient to remove them.

The Class II Problem Defined

In the 1890s, Angle provided the first formal definition of normal occlusion in the natural dentition. Angle's definition was based on the upper first molar, which was the "key to occlusion.¹⁰" The mesiobuccal cusp of the upper first molar should occlude in the buccal groove of the lower first molar on a smooth curving line of occlusion. Angle also described three classes of malocclusion, one of which was the class II. This was illustrated as the lower molar distally positioned relative to the upper molar. After World War II, cephalometric radiography became more commonly used in orthodontic treatment planning. With this new method of diagnosis, it was

more apparent that the jaw relationship as well as the dental relationship contributed to the class II malocclusion.

AETIOLOGY OF CLASS II MALOCCLUSIONS

With the large number of Class II malocclusions, there has been a great deal of focus on its nature throughout orthodontic literature. Here for better understanding this section of the review has been further divided into 4 main sets based on different anteroposterior criteria namely, maxillary skeletal position, maxillary dental position, mandibular skeletal position, and mandibular dental position.

Maxillary Skeletal Position¹¹

One prime component of a class II molar relationship can be assumed to be an anterior positioning of maxillary structures relative to other craniofacial components. In accord to this fact Altemus in 1955 and Rothstein in 1971 have reported this to be the case. While Elsasser and Wylie in 1948 note that although maxillary protrusion occurs in males, the maxilla of females was found in a neutral position. They also interpreted their findings to show that class II div 1 malocclusion cases are a result of maxillary over development in females when the means were compared. They found the maxillary length to be greater in class II div I males, but not the overall mandibular length in females. The overall mandibular length was found to be less in class II div I cases than in class I cases.

Riedel in 1952, recorded that in their samples, the maxilla was normally positioned in both sexes, and concluded that there was evidence of a tendency for the maxilla to become more prognathic with growth, when the younger age group was compared with adults and that there was a tendency of the mandible to become more prognathic with growth as well. In contrast to this, Henry in 1957, indicated that, on the average, the maxilla was in a slightly retrusive position in both sexes, and Henry reports that the SNA angle of his class. II sample averaged 1.5° less than the class I mean to which the class II was compared. It should be noted that the angle SNA may also vary due to the position of Sella. He also concluded that out of the one hundred three cases of class II div 1 studies, the mean position of the upper permanent first molar was distal in relation to cranial anatomy and in a similar manner even the mesio-distal position within the maxilla, when compared to normal. Class II div 1 malocclusion vary considerably and 4 types into which the malocclusion may be classified are readily discernible: - Type 1 - Maxillary alveolar protrusion, Type 2 - Maxillary basal protrusion, Type 3 - Micro-mandible, Type 4 - Mandibular retrusion.

Renfroe in 1948 stated that the maxilla of Class II, division 1 individuals were in a more retrusive position than those comparable to class I or class II, division 2 malocclusion samples.

Maxillary Dental Position

Another obvious component of the class II malocclusion is the position of the maxillary dentition relative to the maxillary skeletal structures.¹³

Previous studies by Riedel in 1952 notes that the maxillary incisor in his class II, division 1 sample was twice as far as anterior to the facial plane as that of those patients having normal occlusions. In contrast, Henry in 1957 notes that, relative to a line from nasion to point A, only 11 of 103 cases exhibited maxillary dentoalveolar protrusion. However, point A may be displaced by the incisor root and so mask some dental protrusion. Altemus in 1955 reports in his study that the posterior dentition was mesially located in the maxilla, while Elsasser and Wylie in 1948 noted no difference in maxillary molar position between groups of class II and class I individuals. Renfroe in 1948, however, reported that the upper first molar in his class II sample was located slightly posterior relative to the class I group.

Baldrige in 1950, concluded that the upper first permanent molar assumes the same relationship to the Frankfort horizontal plane and thus to the face and the cranium maintaining a class I and class II malocclusion. The upper first permanent molar however indicated that a difference is found between different age groups and larger measurement would be found in younger age groups. This would further indicate that the base bone of the maxilla, at least from the lateral aspect, is greater between point A and mesial surface of the upper first molar in the age group having mixed dentition.

Mandibular Skeletal Position¹²

Adams in 1948 and Rothstein in 1971 state that the absolute length of the mandibles in class II patients did not differ from those of class I subjects. Altemus in 1955 reported that the mandible was slightly longer in class II patients than in class I individuals. He suggested that there is a marked and obvious retrognathism, coupled with mandibular underdevelopment with no compensatory chin Hedging" (mental tubercles) to give a pseudo-orthognathism. Elsasser and Wylie in 1948 noted sexual dimorphism in class II individuals. In their studies, the mean value for mandibular length in class II males were within normal limits, while it was less than normal in class II females.

Craig in 1951 noted that the mandibular body is shorter in class II subjects. Most did not differentiate between the absolute size and the position of the mandible, and the lower first permanent molar was more posteriorly placed. Renfroe in 1948 however, noted that while certain class II patients could be characterized as being deficient in mandibular size, other class II patients had mandibles that were well formed and not underdeveloped but were retruded due to a posterior position of the glenoid fossa. The gonial angle was smaller when class II div 1 malocclusion were compared with class I malocclusion. All concluded that the mandible of class II individuals were retrognathic relative to other craniofacial structures.

Mandibular Dental Position

Less attention has been paid to the position of the mandibular dentition relative to the structure of the mandible. Generally, when the position of the mandibular dentition was considered, on the average, the lower incisors were related normally to basal structures. However, there was again some disagreement about the relative position of the lower first

molar.¹⁴ Elman in 1948 reported no difference in the position of the lower molar relative to class I individuals. He concluded that the relationship of the mandibular first permanent molar to the posterior and inferior border of the mandible was in a constant ratio of 3 : 2, i.e., the tooth is maintained in the same relative positioning in class I and class II div 1 malocclusions. Nevertheless, Craig in 1951 and Altemus in 1955 both reported that the lower molar in the class II individual was located more posteriorly and that there can be as it seems, a class II div 1 malocclusion in the teeth quite apart from a so called "class II div 1 face".

Whereas, Gilmore in 1950 found the position of the lower molar was quite variable. He drew the following conclusions-

1. The mandible in the class II div 1 group was found to be significantly smaller than the mandible in the excellent occlusion group. Females however exhibited a larger critical ratio than males.
2. There was no significant difference in the size of the anterior cranial base in either males or females when the excellent occlusion group was compared to the class II div 1 malocclusion group.
3. On the basis of angular measurements, it was demonstrated that the antero-posterior position of the gonion was not significantly different when comparisons were made within these groups on both sexes.
4. The angle N-S-Gn was not a valid means of measuring anteroposterior position of gnathion.
5. No significant difference was observed in gonial angle when the two occlusion groups were compared.
6. The position of mandibular first permanent molar was not found to be constant in its relation to the mandible.

MODE OF ACTION OF FIXED FUNCTIONAL APPLIANCES

The mechanism of action for adapting the mandible in forward and anterior position by fixed functional appliance is similar to that of removable functional appliances. The appliance is classified as a tooth-borne appliance which exerts its effects via first to the teeth and then transmitting it to the underlying bone developed by the continuous forward and anterior posturing of the mandibular jaw.

Even though there are various controversies related to the concepts of fixed functional appliances, the general mode of action is either one or combination of the following features -

- To induce mandibular growth.
- To restrict maxillary growth.
- Changes in the dentoalveolar region.
- Relocation of the glenoid fossa.
- When the anatomy, structure, and function of neuromuscular changes.

COMPLICATIONS WITH USE OF FIXED FUNCTIONAL APPLIANCES

Certain complications are seen with the use of fixed functional appliances which are as follows -

- Bands or splints fracture or when they break.
- Telescopic mechanism fracture.

- Bands or splints loosen down because of wearing out of flexibility or structure defect.
- Buccal mucosa injured or traumatised.

CONCLUSIONS

Removable functional appliances are effective but rely on patient's co-operation for achieving predictable results in reasonable time frame. Patient co-operation is variable and is not always fourth coming with appliances such as head gear or removable functional appliances.

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