Quest Journals
Journal of Medical and Dental Science Research
Volume 9~ Issue 10 (2022) pp: 83-92
ISSN(Online) : 2394-076X ISSN (Print):2394-0751
www.questjournals.org

Research Paper

Fixed Functional Orthodontic Appliances: A Review

Rajeev Sharma, Deepak Mohan Soni
[1] *MDS Orthodontics, PHC Summarkot, Directorate Of Dental Health, Shimla, Health and Family Welfare Department, Himachal Pradesh, India*
[2] *MDS Orthodontics, CHC Kuthera, Directorate Of Dental Health, Shimla, Health and Family Welfare Department, Himachal Pradesh, India*
Corresponding Author: Dr Deepak Mohan Soni

ABSTRACT
Correcting class II malocclusion has always challenged an orthodontist owing to the complex and multifactorial aetiology. Age of patient and selection of the appliance plays an important role in the outcome of the treatment. Growth modification using functional appliances achieves stable results in class II patients. Class II malocclusion though multifactorial in etiology, the main cause is mandibular retrognathia. The treatment aims to modify the direction and amount of mandibular growth rather than restricting the development of the maxilla. An orthodontist has wide variety of fixed and removable appliances for addressing a class II malocclusion. Fixed functional appliances were developed with the aim to correct Class II malocclusion without the need of patient compliance, which was a major concern toward removable functional appliances. Fixed functional appliances are grouped into flexible, rigid and hybrid. 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: *Class II Malocclusion , Functional Correction, Fixed Functional Appliances, Herbst Appliance*

***R**eceived 05 Oct., 2022; **R**evised 16 Oct., 2022; **A**ccepted 18 Oct., 2022 © The author(s) 2022.*
P**ublished with open access at **www.questjournals.org

I. INTRODUCTION

Class II essentially defines the sagittal relationship between the upper and lower permanent molars as propounded by Edward H. Angle. Correct recognition of dysplastic skeletal sagittal relationship of maxilla and mandible to each other and to the cranial base is important. There is no universal appliance for treatment of all class II malocclusions. Therapeutic guidance is to be performed during the active growth period [1,2].

Studies are suggestive that in class II malocclusion mandibular retrognathia is the main cause, rather than maxillary prognathism [3,4].

For Class II patients in whom the mandible is retrognathic, the ideal means of correction is to alter the amount or direction of growth of mandible [5]. In such patients, removable or fixed functional appliances are used for stimulation of mandibular growth by forward positioning of the mandible. [6]

II. CLASSIFICATION OF FUNCTIONAL APPLIANCES

Functional appliances are categorized into either removable or fixed ones (FFAs). An important factor discriminating these two types of appliances is the need for patient compliance [7]. Appliances independent of patient compliance include (1) Intermaxillary appliances and (2) Intramaxillary appliance [8].

Papadopoulos [8], further classified intermaxillary noncompliance appliances into four categories; depending upon the force system used to advance the mandible:

(A) Rigid Appliances
(B) Flexible Appliances
(C) Hybrid appliances (combination of above two)
(D) Appliances acting as substitute for elastics.

Rigid Intermaxillary Appliances (RIMA) include :
• Herbst Appliance • Biopedic Appliance • Ritto Appliance
• Mandibular Protraction Appliance (MPA) • Mandibular Anterior Repositioning Appliance (MARA™)
• Functional Mandibular Advancer (FMA)
Flexible Intermaxillay Appliances (FIMA) include
• Jasper Jumper™ • Scandee Tubular Jumper • Flex Developer (FD)
• Amoric Torsion Coils • Adjustable Bite Corrector (ABC) • Bite Fixer
• Gentle Jumper • Klapper SUPERspring II • Churro Jumper
• Forsus Nitinol Flat Spring • The Ribbon Jumper
Hybrid Appliances include:
• Eureka Spring™ • Sabbagh Universal Spring (SUS) • Forsus™Fatigue-Resistant Device
• Twin Force Bite Corrector (TFBC)
Appliances Acting as Substitutes for Elastics include:
• Calibrated Force Module • Alpern Class II Closers

III. INDICATIONS FOR FFAs:

1. As Class II mechanics.
2. Skeletal Class II patients with retrognathic mandible.
3. Residual Class II correction after extraction treatment.
4. Class II, subdivision, with nonextraction treatment.
5. As anchorage after maxillary molar distalization.
6. As anchorage in extraction cases.
7. As anchorage for space closure with mesialization of posterior teeth in cases of agenesis of mandibular second premolars or extraction of mandibular first molars.
8. Compensatory treatment of mandibular deficiency in adult patients.
9. As mandibular anterior repositioning splint in patients having Temporomandibular disorders.
10. Postsurgical stabilization of Class II/Class III malocclusions in adult patients.
11. Correction of functional midline shifts by using the appliance unilaterally

IV. CONTRAINDICATIONS

cost-benefit analysis must be done in patients having:
1. Periodontal issues.
2. Thin gingiva in the mandibular anterior region.
3. Proclined lower interiors.
4. Marked gingival smile.
5. Tendency to open bite.
6. vertical growth pattern.
7. susceptible root resorption due to extra loading of force generated with FFA.

V. IMPORTANT APPLIANCES

V.1 The Jasper Jumper: (Jaspar J, 1987) [9,10]

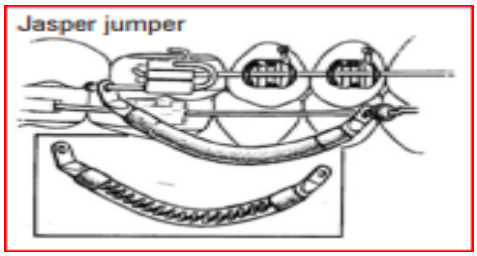

Fig. 1 Jasper jumper appliance

First flexible fixed functional appliance introduced in 1987. It contains a covered spring and is marketed in a kit of different sizes for both left and right sides. It delivers light, continuous functional forces, bite jumping forces, headgear-like forces, elastic-like forces, or a combination of these. Its flexibility makes it more comfortable and oral hygiene easy. It does not interfere with chewing as it curves away from the occlusal table. Potential disadvantages are: a large inventory, the coating material can degrade and fractures.

V.2 The Adjustable Bite Corrector: (Richard P. West, 1995) [11]
It is composed of various pieces, caps, closed coil springs and nickel titanium wire, therefore needs chairside assembly. It is stretchable and flexible and can be used on either side of the mouth with a simple 180° rotation of the lower end cap to change its orientation. This reduces the inventory by half.

Fig. 2 The adjustable bite corrector

Lumen of the spring contains a nickel titanium wire which exerts the "push" force. Repairs and replacements are rapid and easy. Talking, chewing and oral hygiene is comfortable.
V .3 The Klapper Super Spring: (Lewis Klapper, 1999) [12]

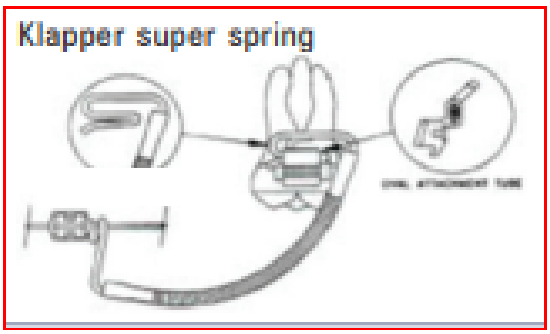

Fig. 3 The Klapper Super Spring

A flexible spring element which rests in the vestibule when activated. This facilitates hygiene and avoids occlusal surfaces. The open helical loop of the spring is twisted like a J-hook onto the mandibular archwire and is attached to the standard headgear tube (Super Spring I) or to a special oval tube(Super Spring II) and secured with a stainless steel ligature. Only two prefabricated sizes are available (with left and right versions of each). The length of the spring can be increased or decreased by simply bending the attachment wire. The horizontal configuration of the attachment wire at the maxillary molar tube permits distalization with good radicular control. The hinging action and the flexibility of the spring allows comfortable mandibular opening, therefore can be used in adults and children both. The SUPER spring II can be used in all Class II cases, vertical facial patterns, shallow overbites to brachyfacial patterns with deep overbites.

V. 4 Churro Jumper: (Castañon R et al. 1998) [13]

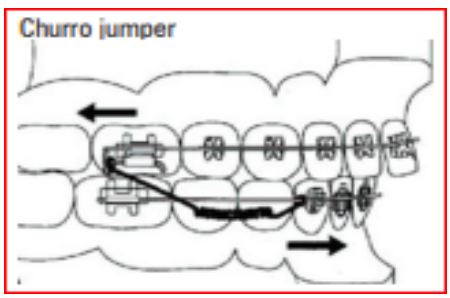

Fig. 4 Churro Jumper

It was developed as an improvement to the MPA, but functions more like the Jasper Jumper. An inexpensive alternative force system for Class II and Class III malocclusions. The mesial and distal ends of the jumper are circles. The distal circle is attached to the maxillary molars by a pin and the mesial end is placed

over the mandibular archwire against the canine bracket. This is the only flexible functional appliance which can be made by the orthodontist in lab with minimal cost and time.

V . 5 The Herbst Appliance: (Herbst E, 1910; Pancherz H, 1979) (Dentaurum, Inc.)[14-16]

Fig. 5 The Herbst Appliance

Introduced by Emil Herbst at the International Dental Congress in the year 1910, later reintroduced by Hans Pancherz in the October 1979 issue of American Journal of Orthodontics. The Herbst appliance consists of two tubes, two plungers, axles and screws. The original design had a bilateral telescopic mechanism consisting of push rod and tube attached to orthodontic bands on the maxillary first permanent molars and on mandibular first premolars (or canines); this maintains the mandible in a continuous protruded position.. As a result, muscles responsible for mandibular retrusion produce distalization force over maxillary teeth, while mesial force is produced against the mandible. Treatment with the banded Herbst appliance usually lasts 6-8 months. The Herbst appliance has undergone several changes in its original design but after seventies few modifications occurred with regard to methods of application (Type I, II and IV enabling it to successfully treat difficult Class II malocclusion cases.

Herbst Appliance Design Evolution When Pancherz[17] reintroduced the Herbst appliance, he used bands. In the 1990s, bands were replaced by metal splints made of a chromium-cobalt alloy. The system ensured accurate fit to teeth, in addition to being resistant and hygienic,thereby shortening chair time. Nevertheless, this increased costs of manufacturing. From 1982 onwards, Howe[18] and McNamara Jr.[19] began developing the Herbst appliance with acrylic splints. However, they noticed decalcification leading to caries and enamel fracture at debonding. Nowadays, it is seldom used. The Herbst appliance consisting of stainless steel crowns bonded to maxillary first molars and an acrylic splint covering the occlusal surface of mandibular teeth was introduced in 1989.[20]The system allowed the mandibular piece to be temporarily removed, thus making oral hygiene and adjustment to under-erupted teeth easier.

Types Of Telescopic Systems The telescopic system also evolved along the appliance design over the years, providing more fracture resistance to the appliance, [21,22] and enhancing patient's adaptation.

The most important models are:

» Dentaurum types I, II, IV and TS (Dentaurum, Ispringen, Germany).
» Flip - Lock (TP Orthodontics, La Porte, IN, USA).
» Hanks-HTH and Miniscope (Fig 1) (American Orthodontics, Sheboygan, WI, USA).
» Abzil Mandibular Protraction Appliance, PMA (3M - ABZIL, São José do Rio Preto, SP, Brazil).
» AdvanSync (Ormco, Orange, CA, USA). » M4 (Specialty Apliances, Cumming, GA, USA).
» Manni Telescopic Herbst (MTH) (Micerium, Avegno, GE, Italy).

Dentoskeletal Effects

Possible mechanisms of action are restricted maxillary growth; increased mandibular growth; maxillary molars distalization; mandibular molars mesialization or a combination of these depending upon appliance design and patient's growth stage.

As regards to mandibular growth, one year of appliance use allows mandible to grow an average of 1.3 to 1.7 mm more.[23,24] In a systematic review on mandibular changes produced by functional appliances, Cozza et al[25] concluded that the Herbst appliance showed the highest coefficient of efficiency.

Mandibular growth can be clinically stimulated; however, not in every Class II patient. Patients with the best responses[26] are those having gonial angle around 122°. Dolichofacial patients do not present satisfactory growth response.[27] Some researchers believe the appliance has long-term effects,[28] however, others claim the appliance speeds up mandibular growth only during appliance use. After removal, it decreases as if no appliance had been used[29,30]. Notably there is lack of systematic reviews and meta-analyses based on stronger evidences dealing with the appliances' long-term effects.

Best Moment To Use The Herbst Appliance: Several studies have shown the best moment to stimulate mandibular growth is right before reaching the peak in pubertal growth spurt.[31] Nevertheless, Behrents[32] published an editorial reporting up-to-date safe scientific evidence suggesting the early Class II treatment onset in cases with patients presenting protruding maxillary incisors.

When Should The Appliance Be Removed?

The appliance is typically used for a period of 8 to 12 months. Condyles must be centered in the mandibular fossa at the time of removal. Relapse in terms of dental relationship seems routine, thus, it is paramount to overcorrect molar relationship and, if possible, reach Class III. After removal, perfect detailing of the occlusion must be accomplished using fixed orthodontics.

Studies have shown that the duration of forward movement is a critical factor in maturation of newly formed bone and stability of outcomes.[33,34] Late appliance removal might prevent little growth and increase maturation of newly formed bone matrix [33]. Studies[33] have shown that a 6-month period is required for newly formed bone (former collagen matrix type III) to mature into collagen matrix type I, with the latter being more stable. Therefore, mandibular advancement for at least six months is necessary.[35]

V. 6 Cantilevered Bite Jumper: (Ormco co.) [8]

In 1994, Mayes [36] introduced this appliance, made of four stainless steel crowns bonded to maxillary and mandibular first molars, with a cantilever welded to mandibular first molar crowns. This extended anteriorly to the premolar and canine area, where the mandibular pivot was placed. Design advantages included use in mixed dentition without the need for premolar bands. Ormco stainless-steel crowns have remained the best option for Herbst appliance manufacture in the past as they were highly resistant, however, debonding was an arduous task. Presently Rollo bands (American Orthodontics) are most widely used for Herbst appliance manufacture. With occlusal surface partially coated, they have retention similar to a crown with the versatility of bands and come in seven different sizes. (Fig 7).

Fig. 6 Miniscope telescopic system: A) Rollo band; B) Universal nut; C) Barrel nut; D) Miniscope (right side); E) Applecore screw.

Disadvantage: Thickness of the screw mechanism can impinge on the patient's cheek.

V. 7 Flip-Lock Herbst Appliance: (TP Orthodontics, Inc.) [37]

The third generation of ball-joint Herbst appliances. The first generation was made from a dense polysulfone plastic but breakage occurred because of the forces generated within the ball-joint attachment. In the second generation, the plastic was replaced with metal. However, fracture problems persisted. The third generation is made of a horse-shoe ball joint. Third generation is more efficient than the previous models, both in terms of application and its resistance to fracture. Compared to other appliances with a ball joint it is thinner and smaller, providing greater patient comfort.

V. 8 The Ventral Telescope: (Professional Positioners, Inc.) [8]

First telescopic rigid fixed functional appliance that appeared as a single unit. Upon reaching maximum opening it remains intact . Available in two sizes and fixing is achieved through ball attachments. Unscrewing the tube allows an activation of around 3 mm. But it is quite thick and suffers from fractures of the brake which stabilizes the joint. As fixing is achieved through ball attachments, great accuracy is necessary with regard to inclination and the welding of components.

V. 9 The Magnetic Telescopic Device: (Ritto AK, 1997) [38]

Two tubes and two plungers with a semi-circular section and NdFeB magnets placed in such a manner that a repelling force is exerted. Fitting is achieved by using the MALU system. This appliance has the advantage of linking a magnetic field to the functional appliance. Its main disadvantages are its thickness, the laboratory work necessary to prepare it and the covering of the magnets.

V. 10 The Mandibular Protraction Appliance: (MPA) (Filho C, 1995, 1997, 1998) [39-41]

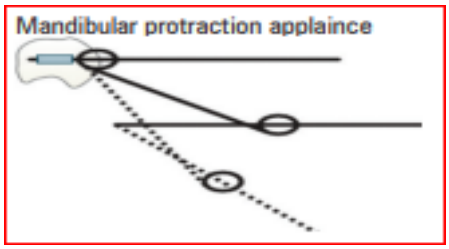

Fig. 7 The Mandibular Protraction Appliance

A rigid fixed functional appliance developed to be quickly made by the orthodontist in the laboratory. Its advantages include ease of manufacture, low cost, infrequent breakage, patient comfort and rapid fitting.
Three main types are:
MPA I: Each side of the appliance is made by bending a small loop at a right angle to the end of a 0.032" SS wire. The length of the appliance is determined by protruding the mandible and another small right-angle circle is bent in an opposite direction. The appliance slides distally along the mandibular archwire and mesially along the maxillary archwire. Bicuspid brackets must be debonded. Limited mouth opening is the major disadvantage.
MPA II: Right-angled circles are made in two seperate pieces of 0.032" SS wire. A piece of slipped coil is slipped over one of the wires. One end of each wire is then inserted through the loop in the other wire. This allows the mouth to open wider than the first version.
MPA III: This version eliminates the archwire stress that occurred with the MPA I and II. It permits a greater range of jaw movement while keeping the mandible in a protruded position. Adaptable to either Class II or Class III malocclusions, it also incorporates a telescopic mechanism but is smaller herbst.

V. 11 The Universal Bite Jumper: (UBJ) (Calvez X, 1998) [42]
Similar to Herbst but smaller in size and more versatile. It can be used in all phases of treatment in mixed or permanent dentition, Class II or III malocclusions. An active coil spring can be added if necessary. No laboratory preparation is required. It is cut to the appropriate length for the desired mandibular advancement after fitting. Activations are made by crimping 2-4 mm splint bushings onto the rods. UBJs with nickel titanium coil springs do not need to be reactivated.

V. 12 The Biopedic Appliance: (GAC International, Inc.) [43]
This uses a cantilever system, attached to a BioPedic buccal tube. Activation is achieved by sliding the appliance along the buccal tube and fixing the screw. It is universally sized for left and right sides. Two pivots on the ends allow the appliance to be rotated when the patient opens his mouth.

V. 13 The Mandibular Anterior Repositioning Appliance: (MARA) [44]

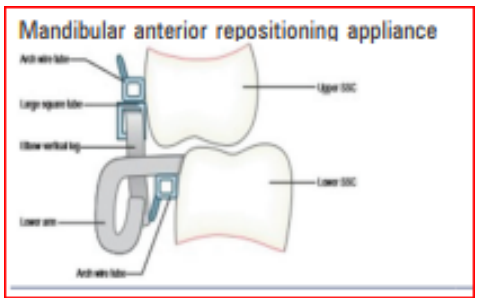

Fig. 8 The Mandibular Repositioning Appliance

Created by Douglas Toll of Germany in 1991and reintroduced by Eckhart in the year 1998, it is considered to be a fixed twin block. Crowding is treated with arch expansion and advancing the incisors. The first molars have stainless steel crowns and the appliance is laboratory manufactured. The patient can pull back his mandible to a Class II relation but can't achieve intercuspation. The appliance is used in conjunction with braces and can be used for Class II treatment and TMJ problems. This is an appliance with simple characteristics which allows good hygiene.

V. 14 The IST Appliance: (Intraoral Snoring Therapy Appliance)(Sheu Dental, Germany) [8]
A novel device designed by Hinz to treat breathing problems during sleep, e.g. obstructive sleep apnea. The IST appliance suppresses snoring by moving the lower jaw forward reducing the obstruction in the pharyngeal area.

V. 15 The Ritto Appliance: (Ritto AK, 1998) [8]

Fig. 8 The Ritto appliance

A miniaturized telescopic device with simplified intraoral application and activation. The construction is based on the mechanism of the Ventral Telescope and is used with a fixed appliance.
Compared to the Ventral Telescope, main differences are:
• No disengagement after maximum extension.
• Better adaptation, aesthetic appearance or speech due to smaller size.
• single format and one size for both sides.
simple to use, comfortable, cost effective, breakage resistant, can be fitted/removed in less than 5 minutes and requires no patient cooperation. Can be used in mixed or permanent dentition using only conventional bands on the upper molars and two tubes on the lower molars and brackets on the lower incisors. Upper fixation is done by placing a steel ball pin from the distal side into the .045 headgear tube on the upper molar band and bending it back. The appliance is fixed onto a prepared lower arch. Activation is achieved by sliding the lock along the lower arch in the distal direction and then fixing it against the Ritto Appliance.

V. 16 Eureka Spring (DeVicenzo and Steve Prins in 1996) [45]

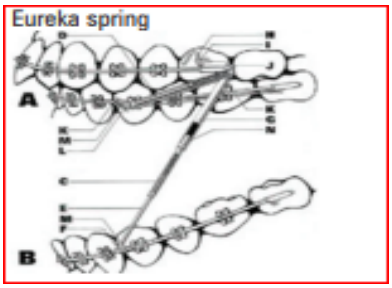

Fig. 9 The Eureka Spring

It is a three part telescopic appliance fixed to upper molar band and distal to lower cuspid and includes an open coil spring. The placement is simple, and patient can open his mouth widely. Available in two sizes: 20 and 23 mm long, the appliance is universal for both right and left side.

V. 17 The Twin Force Bite Corrector [8]

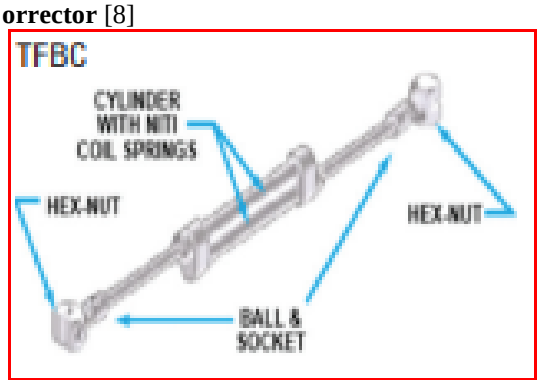

Fig. 10 The Twin Force Bite Corrector

This appliance is quite different in form and constitution. It consists of two internal coil springs and two joint telescopic systems. It is fixed with a ball pin into the buccal tube of the upper molar with a screw to

the inferior arch, distal to the lower cuspid. Available in two sizes, its placement and removal is rapid. It can be used in Class II and Class III treatment and also as an anchorage system. The force produced is difficult to control and the lower dentition needs to be aligned first as 016"x.022, or 017"x.025" stainless steel wires are required for necessary anchorage. So it is recommended for permanent dentition only. For Class III correction a lip bumper tube (LBT) is placed on the lower molar band. Recently the third modernized version of the appliance called "Twin Force Bite Corrector Double Lock" is introduced. It is reduced in size and both the lower and upper placement is based on the system of lock-on screws. The new version facilitates use for Class III correction and allows slightly better control of the force.

V. 18 Forsus^{tm} Fatigue Resistant Device (3M Unitek Corporation) [46]

Fig. 11 Forsus Fatigue Resistant Device

This is an innovative three telescopic appliance with a coil spring in its exterior part. It resembles flexible functional appliances but the coil spring is resistant to breaking. The coil spring is applied by sliding it on a rigid surface avoiding angulations at the fixing points. Kits include different length sizes for left and right side. The appliance slides along the arch and facilitates opening of the mouth and lateral movements. The resulting force concentrates more on the anterior and inferior sectors.

There is no interference with continuous arches used during the treatment. The device gives the power to control the amount of force, whether through various available sizes, or through the direct attachment to the lower arch and the use of a stop for activation. The appliance can be used in mixed dentition and also allows for dental asymmetry correction.

Another device from the same company is the FORSUS^{TM} NITINOL FLAT SPRING which presents a Nitinol flat wire instead of the coil. The appliance's flat surface is comfortable and more esthetically acceptable. It requires no laboratory setup, making chairside installation quick and easy. Available in three different designs, it accommodates a variety of molar attachments. This flexibility eliminates the need for special molar attachments and reduces the inventory of bands and tubes. It is made of Super-Elastic Nitinol which delivers consistent and continous forces. The result is faster and more efficient treatment.

V. 18 Alpern Class II Closers (GAC International, Inc.) [8]

The most recent appliance which is slightly different from the preceding ones and is used as a substitute for elastics. It consists of a small telescopic appliance with an interior coil spring and two hooks for fixing. It functions in the same way as elastics and, similarly, is fixed to the lower molar and upper cuspid, thus enables a comfortable opening of the mouth. It is available in three different sizes.

V. 19 Powerscope: [47]

Fig. 12 Powerscope

Released in 2014, was a new generation of hybrid fixed functional appliance. Just a year later, the appliance was subjected to three changes (stop reinforcement, magnet key, and activation indicator piece), and hence, it was renamed PowerScope 2. It comes as a one-size-fit all appliance, consisting of a telescopic system with three fitting pieces that do not come loose during treatment.

V. 20 Advansync 2 Appliance (Ormco) [48]

Fig. 13 The Advansync 2 Appliance

Advansync was developed by Dr. Bill M. Dischinger and his father in 2008, followed by a couple of years later with the AdvanSync 2 appliance with a few modifications. The appliance is almost half of the size of the MiniScope Herbst appliance. Because of the smaller size, it fits far posterior in the mouth and is less discernible so is more acceptable to patients. Class II correction and fixed orthodontics could be carried out simultaneously thereby reducing the treatment time by 6 months.

VI. TREATMENT OUTCOMES

Functional Jaw Orthopedic treatment responds well in actively growing individuals. Findings of a cephalometric evaluation of 6 months treatment with Herbst appliance by Panchrez in 1979, were:

1) Achievement of normal occlusion in all patients;
2) Slight reduction in SNA indicating maxillary growth restriction or redirection;
3) Increased SNB showing greater than average mandibular growth;
4) Increased mandibular length supportive of condylar growth stimulation;
5) Reduction in hard and soft tissue convexity. [6]

McNamara et al studied 45 patients treated with either Herbst or Fränkel-2 appliances and found that both appliances significantly influenced growth of the craniofacial complex and skeletal changes increased mandibular length and lower facial height. Greater dentoalveolar effects were noted in the group wearing the tooth-borne functional appliance than in those wearing the tissue-borne appliance. [49].

Croft et al., performed a cephalometric and tomographic study of the Herbst appliance and found similar results to those of the Fränkel II appliance. Authors found no significant joint space changes at the end of treatment and rejected the idea of mandibular posturing and condylar repositioning as a factor in relapse. Authors concluded that Herbst treatment in the mixed dentition, in combination with retention, produces significant long-term improvements in dental and skeletal relationships as a result of dentoalveolar and orthopedic effects in both jaws. [50]. A recent systematic review and meta-analysis done by Ishaq et al., in 2016 revealed lack of high-quality evidence concerning relative influence of fixed functional appliances on skeletal and dentoalveolar changes. In addition authors conclude that based on the limited evidence, it appears that they have little effect on the skeletal mandibular parameters [51].

VII. CONCLUSION

Fixed functional appliances can be considered a boon in skeletal Class II treatment especially in individuals who are near to completion of their active growth and rely mainly on dentoalveolar effects, advantageous mainly because of no need for reliance on patient compliance.

COMPETING INTERESTS: Nil

REFERENCES

[1]. Graber TM, Rakosi T, Petrovic AG. Dentofacial Orthopedics with Functional Applications. 1997.
[2]. Pancherz H. Treatment of Class II malocclusions by jumping the bite with the Herbst appliance: a cephalometric investigation. Am J Orthod. 1979; 76: 423-442. Ref.: https://goo.gl/c2ApAA
[3]. McNamara JA Jr. Components of Class II malocclusion in children 8-10 years of age. Angle Orthod. 1981; 51: 177-202. Ref.: https://goo.gl/KF8hN7
[4]. McNamara JA Jr, Brudon WL. Orthodontics and Dentofacial Orthopedics. Ann Arbor Mich. 2001.
[5]. Chen JY, Will LA, Niederman R. Analysis of efficacy of functional appliances on mandibular growth. American Journal of Orthodontics and Dentofacial Orthopedics. 2002; 122: 470-476. Ref.: https://goo.gl/9x4ENF
[6]. McNamara JA Jr, Brudon WL. Orthodontics and dentofacial orthopedics. Ann Arbor. 2001; 67-80.
[7]. Zymperdikas VF, Koretsi V, Papageorgiou SN, Papadopoulos MA. Treatment effects of fixed functional appliances in patients with Class II malocclusion: a systematic review and meta-analysis. Eur J Orthod. 2015; 38: 113-126. Ref.: https://goo.gl/5Xm5Bu
[8]. Zenter A. The problem of compliance in orthodontics. In: Papadopoulos MA, editor. Orthodontic treatment of the Class II noncompliant patient: current principles and techniques. 1st ed. London, United Kingdom. Elsevier. 2006; 9:14.
[9]. McNamara JA Jr, Brudon WL. The Jasper Jumper. In: McNamara JA Jr, Brudon WL, eds. Orthodontics and dentofacial orthopedics. Ann Arbor. 2001: 333-342.
[10]. Blackwood HO. Clinical Management with the Jasper Jumper. J Clin Orthod. 1991; 25: 755-760. Ref.: https://goo.gl/5wJrML
[11]. West RP. The adjustable bite corrector. J Clin Orthod. 1995; 29: 650-657. Ref.: https://goo.gl/sA7kL2

[12]. Klapper L. The SUPERspring II: A new appliance for non-compliant class II patients. J Clin Orthod. 1999; 33: 50-54. Ref.: https://goo.gl/3zar83
[13]. Castañon R, Valdes MS, White LW. Clinical use of the Churro Jumper. J Clin Orthod. 1998; 32: 721-754. Ref.: https://goo.gl/2t4B8H
[14]. Pancherz H. Treatment of Class II malocclusions by jumping the bite with the Herbst appliance. A cephalometric investigation. Am. J Orthod. 1979; 76: 423-442. Ref.: https://goo.gl/UD6vWt
[15]. Pancherz H. The mechanism of Class II correction in Herbst appliance treatment. Am J Orthod. 1982; 82: 104-113. Ref.: https://goo.gl/Sp9X61
[16]. Pancherz H. The Herbst appliance. Its biological effects and clinical use. Am J Orthod. 1985; 87: 1-20. Ref.: https://goo.gl/fQoXzy
[17]. Sanden E, Pancherz H, Hansen K. Complications during Herbst appliance treatment. J Clin Orthod. 2004 Mar;38(3):130-3.
[18]. Howe RP. The bonded Herbst appliance. J Clin Orthod. 1982 Oct;16(10):663-7.
[19]. Howe RP, McNamara JA Jr. Clinical management of the bonded Herbst appliance. J Clin Orthod. 1983 July;17(7):456-63.
[20]. Valant JR, Sinclair PM. Treatment effects of the Herbst appliance. Am J Orthod Dentofacial Orthop. 1989 Feb;95(2):138-47.
[21]. Moro A, Janson G, Moresca R, Freitas MR, Henriques JF. Comparative study of complications during Herbst treatment with cantilever bite jumper and removable mandibular acrylics plint. Dental Press J Orthod. 2011 JanFeb;16(1):29.e-1-7.
[22]. Silva JF, Gerszewski C, Moresca RC, Correr GM, Flores-Mir C, Moro A. Retrospective study of clinical complications during orthodontic treatment with either a removable mandibular acrylic splint Herbst or with a cantilever Herbst. Angle Orthod. 2015 Jan;85(1):64-71.
[23]. Moro A, Janson G, de Freitas MR, Henriques JF, Petrelli NE, Lauris JP. Class II correction with the Cantilever Bite Jumper. Angle Orthod. 2009 Mar;79(2):221-9.
[24]. Yang X, Zhu Y, Long H, Zhou Y, Jian F, Ye N, et al. The effectiveness of the Herbst appliance for patients with Class II malocclusion: a meta-analysis. Eur J Orthod. 2016 June;38(3):324-33.
[25]. Cozza P, Baccetti T, Franchi L, De Toffol L, McNamara JA Jr. Mandibular changes produced by functional appliances in Class II malocclusion: a systematic review. Am J Orthod Dentofacial Orthop. 2006 May;129(5):599. e1-12; discussion e1-6.
[26]. Baccetti T, Franchi L, Stahl F. Comparison of 2 comprehensive Class II treatment protocols including the bonded Herbst and headgear appliances: a double-blind study of consecutively treated patients at puberty. Am J Orthod Dentofacial Orthop. 2009 June;135(6):698.e1-10; discussion 698-9.
[27]. Rogers K, Campbell PM, Tadlock L, Schneiderman E, Buschang PH. Treatment changes of hypo- and hyperdivergent Class II Herbst patients. Angle Orthod. 2018 Jan;88(1):3-9.
[28]. Faltin KJ, Faltin RM, Baccetti T, Franchi L, Ghiozzi B, McNamara JA Jr. Long-term effectiveness and treatment timing for Bionator therapy. Angle Orthod. 2003 June;73(3):221-30.
[29]. Lai M, McNamara JA, Jr. An evaluation of two-phase treatment with the Herbst appliance and preadjusted edgewise therapy. Semin Orthod. 1998 Mar;4(1):46-58. 24. Johnston LE Jr. Functional appliances: a mortgage on mandibular position. Aust Orthod J. 1996 Oct;14(3):154-7.
[30]. Hagg U, Pancherz H. Dentofacial orthopaedics in relation to chronological age, growth period and skeletal development. An analysis of 72 male patients with Class II division 1 malocclusion treated with the Herbst appliance. Eur J Orthod. 1988 Aug;10(3):169-76.
[31]. Behrents RG. One phase or two, and Buridan's paradox. Am J Orthod Dentofacial Orthop. 2016 June;149(6):775-6
[32]. Kinzinger G, Kober C, Diedrich P. Topography and morphology of the mandibular condyle during fixed functional orthopedic treatment: a magnetic resonance imaging study. J Orofac Orthop. 2007 Mar;68(2):124-47.
[33]. Chayanupatkul A, Rabie AB, Hagg U. Temporomandibular response to early and late removal of bite-jumping devices. Eur J Orthod. 2003 Oct;25(5):465-70.
[34]. Tomblyn T, Rogers M, Andrews L 2nd, Martin C, Tremont T, Gunel E, et al. Cephalometric study of Class II Division 1 patients treated with an extendedduration, reinforced, banded Herbst appliance followed by fixed appliances. Am J Orthod Dentofacial Orthop. 2016 Nov;150(5):818-30.
[35]. Chaiyongsirisern A, Rabie AB, Wong RW. Stepwise advancement Herbst appliance versus mandibular sagittal split osteotomy. Treatment effects and long-term stability of adult Class II patients. Angle Orthod. 2009 Nov;79(6):1084-94
[36]. Mayes JH. Improving appliance efficiency with the Cantilever Herbst. A new answer to old problems. Clin Impressions. 1994;3(2):2-5, 17-9
[37]. Miller RA. The Flip-lock Herbst Appliance. J Clin Orthod. 1996; 30: 552-558. Ref.: https://goo.gl/HDu7KE
[38]. Ritto AK. Fixed functional appliances – Trends for the next century. Funct Orthod 1999;16:22-39
[39]. Coelho Filho CM. Mandibular Protraction Appliances for Class II Treatment. J Clin Orthod. 1995; 29: 319-336. Ref.: https://goo.gl/3Vkf6S
[40]. Coelho Filho CM. Clinical Applications of the Mandibular Protraction Appliance. J Clin Orthod. 1997; 31: 92 -102. Ref.: https://goo.gl/NjJLRq
[41]. Filho CM. The Mandibular Protraction Appliance III. J Clin Orthod. 1998; 32: 379-384.
[42]. Calvez X. The universal bite jumper. J Clinical Orthod. 1998; 32: 493-500. Ref.: https://goo.gl/E8niU4
[43]. DeVincenzo DJ. Treatment options for sagittal corrections in noncompliant patients. In: Graber TM, Vanarsdall RL Jr, eds. Orthodontics. Current principles and techniques. St Louis: Mosby. 2000; 779-800.
[44]. Eckart E. Introducing the MARA. Clinical Impressions. 1998; 7: 2-5. Ref.: https://goo.gl/dd23Wa
[45]. Devincenzo J. The Eureka Spring: a new interarch force delivery system. J Clin Orthod. 1997; 31: 454-467. Ref.: https://goo.gl/z1oYaB
[46]. Vogt W. The Forsus Fatigue Resistant Device. J Clin Orthod. 2006; 40: 368-377. Ref.: https://goo.gl/UyeMHG
[47]. MoroA, Borges SW, Spada PP, Morais ND, Correr GM, Chaves CM Jr., et al. Twenty-year clinical experience with fixed functional appliances. Dental Press J Orthod 2018;23:87-109.
[48]. Dischinger BM. Skeletal Class II case presentation: Utilization of the AdvanSync 2 appliance. APOS Trends Orthod 2018;8:168-74.
[49]. McNamara JA, Howe RP, Dischinger TG. A comparison of the Herbst and Fränkel appliances in the treatment of Class II malocclusion. Am J Orthod Dentofacial Orthop. 1990; 98: 134-144. Ref.: https://goo.gl/KC6mzz
[50]. Croft RS, Buschang PH, English JD, Meyer R. A cephalometric and tomographic evaluation of Herbst treatment in the mixed dentition. Am J Orthod Dentofacial Orthop. 1999; 116: 435-443. Ref.: https://goo.gl/MrB7Qq
[51]. Ishaq RA, AlHammadi MS, Fayed MM, El-Ezz AA, Mostafa Y. Fixed functional appliances with multibracket appliances have no skeletal effect on the mandible: A systematic review and meta-analysis. Am J Orthod Dentofacial Orthop. 2016; 149: 612-624. Ref.: https://goo.gl/xCV5Qs