



Review Article

Fixed functional Appliances in Orthodontics-A review

Devinder Preet Singh* and Ramanpreet Kaur

Department of Orthodontics and Dentofacial Orthopedics, Dr. Harvansh Singh Judge Institute of Dental Sciences and Hospital, Sector-25, South Campus, Panjab University, Chandigarh, India

***Address for Correspondence:** Dr. Devinder Preet Singh, Mohali Medical Centre, Phase 2, Opposite Bassi Cinema, Mohali, Punjab, India-160055, Tel: +919316557350; Email: ahluwalia147@gmail.com

Submitted: 22 December 2017

Approved: 09 January 2018

Published: 10 January 2018

Copyright: © 2018 Singh DP, et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Keywords: Class II malocclusion; Fixed functional appliances; Growth modification

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. An orthodontist has wide variety of fixed and removable appliances for addressing a class II malocclusion. In this review article an attempt has been made to compile various available fixed functional appliances.

Introduction

Patients reporting with Class II malocclusion form a major part of orthodontic irregularities. Studies are suggestive that in class II malocclusion mandibular retrognathia is the main cause, rather than maxillary prognathism being responsible for it [1,2].

For Class II patients in whom the mandible is retrognathic, the ideal means of correction is to target the source and try to alter the amount or direction of growth in that jaw [3]. In such patients, for stimulation of mandibular growth by forward positioning of the mandible, removable or fixed functional appliances are used. A wide range of functional appliances aimed to stimulate mandibular growth by forward posturing of the mandible is available to correct class II skeletal and occlusal disharmony [4].

Treatment of class II malocclusion

In strictest sense designation of 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 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 [5,6].

Functional appliances are categorized into either removable or fixed ones (FFAs). An important factor discriminating between the two types of appliances is the need of patient compliance [7]. Various compliance independent class correction appliances are available. These appliances are divided into two categories depending on their mode of action and type of anchorage; which include (1) Intermaxillary noncompliance appliances and (2) Intramaxillary noncompliance appliance [8].

Papadopoulos [8], further classified intermaxillary noncompliance appliances into four categories; depending upon features of force system used to advance the mandible; which include-



- (A) Rigid Intermaxillary Appliances (RIMA)
- (B) Flexible Intermaxillary Appliances (FIMA)
- (C) Hybrid appliances (combination of RIMA and FIMA)
- (D) Appliances acting as substitute for elastics.

Rigid Intermaxillary Appliances (RIMA) include following;

- Herbst Appliance
- Biopedic Appliance
- Ritto Appliance®
- Mandibular Protraction Appliance (MPA)
- Mandibular Anterior Repositioning Appliance (MARA™)
- Functional Mandibular Advancer (FMA)

Flexible Intermaxillary Appliances (FIMA) are:

- 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 (Combination of RIMA and FIMA) are as follows:

- Eureka Spring™
- Sabbagh Universal Spring (SUS)
- Forsus™ Fatigue-Resistant Device
- Twin Force Bite Corrector (TFBC)

Appliances Acting as Substitutes for Elastics includes:

- Calibrated Force Module
- Alpern Class II Closers

The Jasper Jumper: (Jasper J, 1987) (American Orthodontics) [9,10]

This was the first flexible fixed functional appliance to appear. It is made up of a covered spring and is marketed in a kit of different sizes with both left and right sides.

It is accompanied by a quite thorough instruction manual. It is also an appliance which is more comfortable for the patient because of its covering. Potential disadvantages are: the large inventory that must be kept, the coating material may degrade and fractures can occur with some frequency.

The Amoric Torsion Coils: (Amoric M, 1994) [8]

This appliance is made up of two springs, one of which slides inside the other. They are intermaxillary springs without covering and have a simplified application system of rings on the ends. These rings are fixed to the upper and lower arches with double ligatures. They are marketed in one size only and are bilateral. A large stock of material is therefore, not necessary. The force exerted by the appliance is variable in accordance with the fixing points on the arch.

The Adjustable Bite Corrector: (Richard P. West, 1995) (Orthoplus, Inc Santa Rosa, CA) [11]

This is an appliance which is assembled by the orthodontist as it is composed of various pieces, caps, closed coil springs, nickel titanium wire. It 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 as much as one half. In the center lumen of the spring we find a nickel titanium wire which is responsible for the “push” force generated. Repairs and replacements are rapid and easily carried out with this kit. The cost of repair is minor.

The Scandee Tubular Jumper: (Saga Dental AS, 2201 Kongsvinger, Norway) [8]

This is a coated intermaxillary torsion spring sold in a kit which includes the spring, the covering, the connectors, the ballpins and the glue. There is no distinction between left and right. The covering can be of different colors making it more attractive for patients. The orthodontist constructs the appliance, cutting the spring to the length seen fit. When a fracture occurs, it is only necessary to replace individual components. It has the drawback of being thick after the covering is applied.

The Klapper Super Spring: (Lewis Klapper, 1999) (Trademark of Orthodesign, Falls Circle, Lake Forest) [12]

This is a flexible spring element which is attached between the maxillary molar and the mandibular canine. The length of the element causes it to rest in the vestibule when activated. This facilitates hygiene and avoids occlusal surfaces. The ends (fixing points) are different. The open helical loop of the spring is twisted like a J-hook onto the mandibular archwire. On the maxillary end it is attached to the standard headgear tube (Super Spring I) or to a special oval tube and secured with a stainless steel ligature (Super Spring II). This new version prevents any lateral movement of the spring in the vestibule. 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.

Bite Fixer: (Ormco 1717 West Collins Avenue, Orange, CA) [13]

This is a new intermaxillary spring coil. The spring is attached and crimped to the end fitting to prevent breakage between the spring and the end fitting. Polyurethane tubing is inside the spring to prevent it from becoming a food trap. The Bite Fixer is supplied in a kit with various sizes for both left and right.

Churro Jumper: (Castañon R et al. 1998) [14]

This is an inexpensive alternative force system for the anteroposterior correction of 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. So far, this is the only flexible functional appliance which can be made up by the orthodontist in his lab. The costs are reduced and the time spent is minimal.

The Herbst Appliance: (Herbst E, 1910; Pancherz H, 1979) (Dentaurum, Inc, Pheasant Run, Newtown, PA) [15-17]

The Herbst appliance was first described by Emil Herbst in 1905 at the Berlin Dental Congress. After that very little was written on this appliance until the end of the seventies when Hans Pancherz brought it back into discussion with the publication of a series of articles. The Herbst appliance consists of two tubes, two plungers, axles and screws. The original device is a banded Herbst design. The Herbst appliance has undergone some changes in its original design but since the seventies has maintained its general shape with only a few modifications taking place with regard to methods of application (Type I, II and IV).

Cantilevered Bite Jumper: (Ormco 1717 West Collins Avenue, Orange, CA) [8]

More recently, the use of a cantilever has been proposed. The biggest difference resides in the fact that the Herbst style appliance is fitted directly to the lower molar bands through a cantilever arm. This system means that crowns have to be fitted to the upper and lower molars. The cantilever secured to the mandibular stainless steel crowns has a disadvantage in that the thickness of the screw mechanism can impinge on the patient's cheek. The parts are available in kit form with pre-welded screw mechanisms and cantilever arms on crowns of seven different sizes.

MALU Herbst Appliance: (Saga Dental Supply A/S, Kongsviner, Norway) [18]

The MALU Mandibular Advancement Locking Unit is a recently developed attachment device for the Herbst. It consists of two tubes, two plungers, two upper "Mobe" hinges with ball pins and two lower key hinges with brass pins. The major advantages are the lower cost, no laboratory needed, flexibility and the possibility of using combined with edgewise therapy. Each upper Mobe hinge is inserted into the hole at the end of the MALU tube and secured to the first molar headgear tube with ball pin. Each lower key hinge is inserted into the hole at the end of the plunger and locked to the base arch, distal to the cuspid, with the brass pin.

Flip-Lock Herbst Appliance: (TP Orthodontics, Inc., 100 Center Plaza, LaPorte, IN) [19]

This is the third generation of ball-joint Herbst appliances available from this company. 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. This system has proved to be more efficient than the previous models, both in terms of application as well as its resistance to fracture. One of the advantages of this appliance over other similar appliances with a ball joint is that it is thinner and smaller which means greater patient comfort.

The Ventral Telescope: (Professional Positioners, Inc. Three Mile Road, Racine Wisconsin) [8]

This was the first telescopic rigid fixed functional appliance that appeared as a single unit; i.e. upon reaching maximum opening it does not come apart. This appliance is available in two sizes and fixing is achieved through ball attachments. It is particularly easy to activate. The operation is simple and is carried out by unscrewing the tube thus allowing an activation of around 3 mm. Its disadvantages lie in the fact that it is quite thick and suffers from fractures to the brake which stabilizes the joint. As with the other appliances where fixing is achieved through ball attachments, great accuracy is necessary with regard to inclination and the welding of components.

The Magnetic Telescopic Device: (Ritto AK, 1997) [8]

This consists of two tubes and two plungers with a semi-circular section and with 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.

The Mandibular Protraction Appliance: (MPA) (Filho C, 1995, 1997, 1998) [20-22]

This is a rigid fixed functional appliance which was developed to be quickly made up by the orthodontist in the laboratory. Its advantages include ease of manufacture, low cost, infrequent breakage, patient comfort and rapid fitting. Another advantage it offers is that it can be made up at any time. This is helpful when there has been a failure in the supply of other commercially available appliances or if the orthodontist practices in an area where it is difficult to quickly obtain certain other alternatives.

The designer of the MPA developed three different types:

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 then determined by protruding the mandible and another small right-angle circle is then 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: This is made by making right-angles circles in two pieces of 0.032" SS wire. A small 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 version allows the mouth to open wider than the first version.

MPA III: This version eliminates much of the archwire stress that occurs with the MPA I and II. It permits a greater range of jaw movement while keeping the mandible in a protruded position. It is adaptable to either Class II or Class III malocclusions. It resembles the Herbst by also incorporating a telescoping mechanism but is smaller in size. It requires more time to be built and a good electronic welder that does not darken or weaken the wire.

The Universal Bite Jumper: (UBJ) (Calvez X, 1998) [23]

This is like a Herbst but is 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 fitted in the patients mouth and cut to the appropriate length for the desired mandibular advancement. 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.

The BioPedic Appliance: (GAC International, Inc. Oval Drive, Central Islip, NY) [24]

This is a bite jumping appliance which is engaged on the maxillary and mandibular molars, using a cantilever like system. It is then 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.

The Mandibular Anterior Repositioning Appliance: (MARA) [25]

This was created by Douglas Toll of Germany in 1991. It consisted of cams on the molars which guided the patient to bite into Class I. The first molars have to be covered with stainless steel crowns and the appliance must be laboratory manufactured. The patient can pull back his mandible to a Class II relation but will be unable to achieve

intercuspatation. This means that the lower molars will make direct contact with the metal, giving an unpleasant sensation. Furthermore, should the orthodontist opt for bands instead of crowns, fractures will often occur. The appliance design allows for use in conjunction with braces. It can be used for Class II treatment and for TMJ problems. This is an appliance of simple characteristics which allows good hygiene during the correction stage. With a small modification to the original design using only wire and composite, a very interesting appliance can be created for finishing treatment of a Class II malocclusion treated with a functional appliance.

The IST Appliance: (Intraoral Snoring Therapy appliance)(Sheu Dental, Germany) [8]

The Intraoral Snoring-Therapy Appliance is a new device designed by Hinz in order to treat patients who suffers from breathing problems during sleep, e.g. obstructive sleep apnea. According to the inventor, the IST appliance suppresses snoring by moving the lower jaw forward reducing the obstruction in the pharyngeal area.

The device offers two very important advantages:

- The telescope is threaded so the orthodontist can change the protrusion on each side individually up to 8mm.
- An end stop in the guiding sleeve prevents the telescope from disengaging. The appliance is available in two different lengths.

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

The Ritto Appliance can be described as a miniaturized telescopic device with simplified intraoral application and activation. The construction of this appliance is based on the mechanism and function used in the Ventral Telescope adapted for use in conjunction with a fixed appliance.

The main differences when compared to the Ventral Telescope appliance are:

- The appliance does not come apart (no disengagement after achieving maximum extension).
- The smaller size facilitates adaptation and it does not affect aesthetic appearance or speech.
- It comes in a single format which allows it to be used on both sides and is available in only one size.

The Ritto Appliance is simple to use, comfortable, cost effective, breakage resistant and requires no patient cooperation. The fact that the appliance does not disengage creates enormous advantages. It eliminates the time lost in measuring length before fitting, as in other appliances. This feature makes it possible to fit the appliance in approximately 5 minutes and remove it in about half that time. It is even possible to carry out the treatment of Class II retromandibular cases 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. Fixation accessories consist of a steel ball pin and a lock. Upper fixation is carried out by placing a steel ball pin from the distal into the .045 headgear tube on the upper molar band, through the appliance eyelet and then bending it back. The appliance is fixed onto a prepared the lower arch. The thickness and type of arch is chosen, its length is adjusted, locks are fitted and the Ritto appliance is then inserted. Activation is achieved by sliding the lock along the lower arch in the distal direction and then fixing it against the Ritto Appliance.

The Calibrated Force Module [8]

It was a fixed appliance designed to substitute Class II elastics and it was developed in 1988 by the CorMar Inc. Available in three sizes, it was applied to the inferior arch

close to the molars and fixed by a screw, and mesial or distal to upper cuspids, and also fixed to the arch. Its coil spring produced a force between 150 and 200 gm. The same company proposed a Herbst appliance with an exterior coil spring, attached to the inferior tube. That system generated tooth movement by employing gentle and continuous force 24 hours a day.

Eureka Spring [26]

This appliance appeared on the market in 1996 and it was developed by DeVicenzo and Steve Prins. It is a three part telescopic appliance fixed to the upper arch at the level of the molar band and to the lower arch distal to the cuspid. The appliance has an open coil spring that is placed inside of a part of the system. The placement system is relatively simple, and the patient can open his or her mouth widely without any difficulties due to the telescopic effect of the appliance. It is available in two sizes: 20 and 23 mm long. The appliance is universal and it can be applied both to the right as well as to the left side. Eureka Spring is a trademark of Eureka Spring, San Luis Obispo, California.

The Twin Force Bite Corrector [8]

This appliance differs from others in form and constitution because it has two internal coil springs. It consists of two joint telescopic systems. At the superior level it is fixed with a ball pin that is fitted into the buccal tube of a molar band. The placement in the lower arch is slightly different; it involves a fitting-in system that is later fixed with a screw to the inferior arch. Normally it is placed distal to the lower cuspid. Generally this type of fixing allows for rapid placement and removal of the appliance. It is available in two sizes and accompanied by a screwdriver to fix the screw in the lower arch. Such as in the previous appliance its application varies between Class II and Class III treatment, and it may be also used as an anchorage system. These appliances are suitable for cases where there is a need to carry out correction that requires predominantly dentoalveolar movement. In order to avoid protrusion of the lower incisors it is recommended to use stronger steel wires or to resort to other accessories. The major drawback of this appliance is the difficulty to control the force. If we want less force, we should bend the mesial part of the ball pin in order to have more wire distal to the tube. This situation, however, may create discomfort and impingement problems. The other disadvantage lies in the fact that the lower the lower dentition needs to be already aligned as it is recommended to use 016"x.022, or 017"x.025" stainless steel wires that guarantee necessary anchorage. In this way the device is in principle recommended for permanent dentition. For Class III correction it is necessary to put a lip bumper tube (LBT) on the lower molar band. Recently the third modernized version of the appliance has been presented under the name "Twin Force Bite Corrector Double Lock". It is reduced in size and both the lower and upper placement is based on the system of lock-on screws. This new version facilitates the use of the appliance for Class III correction and it allows for a slightly better control of the force although it still falls short of the full control.

FORSUS™ Fatigue Resistant Device [27]

This is an innovative three telescopic appliance with a coil spring in its exterior part. This feature makes it resemble some flexible functional appliances. In comparison with flexible functional appliances its great advantage lies in coil spring resistance to breaking. The coil spring is applied by its sliding on a rigid surface avoiding in this way angulations at the fixing points. It is sold in kits that include different length sizes for left and right side. In the original presentation the appliance is placed in the mandible on the round-segmented arch that is included in the kit. 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.

In this way there is no interference with continuous arches used during the treatment, which offers wide application independently of the method applied. The device gives you 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. Thus the appliance may be used in cases of mixed dentition and it allows for dental asymmetry correction when higher force on both sides is needed. The device allows your patient to open and move their jaw freely. Another device from the same company is the FORSUS™ NITINOL FLAT SPRING which presents a Nitinol flat wire instead of the coil. The appliances flat surface is more esthetically acceptable and it offers more comfort. It is available in various sizes for different patients or to get more activation. Forsus Nitinol Flat Spring requires no laboratory setup, making chairside installation quick and easy. The Forsus Nitinol Flat Springs, available in three different bypass designs, accommodate a variety of molar attachments making it compatible with your current appliance system. This flexibility eliminates your need for specialty molar attachments and reduces your inventory of bands and tubes. The Forsus Nitinol Flat Spring is slim, flat and made of Super-Elastic Nitinol. Nitinol is always at work, delivering consistent forces. Force levels remain constant from the initial setup to the time of removal. The result is faster, more efficient treatment. FORSUS is a trademark of 3M Unitek Corporation.

Alpern Class II Closers [8]

This appliance is slightly different from the preceding ones and it is also the most recent. It is predominantly applied in Class II correction and 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 to the upper cuspid. It is available in three different sizes. Its telescopic action enables a comfortable opening of the mouth. GAC International, Inc.

Treatment outcomes

Functional Jaw Orthopedic treatment responds well in actively growing individuals. In 1979, Panchrez performed a cephalometric evaluation of class II patients treated with Herbst appliance by jumping the bite. Treatment time was 6 months. His findings 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 that skeletal changes increased mandibular length and lower facial height. Greater dentoalveolar treatment effects were noted in the group wearing the tooth-borne functional appliance than in those wearing the tissue-borne appliance. [28].

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 changes and orthopedic effects in both jaws. [29]. 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 [30].

References

1. 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>
2. McNamara JA Jr, Brudon WL. *Orthodontics and Dentofacial Orthopedics.* Ann Arbor Mich. 2001.
3. 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>
4. McNamara JA Jr, Brudon WL. *Orthodontics and dentofacial orthopedics.* Ann Arbor. 2001; 67-80.
5. Graber TM, Rakosi T, Petrovic AG. *Dentofacial Orthopedics with Functional Applications.* 1997.
6. 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>
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. Awbrey JJ. The bite fixer. *Clin Impressions.* 1999; 8: 10-17.
14. Castañon R, Valdes MS, White LW. Clinical use of the Churro Jumper. *J Clin Orthod.* 1998; 32: 721-754. **Ref.:** <https://goo.gl/2t4B8H>
15. 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>
16. Pancherz H. The mechanism of Class II correction in Herbst appliance treatment. *Am J Orthod.* 1982; 82: 104-113. **Ref.:** <https://goo.gl/Sp9X61>
17. Pancherz H. The Herbst appliance. Its biological effects and clinical use. *Am J Orthod.* 1985; 87: 1-20. **Ref.:** <https://goo.gl/fQoXzy>
18. Shiavoni R, Bonapace C, Grenga V. Modified Edgewise-Herbst Appliance. *J Clin Orthod.* 1996; 30: 681-687. **Ref.:** <https://goo.gl/eQn41M>
19. Miller RA. The Flip-lock Herbst Appliance. *J Clin Orthod.* 1996; 30: 552-558. **Ref.:** <https://goo.gl/HDu7KE>
20. Coelho Filho CM. Mandibular Protraction Appliances for Class II Treatment. *J Clin Orthod.* 1995; 29: 319-336. **Ref.:** <https://goo.gl/3Vkf6S>
21. Coelho Filho CM. Clinical Applications of the Mandibular Protraction Appliance. *J Clin Orthod.* 1997; 31: 92-102. **Ref.:** <https://goo.gl/NjJLRq>
22. Filho CM. The Mandibular Protraction Appliance III. *J Clin Orthod.* 1998; 32: 379-384.
23. Calvez X. The universal bite jumper. *J Clinical Orthod.* 1998; 32: 493-500. **Ref.:** <https://goo.gl/E8niU4>
24. 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.
25. Eckart E. Introducing the MARA. *Clinical Impressions.* 1998; 7: 2-5. **Ref.:** <https://goo.gl/dd23Wa>
26. Devincenzo J. The Eureka Spring: a new interarch force delivery system. *J Clin Orthod.* 1997; 31: 454-467. **Ref.:** <https://goo.gl/z1oYaB>



27. Vogt W. The Forsus Fatigue Resistant Device. *J Clin Orthod.* 2006; 40: 368-377. [Ref.: https://goo.gl/UyeMHG](https://goo.gl/UyeMHG)
28. 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](https://goo.gl/KC6mzz)
29. 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](https://goo.gl/MrB7Qq)
30. 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](https://goo.gl/xCV5Qs)