



## Fixed Functional Appliances- A Review

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### Abstract

Functional orthopaedic treatment aims to correct malocclusion and harmonize the orofacial function. Correcting class II malocclusion is difficult due to its complex and multifactorial aetiology. As several removable and fixed appliances are available the orthodontist can choose the appliance depending on patient's needs. In this review article an attempt has been made to review various available fixed functional appliances.

**Keywords:** Class II malocclusion; Rigid appliances; Fixed functional appliances; Herbst appliance; Forsus; Mandibular protraction appliance; Advan Sync

### Introduction

Functional Appliances: A removable or fixed appliance which is designed to alter the posture of the mandible by stretching the musculature and changing the neuromuscular environment to produce movement of teeth and modification of growth [1]. Due to the bulk and inconvenience [2], their intermittent wear which does not elicit continuous muscle activity, Patient cooperation has long been recognized as an important factor in the outcome of orthodontic treatment. Failure of patient compliance to prescribed schedules of removable appliance wear will result either in slow treatment response or no response. To reduce these inadequacies, non-compliant appliances or fixed functional appliances were developed. An unfavourable response to functional appliances treatment can be summarized as due to excessive use, Poor or wrong diagnosis, Inadequate training, Poor knowledge of growth, Improper bite registration, Poor design/fabrication, Poor patient co-operation, Poor patient selection and Impatience of orthodontist. These factors combined with need for unprecedented demand for harnessing growth to its zenith led to the development of fixed functional appliances.

### Historical Perspective

In the 19<sup>th</sup> century, Norman Kingsley introduced bite plate for jumping the bite. He was the first to use the forward positioning of the mandible in orthodontic therapy. In the 20<sup>th</sup> century, Pierre Robin (1867-1950), described the construction and properties of the monobloc. Cope JB showed that majority of class 2 corrections was due to dental rather than skeletal change. Clockwise or backward rotations were evident for the mandible. Weiland FJ and Bantleon gave a report of treatment of class 2 malocclusion with jasper jumper. It concluded that correction was a result of skeletal 40% and dental 60% changes.

Jasper JJ and McNamara gave an article describing in detail about anchorage preparation, torque application methods of anchoring, activating, and reactivating the modules. Carlos introduced the mandibular protraction appliance (MPA) for class 2 treatment. West R.P devised the adjustable bite corrector; it is a stretchable closed coil spring. Schiavaini et al described an attachment for Herbst appliance called the Mandibular Advancement Locking Unit (MALU). Korrodi Ritto invented the Magnetic Telescoping Device which linked a magnetic field to the functional appliance. Klapper Lewis (1999) introduced the Super spring II in non-complaint class II patient. Ritto described a Miniaturized Telescopic Device, the Ritto appliance. Cozza et al (2006) performed a systematic review of literature to evaluate the

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effectiveness of functional appliances in enhancing mandibular growth in class II subjects. Selmi Arici Huseyin Akan (2008) tested the hypothesis that functional appliance treatment in a group of class II div I patients with mandibular retrusion changes the condyle position in the glenoid fossa.

## Classification of Functional Appliances

### Based on mode of action of the muscles

**Myotonic appliances:** Are those relying on muscle mass and resting pressure. The original appliance designed by Anderson and Haupl and its modifications [3].

**Myodynamic appliances:** Are those using muscle activity or movement. The “Elastischer Gebissformer” by H.P Bimler.

### Based on components included in appliance design

**Passive Tooth-borne appliances:** are those with no intrinsic force generating components such as springs or screws but depend on soft tissue stretch and muscular activity to produce results. e.g.; activator, bionator, herbst appliance, twin block [3].

**Active Tooth-borne appliances:** include modifications of activator, bionator designs (screws or springs) e.g.; expansion activator, orthopaedic corrector.

**Tissue-Borne appliances:** are those mostly located in the vestibule and have little or no contact with the dentition. e.g.; Functional regulator by Frankel.

Korrodi Ritto classified fixed functional appliances as

- Rigid Fixed Functional Appliances
- Flexible Fixed Functional Appliances
- Hybrid Appliances

### Rigid fixed functional appliances

RFFAs do not fracture easily and lack elasticity or flexibility E.g. Herbst appliance, Mandibular Anterior Repositioning Splint (MARS), Mandibular Anterior Repositioning Appliance (MARA), Mandibular Protraction Appliances (MPA), Biopedic appliance, Universal Bite Jumper

### Flexible fixed functional appliances

Flexible fixed functional appliances (FFFA) can be described as an inter-maxillary torsion coil. E.g. Jasper Jumper, Churro Jumper, Klapper Spring II, Adjustable Bite Corrector

### Hybrid appliances

Hybrid appliances represent combination of rigid fixed functional appliance (RFFA) and flexible fixed functional appliance (FFFA). They could be described as rigid appliances with coil spring-type systems used to move teeth and not to reposition the mandible anteriorly E.g. Eureka spring, Twin force bite corrector, Alpern class II closers, Forsus, Power scope, Advance sync.

## Herbst Appliance

Herbst was a remarkable man, far ahead of his times. Herbst appliance was developed by in 1900s. Herbst presented the original banded design appliance for the first time at the 5th International Dental Congress in Berlin in 1909. It is a fixed bite jumping device. After 1934 very little was published about the Herbst appliance until it was rediscovered by Hans Pancherz of Malmo, Sweden in the late 1970's.

### Design of the Herbst appliance

The Herbst appliance is basically a fixed bite jumping device used for correction of skeletal Class II malocclusions. A bilateral telescope mechanism forces the mandible in an anterior-forced position during all mandibular functions [4]. The telescope mechanism (tube and plunger) is attached to orthodontic bands, crowns, or splints. Herbst appliance (Figure 1) consists of 2 telescopic devices.



*Figure 1: Herbst appliance.*

Telescopic device consists of –

- A tube
- A plunger
- 2 pivots
- 2 screws
- Pivot tube soldered to the permanent maxillary 1st molar band.
- Pivot (plunger) to the mandibular 1st premolar band.
- The screws prevent the telescopic parts from slipping off the pivots. The length of the tube determines the amount of advancement (bite jumping).
- If the plunger is too long, it may extend far behind the tube & injure the buccal mucosa distal to upper 1st molar. To permit the lateral movements it may be necessary to widen the pivot opening.

The standard anchorage system used by Herbst:

- Crowns on the maxillary permanent first molars and mandibular first premolars (sometimes canines).
- Crowns joined by wires that run along the palatal surfaces of the upper teeth and the lingual surfaces of the lower teeth (Figure 2).

- If upper second permanent molars have not erupted the appliance is anchored firmly by placing bands on the upper canines, which were soldered to the palatal arch wire as were the upper molars.
- An alternative to bands on the upper canines is placing a thin gold wire on the labial surfaces of the upper incisors and soldered to the palatal arch wire.

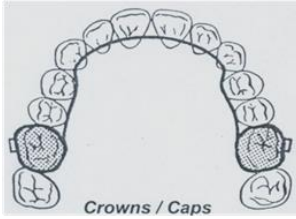


Figure 2: Standard anchorage system used by Herbst.

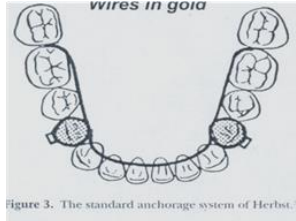


Figure 3. The standard anchorage system of Herbst.

## Modifications of the Herbst Appliance

### In patients with class II malocclusions

In cases of narrow maxillary arches, expansion is done by soldering a quad helix lingual arch wire or a rapid palatal expansion device to Herbst to the upper premolar and molar bands or to the splint.

**The cast splint herbst:** As the name suggests the bands are replaced by splints, cast from cobalt-chromium alloy are cemented to the teeth with GIC. Sectional arch wires are used to incorporate upper and lower front teeth. Advantages of using this appliance is that it ensures a precise fit on the teeth, is strong and hygienic, saves chair time and causes very few clinical problems [5] (Figure 3).



Figure 3: The Cast Splint Herbst.

**Herbst with stainless steel crowns:** Norris M. Langford in 1982 [6] suggested using stainless steel crowns on the upper first molar and the lower first premolar and canine for the Herbst appliance to make it resistant to breakage and becoming loose (Figure 4).

**The Bonded Herbst appliance:** Introduced by Raymond [7]. The bonded Herbst appliance has eventually evolved into the acrylic splint Herbst appliance. It is composed of a wire framework over

which Bio acryl, 2.5-3.0 mm thick splint, using a thermal pressure machine has been adapted. The maxillary splint covers the posterior dentition and the mandibular part of the appliance always is removable. A splint covers the entire posterior dentition as well as the lower anterior teeth.



Figure 4: Herbst with stainless steel crowns.

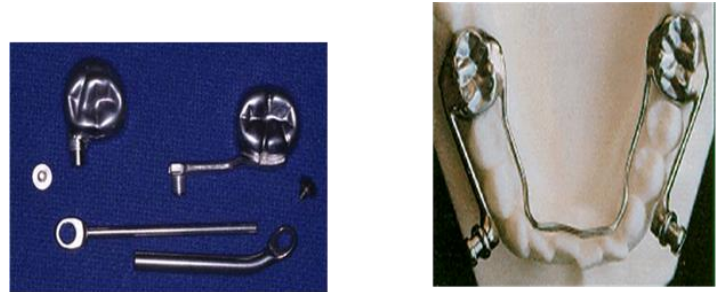


Figure 5: Cantilevered Herbst appliance.

**Cantilevered Herbst appliance:** This was a design given by Larry W. White in 1997 [8] Buccal cantilever wire is made by doubling .045" wire and soldering the two strands together. Advantage: Useful when mandibular bicuspids are absent, or the primary molars cannot withstand functional forces (Figure 5).

**The EMDEN Herbst:** Introduced by Tarek Zreik [9], 1994 to overcome breakage problems of Herbst appliance. This modification makes the Herbst more durable, simple, and hygienic (Figure 6).

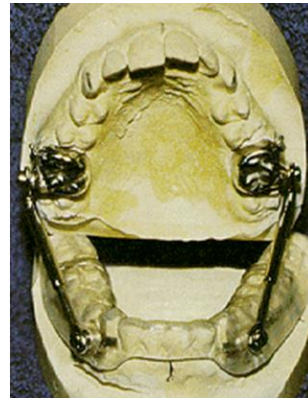


Figure 6: The EMDEN Herbst.

The Herbst mechanism is attached to stainless steel crowns on the maxillary first permanent molars and to the lower arch through a removable acrylic splint. Double buccal tubes on the stainless-steel crowns can hold utility, sectional or continuous arch wire

**Edgewise bio progressive herbst appliance:** It was introduced by Terry G. Dischinger, 1989 [10]. It incorporates edgewise brackets and bio progressive mechanics. It allows orthodontic tooth movements (torque control) during orthopaedic correction and permits a smooth transition from Herbst treatment into fixed finishing appliances (Figure 7).

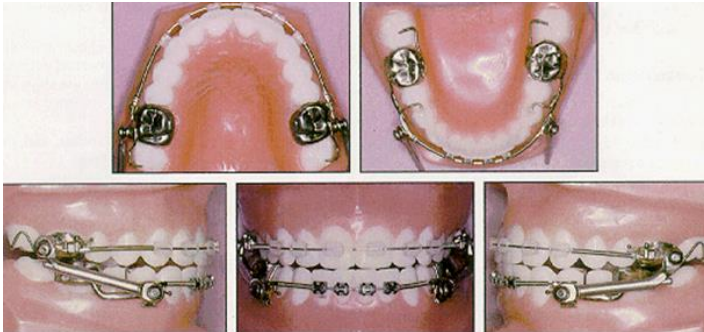


Figure 7: Edgewise bioprogressive Herbst appliance.

**Flip-Lock herbst appliance:** This new design reduces the number of moving parts that can lead to breakage or failure. As a ball joint connector replaces the conventional screw attachment it makes it use simpler and increases patient comfort. Robert Miller 1996 [11]. The 1<sup>st</sup> generation was made from a dense polysulfide plastic but the forces generated within the ball-joint attachment would often cause breakage (Figure 8).

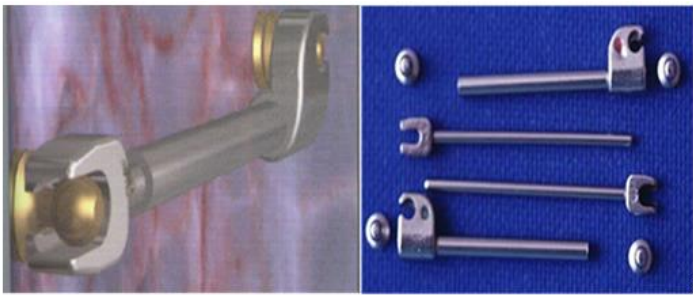


Figure 8: Flip-Lock herbst appliance.

In the second generation, the polyphene plastic was replaced with metal. The third generation is made of a horse-shoe ball joint. It has proved to be more efficient than the previous models, in terms of application as well as resistance to fracture. End of rod crimped onto mandibular ball.

### Effects of herbst appliance

The effects on Dentofacial complex can be discussed under:

- Treatment effects.
- Early post treatment effects.
- Late post treatment effects.

### Skeletal effects

Restrains maxillary growth and decrease of SNA angle. Increases mandibular length. (Pancherz 1979, 1981, 1982) [12]. This finding agrees with several bite jumping experiments in growing monkeys (Stockle and Willert 1971, McNamara 1972, 1973, 1975) and rats (Petrovic and Stutzman 1969).

Three adaptive processes in the TMJ are thought to contribute to the changes of mandibular position

- Condylar remodelling.
- Glenoid fossa remodelling.
- Condylar position changes within the fossa.

### Dental changes

- Dental changes are basically a result of anchorage loss in the two dental arches.
- The telescope mechanism produces a posterior directed force on the upper teeth and an anterior directed force on the lower teeth.
- This results in distal tooth movements in the maxillary buccal segments and mesial tooth movements in the mandible.

**Proclination of lower anterior:** Mandibular incisors proclined on an average of 6.6° for 6 months (Pancherz, 1985).

**Changes in arch perimeter:** The distalizing forces of the telescope mechanism and the anteriorly directed forces on the lower front teeth, increases the maxillary and mandibular arch perimeters during treatment (Hansen et al, 1995).

**Changes in arch width:** Hansen et al (1995) observed the lateral expansion in both canine and molar areas in maxillary and mandibular dental arches expand laterally in both canine and molar areas.

**Vertical changes:** In deep bite cases, overbite may be reduced significantly by Herbst therapy (Pancherz, 1982, 1985) an average of 3.0mm (55%) during 6 months of treatment. Eruption of lower posterior teeth increases lower anterior facial height. There is increase in gonial angle. This may be due to a more sagittal directed growth of the condyle or it may result from resorptive bone changes in the gonion region, probably because of an altered muscle function during bite jumping. (Pancherz & Littman, 1989).

**The jasper jumper:** It was introduced by Dr. James Jasper in 1987. The system is composed of two parts the force module and the anchor units.

### Force module

The force module is analogous to the tube and plunger of the Herbst bite—but is flexible. It is constructed of stainless-steel coil of spring attached at both ends to stainless steel end caps in which holes have been drilled in the flanges to accommodate the

anchoring unit (Figure 9). This opaque poly urethane covering around the module makes it hygienic and comfortable. The modules are available in seven lengths ranging from 26 to 38 mm in 2 mm increments. They are designed for use on either side of the dental arch.

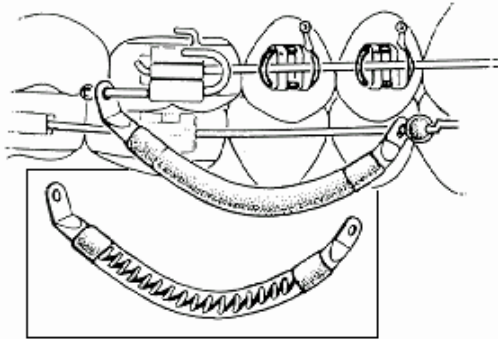


Figure 9: Force module.

### Principle of action

Straight force module = passive appliance.

Curved module = exerts force from 1 to 16 ounces

### Mars Appliance: Mandibular Advancing Repositioning Splint

This appliance was introduced by Ralph M Clements and Alex Jacobson in 1982 [13] and was a substitute for intermaxillary elastics (Figure 10).

- Piston
- Cylinder
- Locking devices

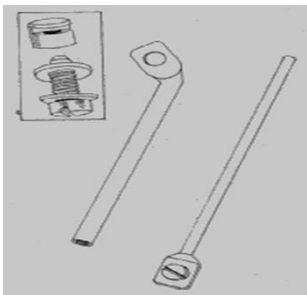


Figure 10: MARS appliance.

The MARS appliance is composed of a pair of telescopic struts (piston & cylinder of 0.045" thickness), the ends of which are attached to the upper and lower arch wires of a multi-banded fixed appliance by means of locking device. The appliance is placed after levelling and alignment is done. It is attached to the heaviest rectangular arch wires i.e. the wire that can be accommodated by the brackets and tubes.

Disadvantages: Need for a fixed multi-banded appliance limits its use in mixed dentition cases.

### Mandibular Protraction Appliances

This appliance was developed by Carlos Martin & Coelho Filho in 1995 [14]. It was developed to be quickly made up by the orthodontist in the lab (Figure 11).



Figure 11: Mandibular protraction appliances.

#### MPA- I

A small loop is bent on each side at a right angle to the end of an 0.032" SS wire. Patient is asked to protrude the mandible into a position with proper overjet, overbite to determine the length of the tube. The distance from the mesial of the maxillary tube to the stop on the mandibular arch wire is measured. Another small right-angle circle is then bent in an opposite direction into the other end of the .032" stainless steel wire. One appliance circle is placed over the maxillary arch wire against the molar tube, and the other circle against the mandibular arch wire stop.

#### MPA- II

The right angles circle is made 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 end. This version allows mouth to open wider than the previous version.

#### MPA- III

Appliance length measured from mesial of maxillary tube to mandibular arch wire stop with mandible in proper protruded position. This helps to eliminate arch wire stress that was experienced with MPA I and II. It permits a greater range of jaw motion while keeping the mandible in a protruded position. The MPA IV is much easier to construct and install, more comfortable. The MPA IV assembly consists of: "T" tubes, Upper molar locking pin, Mandibular rod, Mandibular arch wire.

### Adjustable Bite Corrector (ABC)

Introduced by Richard P. West [15]. The assembly consists of: A stretchable closed coil spring made of 0.018" stainless steel and

internally threaded end cap Nickel titanium wire in the centre lumen of the spring (Figure 12). The closed coil spring will stretch to about 25% beyond its original length without permanent deformation. The ABC 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. The NiTi wire is responsible for the push force.



*Figure 12: Adjustable bite corrector.*

### The Eureka Spring

Introduced by John DeVincenzo and Steve Prins [16]. 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 (Figure 13). The main component of the Eureka spring is an open coil spring encased in plunger assembly [17].



*Figure 13: Eureka spring.*

### The Churro Jumper

Introduced by Ridhardo Castanon, Mario S Valdes and Larry White [18]. It is an effective and inexpensive alternative force system for the anteroposterior. It was developed as an improvement of the MPA of Coelho. The distal circular end is attached to the maxillary molars by a pin and the mesial circular end is placed over the mandibular arch wire against the canine bracket (Figure 14).



*Figure 14: Churro jumper*

Till date, this is the only flexible functional appliance which can be made up by the orthodontist making it cost effective.

### The Ritto Appliance

The Ritto Appliance [19] (Figure 15) can be described as a miniaturized telescopic device with simplified intraoral application and activation. Its mechanism is of the ventral telescope without any disengagement. It comes in a single format which allows it to be used on both sides and is available in only one size. It is comfortable, easy to adapt, cost effective, esthetical and breakage resistant. Conventionally banding the upper and lower molars and placing brackets on the lower incisor makes it useful in mixed dentition. The appliance is fixed onto a prepared lower arch, its length is adjusted, locks are fitted, and the appliance is then inserted. It is activated by sliding the lock along the lower arch in the distal direction and then fixing it against the Ritto Appliance.



*Figure 15: Ritto appliance.*

### Alpern Class II Closers

It consists of a small telescopic appliance with an interior coil spring and two hooks for fixing (Figure 16). It is fixed to the lower molar and to the upper cuspid like the elastics. Its telescopic action eases opening of the mouth.



*Figure 16: Alpern class II closers.*

### The Mandibular Anterior Repositioning Appliance (MARA)

This was created by Douglas Toll of Germany in 1991. It consists of shim on the molars, the elbow fits in the shim and guides the patient to bite into Class I. If the patient pulls back his mandible to a Class II relation, he will be unable to achieve intercuspation (Figure 17). This means that the lower molars will make direct

contact with the metal, giving an unpleasant sensation. The appliance design allows for use in conjunction with braces.

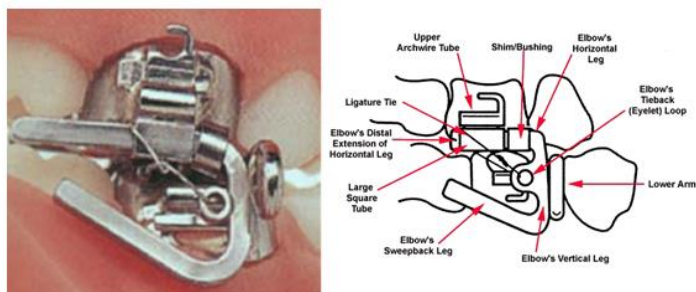


Figure 17: The Mandibular Anterior Repositioning Appliance (MARA).

### The Klapper Super Spring I & II

Introduced by Lewis Klapper in 1997 [20]. It is a flexible spring element which rests in the vestibule when activated and is attached to the maxillary molar and the mandibular canine. The open helical loop of the spring is twisted like a J-hook onto the mandibular arch wire (Figure 18). 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 movements of the spring in the vestibule. The horizontal configuration of the attachment wire at the maxillary molar tube permits distalization with good radicular control.



Figure 18: The Klapper Super Spring I & II.

### Forsus-Fatigue Resistant Device

This is an innovative three telescopic appliance with a coil spring in its exterior part [21]. It is available in different length sizes for left and right side (Figure 19). In the original presentation, the appliance is placed in the mandible on the round-segmented arch. The appliance slides along the arch and helps opening of the mouth and lateral movements. Since the resulting force concentrates more on the anterior and inferior sectors. There is no interference with continuous arches used during the treatment. The appliance may be fixed according to the needs of the patient. The appliance may be used in mixed dentition cases and for

dentil asymmetry correction. The device allows the patient free mouth opening. Similar device is the forsus nitinol flat spring which presents a Nitinol flat wire instead of the coil. The appliance's flat surface is more esthetical and comfortable. It is available in three different designs, with various molar attachments. The Forsus Nitinol Flat Spring is slim, flat, and made of Super-Elastic Nitinol. Force levels remain constant from the initial setup to the time of removal.



Figure 19: FORSUS.

### Power Scope

It has a ready-to-use concept [22], eliminating the need for measuring, or assembly or appliance manipulation. It does not need gingival headgear tubes or special band assemblies and can be used with either banded or bonded tubes (Figure 20).



Figure 20: PowerScope.

### Features

- It has one-size-fits which reduces inventory requirement [23]
- It features a low profile which gives aesthetic appearance. Its smooth and rounded-edge design provides better patient comfort. Its telescopic system features will not disengage during treatment, thus avoid unnecessary emergency visits. Ulceration is not seen as the piston does not extend distally.
- A NiTi internal spring mechanism delivers 260 grams of force for continuous activation during treatment. Painful pinching of the cheeks and food entrapment is avoided by enclosed design [24]. The ball-and-socket joint helps lateral mandibular movement for improved patient comfort and acceptance.

### Advance Sync

The AdvanSync combines two distinct treatment phases i.e. mandibular advancement along with malocclusion correction.

Therefore, it helps in to achieve skeletal as well as dental corrections at the same time; hence reduces treatment time [25].

AdvanSync is designed to advance the mandible to a Class I occlusion within six to nine months – while the patient has been bonded upper and lower 5 to 5 [26-30]. Since it is fixed it does not need patient compliance. Its compact design provides maximum comfort and range of movement. It is placed simultaneously with initial bonding, synchronizing Class II treatment with orthodontic therapy [31-35] (Figure 21).



Figure 21: AdvanSync.

## Conclusion

- The factors affecting mandibular growth with functional appliances are more important and should be considered, rather than concentrating on short term results. Significant mandibular growth and long-term retention basis are still debatable. Because of individual differences in growth rates and direction may explain some of the discrepancies reported in clinical studies in human beings. This may also be one of the reasons, in some reports there increased condylar growth, whereas in other investigation it was of minor clinical value
- Another area, where we have still lack of knowledge is soft tissue changes and adaptations after functional appliance therapy.
- Future long-term studies, clinical trials with control group, are required to know whether we can grow mandibles and retain it for lifetime.

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