Review Article

Hybrid fixed functional appliances

ABSTRACT

Since 1930s Class II malocclusion benefits from functional appliances. These appliances alter the arrangement of various muscle groups to correct the position of mandible to grow out of the skeletal disharmony. These appliances have been broadly divided into removable and fixed functional appliances. Fixed functional appliances also known as "noncompliant Class II correctors" have gained significant ground in the last few years. With them in use, the treatment duration is reduced by 6 months. They are divided into rigid, flexible, and hybrid appliances. Rigid fixed functional appliances restrict the mandibular movements and flexible fixed functional appliances have frequency of breakage to a greater extent. To overcome these drawbacks, hybrid fixed functional (HFF) appliances have come into play. HFF appliances offer the advantages of previous ones, thus eliminating their pitfall. Recent advances have also lead to the improvisation with the use of HFF appliances. This review article provides the gist of different HFF appliances till date with their considerations in use, mode of action, biomechanical effects, and advances in this field.

Keywords: Class II malocclusion, growth modification, hybrid fixed functional appliances, mandibular advancement

INTRODUCTION

The original concept of functional jaw orthopedics essentially encompasses growth modulation for the correction of mandibular retrognathia, skeletal Class II malocclusion not only by active forces of appliances but also by the forces generated from the muscles when the mandible is held forward. These functional forces indirectly produce growth modulation and bring about changes in jaw bones and hence the term "functional jaw orthopedics." It has now been applied for any device which includes a variety of removable and fixed functional appliances.[1]

The lack of success of removable functional appliance has in some circumstance been attributed to lack of patients' compliance in appliance wear due to removable in nature which leads to failure to achieve optimum results.

This led to the evolution of fixed functional appliances which are fixed to the upper or lower jaws for nonmotivated, noncompliant patients. They are well known as "noncompliant Class II correctors." They are rigid, flexible, and hybrid fixed functional (HFF) appliances.[1]

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With rigid appliances, the patients could not close in centric relation reducing the mandibular movements during the therapy stage making it quite inconvenient.[2] It further leads to improvement in the design making them flexible, and hence, the name flexible fixed functional appliances. These appliances allow a greater range of mandibular movement and a good mandibular opening; but chances of breakage were more commonly observed.

All these shortcomings lead to improvisation to the present state by the pioneers in this field who rightly deserve rich accolades to the discovery of "HFF Appliances."

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WHY TO CHOOSE FOR HYBRID FIXED FUNCTIONAL APPLIANCES?

Hybrid appliances are a combination of rigid as well as flexible fixed functional appliances. These appliances serve the main objective to move the teeth by applying 24-h elastic continuous force. They generate forces that vary between 150 and 200 g.

Their advantages are:

- Replaced the traditional use of elastics and extra-oral force
- Reduction in need of patient cooperation
- Reduced chances of breakage
- Increase in mandibular and lateral movements
- Ease of placement.

CONSIDERATIONS FOR USE OF HYBRID FIXED FUNCTIONAL APPLIANCES

Age factor

These appliances can be used in post-adolescent patients in whom very less growth is remaining.[1]

Growth considerations

The prognosis of the HFF therapy is poor in patients with hyperdivergent facial growth patterns.

Esthetic considerations

HFF appliances yield excellent results in patients with skeletal Class II bases with retrognathic mandible who have a positive visual treatment objective (VTO). On the contrary, these appliances are not recommended in patients with a negative VTO because of unsatisfactory results.[1]

Compliance

Being hybrid fixed type of appliances they have an advantage that they do not demand patient compliance which is an important factor in the success of removable type of functional appliances.

MODE OF ACTION OF HYBRID FIXED FUNCTIONAL APPLIANCES

HFF appliances make use of natural forces such as muscle activity, growth, and tooth eruption for their effectiveness. The type of forces is compressive, tensile, and shearing forces. External and internal forces can be seen with each force application.

Occlusal and muscle forces such as forces of lips, tongue, and perioral musculature are the type of primary forces. Secondary forces or reactions produced by tissues are a response to external forces. They produce strain in tissue leading to the deformation of the alveolar process which leads to remodeling and displacement of bone. Depending on forces used, the concept of force application and Force elimination can be seen. With the help of these forces, the mode of action is one or a combination of the following:[1]

- Mandibular growth induction
- Maxillary growth restriction
- Dentoalveolar changes
- Glenoid fossa relocation
- Changes in neuromuscular anatomy and function.

Graber *et al*. (1997) stated that the results obtained by functional appliances in the correction of Class II malocclusion consist of a combination of orthopedic (30%–40%) and dentoalveolar (60%–70%) effects. HFF appliances, according to growth relativity hypothesis, work on the hyperactivity of lateral pterygoid muscle which promotes condylar growth. Variation in the postural activity of the lateral pterygoid muscle because of the hybrid functional appliances induced increased contractile activity and the iterative activity of the retrodiscal pad, and subperiosteal ossification of the posterior border of ramus which modifies the condylar cartilage's growth rate and direction. This produces a more anterior or posterior growth rotation of the mandible, which lengthens the mandible[3] [Figure 1].

CELLULAR AND MOLECULAR ALTERATIONS IN THE CONDYLE

Contemporary research has shown that insulin-like growth factor 1 (IGF-1), fibroblast growth factor 2 (FGF-2), and their

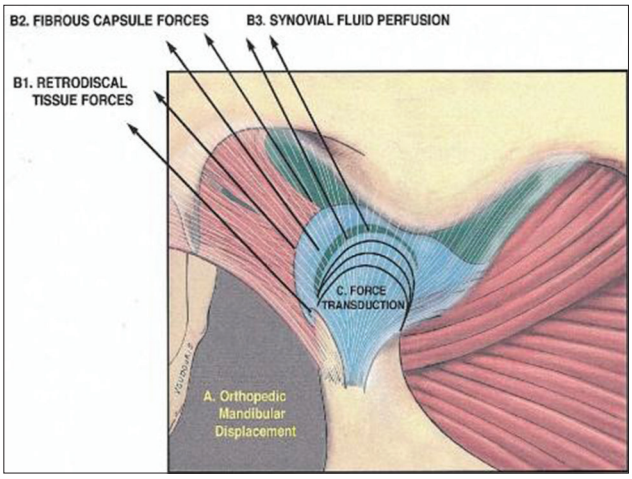

Figure 1: Growth relativity hypothesis for condylar and glenoid fossa growth with continuous orthopaedic displacement. Three factors influence growth modification: (A) displacement; (B) viscoelastic tissue pull (arrows); and (C) transduction with fibrocartilage. Viscoelastic tissues include B1, superior and inferior bands of the retrodiscal fibers; B2, fibrous capsule (fine white lines); and B3, synovial fluid perfusion in a posterior direction

receptors (IGF-1r, FGFr1, 2, 3) show enhanced expression, which after alteration in mandibular posture, might to a certain extent contribute to changes in the proliferative activity of condylar cartilage. New bone formation was preceded by increased neovascularization indicated by increased expression of vascular endothelial growth factor.

Higher levels of parathyroid hormone-related peptide (PTHrP) expression have been seen to coincide with the reduction in the rate of chondrocyte hypertrophy. It was, therefore, concluded that the advancement of mandible promotes mesenchymal cell differentiation and trigger PTHrP expression, which leads to a slowing of their further maturation to allow for more growth.[2] A significantly increased expression of Type X collagen, Sox, and Ihh were also observed during mandibular protrusion. However, much more information is awaited on precise control of growth alterations, which once known could prove useful to the clinicians in the manipulation of jaw growth to the best of advantage for the patients with the smaller jaw.[2]

BIOMECHANICAL EFFECTS OF HYBRID FIXED FUNCTIONAL APPLIANCES

HFF appliances have effects similar to that of functional appliances.

- The displacement resulting from fixed functional therapy is predominantly dentoalveolar in nature
- Forward and downward displacement of mandibular incisors was the most pronounced dentoalveolar effect, followed by mandibular molar displacement[4] [Figure 2]
- The mandible rotates in the forward and downward direction, but the pterygoid plate and maxillary dentition demonstrate posterior and superior displacement similar to that seen with the use of headgear[4] [Figure 2]
- Tensile stress is found in the entire dentoalveolar structure, except at ANS[4] [Figure 3]
- Maximum tensile and von Mises stresses are found in the condylar neck and condylar head[4] [Figures 3 and 4].

CLASSIFICATION

These are appliances producing pushing force vector.[5] According to Korrodi (2001), they are as follows:

- The calibrated force module
- Eureka Spring
- Sabbagh Universal spring
- FORSUS-Fatigue-resistant device
- The Twin Force Bite Corrector (TFBC)
- Alpern Class II closers.

Figure 2: Displacement pattern

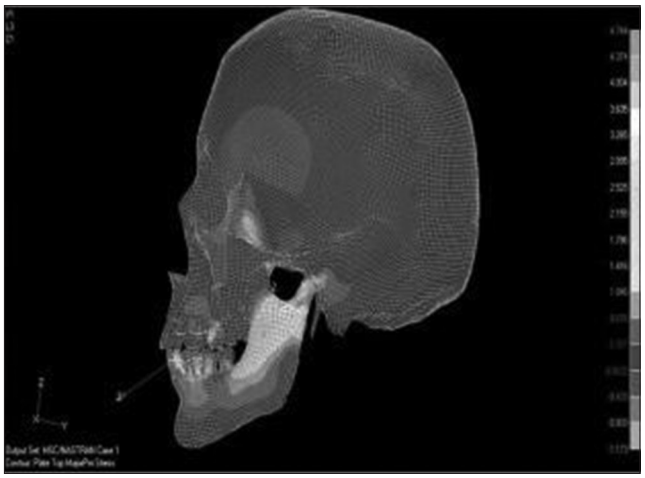

Figure 3: Tensile stress distribution

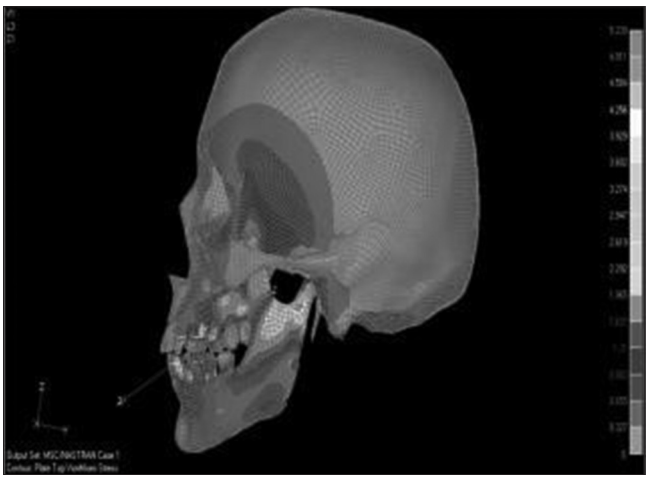

Figure 4: Von Mises stress distribution

Recent advances include

- Forsus Nitinol Flat Spring
- Vibhute Class II Correction Appliance (VCCA)
- Powerscope
- Advansync.

The Calibrated Force Module: (The Cormar Inc., 1988)

This device includes a spring module having a telescope mechanism with inner plunger portion and an outer tube portion, and with a calibrated compression coil spring concentrically positioned on the inner plunger portion within the tube portion. The telescope plunger consists of a bent arm to provide clearance relative to other installed orthodontic means. It has a notch in the forward inner wall of the telescope tube to control operation of the spring. Archwire is secured on the teeth with bifurcated yoke on the end of a plunger and anchor pin of ball and socket type. It is available in three sizes. It is attached to the lower arch close to the molars with the screw and mesial or distal to upper cuspids. Its coil spring produced a force between l50 and 200 gm. "This system generates tooth movement by employing gentle and continuous force 24 h a day"[1,6] [Figure 5].

Eureka spring: (Eureka Spring, San Louis Obispo, California, 1966)

This appliance was developed by DeVincenzo and Steve Prins. It is a three-part type of a telescopic appliance. It is fixed to the upper arch on the molar band and to the lower arch distal to the cuspid. The main component of spring is an open wound coil spring encased in plunger assembly. The placement system is relatively simple; it is available in two sizes: 20 and 23-mm long. The force of open wound spring is linear throughout the length of the Ram thrust and is 16.6 g for every mm of Ram compression. It produces dentoalveolar effects. Its advantages include minimal patient co-operation due to small size, esthetic acceptability, resistance to breakage, avoidance of tissue irritation, and ease of placement. With extended treatment time, it causes intrusion of first molars and anterior teeth[7] [Figure 6].

Sabbagh Universal spring: (Dentaurum international)

Sabbagh universal spring is the inter-arch compressive spring, resembling Eureka Spring It is a combination of the Herbst appliance (as a telescope) and the Jasper jumper (as a spring), aiming to increase the efficacy of the treatment and to minimize their disadvantages. It has got a dual telescopic design [Figure 7].

The unique aspect includes a slotted screw for the partial adjustments of the distal aspect of the plunger assembly, which has been tapped and threaded to the inner portion of the molar assembly. One of the other second coil springs is placed during placement. It produces a force of about 300 gm/cm^2. It is mainly used in noncompliant patients with limited growth potential, TMJ dysfunction, handicapped patients, and those who require molar distalization.[6,8,9]

FORSUS™ Fatigue Resistant Device: (3M Unitek Corporation, 2001)

Forsus spring was given by an American orthodontist William Vogt of Philadelphia. This is an innovative three telescopic appliance with a coil spring unit in its exterior part. It resembles a flexible functional appliance. It comprises a 0.5 mm × 3.0 mm spring bar (45% nickel, 55% titanium) with a transparent plastic coating. The initial design used a bypass wire to attach the appliance to the lower arch. The new design has a Direct Push Rods, so-called, because they allow the appliance to be attached directly to the mandibular archwire instead of a bypass wire. Recently developed is "Forsus Fatigue Resistant Device EZ Module"[10] [Figure 8].

It has kits of different length 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 via its bent ends the spring can be attached to bands and archwires of the previously placed fixed orthodontic appliance. Produces about 200 g of force when fully compressed.[10]

It can be used instead of Class II elastics in mild cases and instead of Herbst appliances in severe cases. Forsus springs

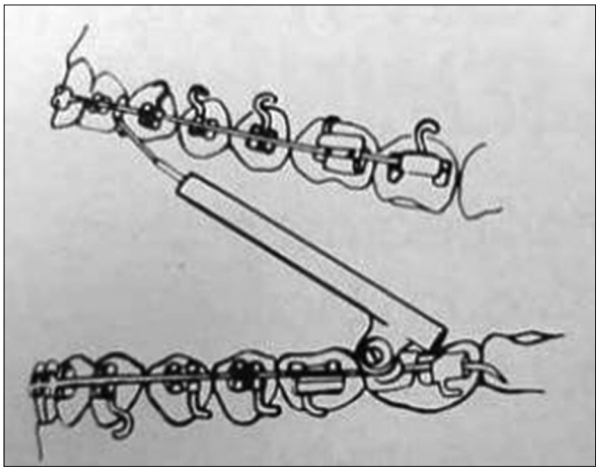

Figure 5: Calibrated Force Module

Figure 6: Eureka spring

work best in patients with a convex profile, but they are indicated in any Class II patients except those with normal mandibles and protrusive maxilla, or with protrusive or overly large mandibles relative to other cranial structures.

On an average, the FRD corrects a full Class II malocclusion in 6 months.[11]

Twin Force Bite Corrector: (3M Unitek Corporation)

The TFBC is a fixed, push-type intermaxillary functional appliance with ball-and-socket joint fasteners that allow a wide range of motion and lateral jaw movement. It differs from others in form and constitution because it has two internal coil springs. It consists of two joint telescopic systems. These contain nickel-titanium coil springs that deliver a constant force of approximately 210 g.[12]

The appliance is attached to the maxillary and mandibular archwires by hex nuts fastened with a ball pin that it fitted into buccal tube mesial to the maxillary first molars and distal to the mandibular canines with a screw. When it is full compressed, the TFBC positions the patient's mandible forward into an edge-to-edge occlusion[13] [Figure 9].

It is available in two sizes and accompanied by a screwdriver to fix the screw in the lower arch. This appliance is suitable for cases where there is a need to carry out a correction that requires predominantly dentoalveolar movement.

To avoid protrusion of lower incisors, it is recommended to use stronger steel wires or to resort to other accessories. The major drawback of this appliance is to control the force. If we want less force, we should bend the mesial part of ball pin to have more wire distal to the tube, which creates discomfort. This device is in principle recommended for permanent dentition.[12]

Alpern Class II Closers: (GAC international)

This appliance is slightly different from preceding ones and it is also the most recent one. It incorporates 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 upper cuspid. It is available in three different sizes. Its telescopic action enables a comfortable opening of the mouth[6] [Figure 10].

FORSUS™ Nitinol Flat Spring: (3M Unitek Corporation, 2001)

The forsus nitinol flat spring is newly introduced by Heinig and Goz. The flat spring is, in essence, a leaf spring; the force of which is increased by reducing the radius of curvature. It presents a Nitinol flat wire instead of the coil. Its flat surface

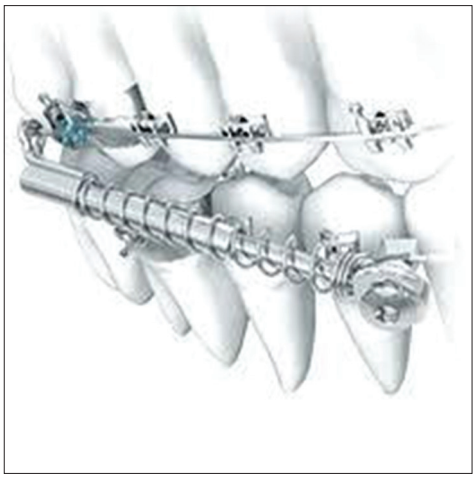

Figure 7: Sabbagh Universal spring

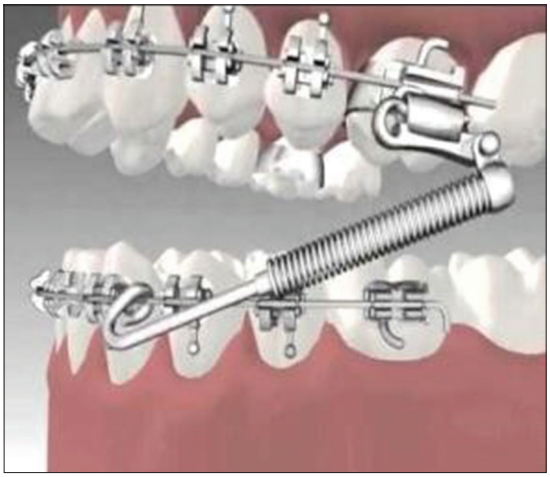

Figure 8: Forsus Fatigue Resistant Device (EZ Module)

Figure 9: Twin Force Bite Corrector

is more esthetically acceptable and it offers more comfort. It is available in various sizes according to patients.

The length of the spring is determined by the distance between the mesial surface of the maxillary first molar

headgear tube and the distal surface of the mandibular canine bracket plus 10–12 mm, when the patient has closed in habitual occlusion (4 mm for play, 4 mm for the headgear tube and 4–5 mm for the activation).[10,11] Forsus nitinol flat spring does not need laboratory setup. It makes the chairside installation quick and easy. The Springs, available in three different bypass designs, accommodates a variety of molar attachments making it compatible with the current appliance system. This flexibility eliminates the need for specialty molar attachments and reduces the inventory of bands and tubes. The forsus nitinol flat spring is slim and flat. It is made of superelastic 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. It, however, breaks easily, less comfortable for the patient and causes more tissue irritation on breakage[10,11] [Figure 11].

Vibhute Class II Correction Appliance

VCCA is an open coil NiTi spring loaded hybrid type fixed the functional appliance. This custom-made tinier and hygienic design provides stable fixation, less breakages with an increased range of mandibular movements involving unrestricted mouth opening. VCCA permits quick chairside fabrication with ease in installation of the appliance and is inexpensive.[14]

Figure 10: Alpern Class II closers

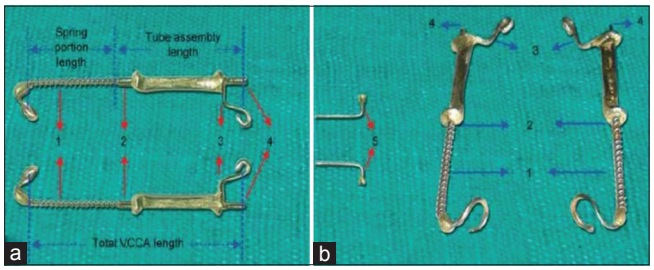

Figure 12: Vibhute Class II Correction Appliance. Mandibular push component inserted through the maxillary tube assembly: (a) Length of maxillary tube component outside soldered part may be kept as per patient need and comfort, (b) length of maxillary tube component may be reduced as shown by arrows 2 and 4

Total length of the appliance is decided by measuring the distance from distal of maxillary headgear tube to the distal of the mandibular canine in desirable advanced mandibular position.

This is a spring-loaded customized design that has more scope for chairside alteration as per the patient requirement, unlike the other commercially available devices. The results are similar to those of other commercially available designs used for Class II correction[14] [Figure 12].

Powerscope: (American Orthodontics)

Power scope was developed by Dr. Andy Hayes. This Class II Corrector was planned to provide the force to the lower anterior for protracting the premolars and molars into the substituted position. This is a wire-to-wire attached Class II corrector.

When fully activated, it will consistently provide 260 g of force for the protraction of the unilateral buccal segment. Powerscope has no extrusive forces applied to the maxillary anterior teeth as with Class II elastics. It can be used

Figure 11: Forsus Nitinol Flat spring

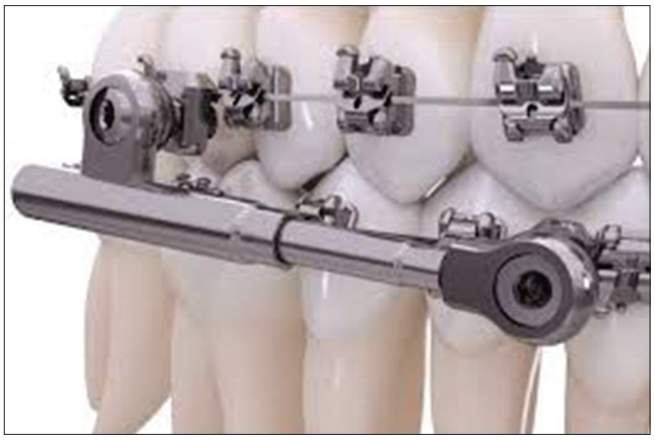

Figure 13: Powerscope

unilaterally without fear of canting the maxillary anterior occlusal plane in the esthetic zone[15] [Figure 13].

Other advantages of this Class II corrector are:

- Compliance free
- Available in one size for all patients
- Quick and easy wire-to-wire installation
- Needs no headgear tube or special band assemblies
- Can be used with banded or bonded molar tube
- Smooth, rounded design for better patient comfort
- Ball and socket joint for maximum lateral movement
- Telescoping mechanism that will not disengage during treatment.

The only requirements to use the appliance are rectangular stainless-steel arch wires of 0.025'' in the horizontal dimension. This will provide a precise fit for the direct-to-wire attachments and restrict the appliance from making unwanted movements and irritating the soft tissues. The Powerscope does not intend to physically reposition the mandible anteriorly. Rather, the internal spring does the work while the patient functions in a maximum intercuspation position.[15]

AdvanSync: (Ormco)

(Advancing the mandible, simultaneously with bracketed orthodontic treatment).

The most recent of today's time with daunting expertise is the discovery of AdvanSync. Design enhancements incorporated into AdvanSync takes the Class II correction to the next level in quality, comfort, and efficiency. This appliance as the name suggests corrects the malocclusion while simultaneously advancing the mandible. Patient application of AdvanSync is simple and can be performed the same day when the orthodontic appliances are bonded. It also pleases the patient's expectations while driving the results required in the treatment plan[16] [Figure 14].

Advantages of AdvanSync are as follows:

Class II Treatment in Class I Time.[16]

- Placed simultaneously with initial bonding, eliminating the need for two-phase treatment
- It gives constant activation and has no need for patient compliance.

Engineered for efficient correction.[16]

- Reinforced Spiralock threading maximizes screw engagement [Figure 15]
- Advanced metal injection molding provides a highly durable and robust appliance
- Upper and lower dual screw housing allow higher versatility throughout treatment
- Electropolished manufacturing process provides smoother operation[16] [Figure 16]

Convenient and Easy-to-Use.[16]

- Easy to deliver for doctors and staff
- Allows freedom of movements mesial to the molar crowns
- Has built-in activation.

Improved patient comfort and satisfaction.[16]

- Has 50% shorter arms which reduces discomfort and tissue irritation
- Sits further back in the mouth than other Herbst appliances, for a more discrete appearance
- Facilitates enhanced lateral jaw movement [Figure 15]
- Speech is unaffected– unlike removable appliances
- Design enhancements facilitate increased hygiene[16] [Figure 17].

Figure 14: Advansync

Figure 15: Parts of Advansync: Lumens are 16% larger with radiused internal edges for increased lateral movement

Figure 16: Parts of Advansync: Mechanisms feature radiused corners and electro-polished internal sleeves for smoother operation

Figure 17: Parts of Advansync: Unique design increases hygiene

CONCLUSION

Class II malocclusion is the most common universal rationale, both in occurrence and for availing orthodontic treatment. Various appliances have been developed which have their own surplus as well as drawbacks. It started back from the usage of orthopedic and functional appliances which depend on the onus of patient compliance to fixed functional appliances. Nowadays, rigid and flexible fixed functional appliances have been overpowered by HFF appliances due to the factors such as the range of movement of mandible, breakage, and patient cooperation. However, these appliances also work on their indications and contraindications, which should not be neglected. Newer inventions in hybrid appliances have also improved their usage and opened the doors for their long-term efficacy. Finally, it is not the appliance, but the orthodontist behind the appliance who makes the difference between success and failure.

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Conflicts of interest

There are no conflicts of interest.

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