A BRIEF REVIEW OF FORSUS: FRD; HYBRID FIXED FUNCTIONAL APPLIANCE

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Abstract: Fixed functional appliances are those functional appliance that are fixed to the upper or lower jaws and which cannot be removed by the patient. Eliminating the need for patient compliance and placing treatment outcome under the control of orthodontist was the aim of developing such appliances.With fixed functional appliances, the treatment duration was reduced to around 6 months. Beside this faster result, it became possible to use the advantage of growth modification treatment in those unfortunate patients who were near the completion of growth and were unable to take treatment during early mixed dentition period .FORSUS FRD is an innovative a three telescopic hybrid fixed functional appliance with a coil spring in its exterior part allowing forwad movement of the mandible in cases with positive VTO.
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Keywords- *nitinol spring, gurin lock, l-pin*

Introduction

Orthodontists are fortunate that majority of malocclusions are dentoalveolar in origin and respond favourably to conventional tooth moving mechanotherapies. However, clinicians are periodically confronted with malocclusions that do not respond favourably to such tooth moving mechanotherapies because the disharmony exists in the basal jaw bone.

In order to treat the full spectrum of malocclusions effectively, a clinician must recognise and assess such developing skeletal pattern at an early age. If conservative orthodontic therapy cannot be provided at a proper time, then such skeletal problems may have to be treated surgically or camouflage treatment might be instituted which might prevent us from providing the ideal in terms of esthetics for the patient. Beside genetic factors, the role of normal function for optimum growth and development of oro-facial complex is well known. Importantly "dysfunction" in the etiology of skeletal disharmony is also well established[1].One of such means of treatment is the use of functional appliances.The functional appliances are "those removable or fixed appliance that alters the posture of mandible and transmits the force created by the resulting stretch of the muscle and soft tissue and change of neuromuscular environment to the dental and skeletal tissues to produce movement of the teeth and modification of growth"[2].Initial removable appliance were bulkier and inconvenient. They failed to attract patient co-operation . Also with their use it was difficult to carry out functions like speaking and mastication. Further more, intermittent wear does not elicit continuous muscle activity, which is very essential for promoting the skeletal change[3].

Failure to adhere to prescribed schedule, usually seen with removal appliances resulted in slow treatment response or some time no response at all.Thus successful orthodontic treatment was dependent on patient cooperation in wearing of the appliance Importantly even the treatment duration with the removable functional appliance was around one and one-half years, which was long enough to promote non – compliance and burnout. Fixed functional appliances are those functional appliance that are fixed to the upper or lower jaws and which cannot be removed by the patient. Origin of fixed functional appliance can be traced back to Emil Herbst's introduction of his appliance for the temperomandibular joint patient in 1905[2]. This appliance was reintroduced by Hans Pancherz of Malmo, Sweden in 1979, who actually showed the potential of this appliance in stimulating the mandibular growth[2]. Eliminating the need for patient compliance and placing treatment outcome under the control of orthodontist was the aim of developing such appliances. With fixed functional appliances, the treatment duration was reduced to around 6 months. Beside this faster result, it became possible to use the advantage of growth modification treatment in those unfortunate patients who were near the completion of growth and were unable to take treatment during early mixed dentition period . Thus to reap the benefits of functional appliance and to eliminate the non-compliance and other disadvantage fixed functional appliances have been developed . They have been improved to the present state by the pioneers of this field who rightly deserve rich accolades. Hence before going to the details of the individual appliance, let us be browse through the history of development of these appliance in brief.

II. Classification Of Fixed Functional Appliance

Ritto's classification[4]

a) Flexible Fixed Functional Appliances (FFFA)

1) Jasper Jumper
2) Amoric Torsion Coils
3) Adjustable Bite Corrector
4) Scandee Tubular Jumper
5) Klapper Super Spring
6) Bite Fixer
7) Churro Jumper

b) Rigid Fixed functional appliances (RFFA)

1) Herbst Appliance
2) Cantilevered Bite Jumper
3) MALU Herbst Appliance
4) Flip-Lock Herbst Appliance
5) Ventral Telescope
6) Magnetic Telescopic Device
7) Mandibular Protraction Appliance
8) Universal Bite Jumper
9) BioPedic Appliance
10) Mandibular Anterior Repositioning Appliance
11) IST – Appliance
12) Ritto Appliance

c) Hybrid Appliances

1) Calibrated Force Module
2) Eureka Spring
3) Twin Force Bite Corrector
4) Forsus – Fatigue Resistant Device
5) Alpern Class II Closers

III. Moschos A. Papadopoulos's classification Appliance Author Manufacturer

1) Herbst appliance

- Banded Herbst design — Pancherz (1979) — Dentaurum Inc.
- Cap Splint Herbst design — Pancherz (1997)
- Herbst design — Stainless Steel Crown — Langford (1982) — Dischinger (1989)
- Acrylic Splint Appliance — Speciality Herbst Appliance work

(cemented or bonded) — Howe (1982)
(removable) — Howe(1987)
(upper bonded and lower removable) — McNamara (2001)

- Herbst — Goodman's modified — Goodman and McKenna (1985)
- And lower acrylic — Upper Stainless Steel crown — Valant (1989) — Dentaurum Inc
- Design — Flip- Lock Herbst TP — Miller (1996) — Ortho Inc
- (2003) Herbst design — Hanks Telescoping — Hanks American Ortho
- Open bite intrusion Herbst design — Dischinger (2001) — AOA / Pro Orthodontic App.

2) Mandibular Advancing Splint (MARS) — Clement and Jacobson (1982) — Dentaurum Inc. Rocky Mountain Ortho — Repositioning

3) Cantilever bite jumper (CBJ) — Mayes (1996) — AOA / Pro

		Orthodontic
	Ormco	
4) Molar moving Bite Jumper (MMBJ)	Mayes (1998)	AOA / Pro Orthodontic
	Ormco	
5) Mandibular Corrector Appliance (MCA)	Jones (1985)	Cormar Inc.
6) Mandibular Protraction Appliance (MPA)		
Type I	Coelho Filho (1995)	
Type II	Coelho Filho (1997)	
Type III	Coelho Filho (1998)	
Type IV	Coelho Filho (2001)	
7) Mandibular Anterior Repositioning Appliance (MARA)	Eckhart (1998)	AOA / Pro Orthodontic App / Ormco
8) Ritto Appliance	RittoOrthod Cyber-J Archives	
9) Functional Mandibular Advancer (FMA)	Kinzinger (2002)	

(A) <u>Rigid intermaxillary appliances (RIMA)</u>

1) Herbst appliance

- Banded Herbst design — Pancherz (1979) — Dentaurum Inc.
- Cap Splint Herbst design — Pancherz (1997)
- Stainless Steel Crown — Langford (1982)

Herbst design — Dischinger (1989)

- Acrylic Splint Appliance — Speciality Herbst Appliance work

(cemented or bonded) — Howe (1982)
(removable) — Howe(1987)
(upper bonded and lower removable) — McNamara (2001)

- Goodman's modified Herbst — Goodman and McKenna (1985)
- Upper Stainless Steel crown And lower acrylic — Valant (1989) — Dentaurum Inc
- Flip- Lock Herbst Design — Miller (1996) — TP Ortho Inc
- Hanks TelescopingHanks (2003) Herbst design — American Ortho

- Open bite intrusion Dischinger (2001) AOA / Pro
  Herbst de Orthodontic App.

2) Mandibular Advancing Clement and Dentaurum Repositioning Splint (MARS)
Jacobson (1982) Inc. Rocky
Mountain
Ortho

3) Cantilever bite jumper (CBJ) Mayes (1996) AOA / Pro
Orthodontic
Ormco

4) Molar moving Bite Mayes (1998) AOA / Pro
Jumper (MMBJ) Orthodontic
Ormco
5) Mandibular Corrector Jones (1985) Cormar Inc.
Appliance (MCA)

6) Mandibular Protraction Appliance (MPA)
Type I Coelho Filho (1995)
Type II Coelho Filho (1997)
Type III Coelho Filho (1998)
Type IV Coelho Filho (2001)

7) Mandibular Anterior Eckhart (1998) AOA / Pro
Repositioning Appliance (MARA) Orthodontic App /
Ormco
8) Ritto Appliance RittoOrthod
Cyber-J Archives

9) Functional Mandibular Kinzinger (2002)
Advancer (FMA)

(B) <u>Flexible intermaxillary appliances (FIMA)</u>

1) Jasper Jumper Jasper (1987) American
Ortho
2) Scandee Tubular Jumper Saga Dental
Supply AS
3) Flex Developer (FD) Winsauer (2002) LPI Ormco
4) Amoric Torsion Coils Amoric (1994)
5) Adjustable Bite West (1995) Ortho Plus
Inc
6) Bite Fixer Awbrey (1999) Ormco
Corpration

7) Gentle Jumper American

	ortho		
8) Klapper	Superspring II design	Klapper (1999)	Ortho
9) Churro Jumper		Castanon (1998)	
10) Forsus	Nitinol Flat Spring	Heinig&Goz (2001)	3M Unitek
11) Ribbon Jumper		American Ortho	

(C) Hybrid appliances (combination of RIMA and FIMA)

1) Eureka Spring		DeVincenzo (1997)	Eureka Ortho
2) Sabbagh Universal Spring (SUS)	-	Dentaurum Inc	
3) Forsus Fatigue Resistance Device	-	3M	Unitek
4) Twin Force Bite Corrector	Corbett and Molina (2001)	Ortho Organizers	

FORSUS [4,5] FATIGUE RESISTANT DEVICE

FORSUS™ springwas given by an American orthodontist **WILLIAM VOGT** of Philadelphia.This is an innovative three telescopic appliance with a coil spring in its exterior part. This feature makes it resemble some flexible functional appliances. It comprises a 0.5×3.0 mm spring bar (45% nickel,55% titanium) with a transparent plastic coating.

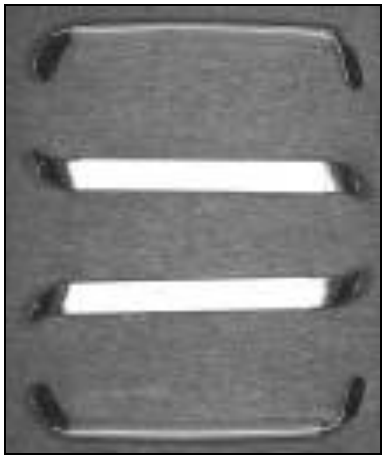

Figure 1.Forsus

In comparison with AFF 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 angulation 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. Via its bent ends the spring can be attached to bands and archwires of the previously placed fixed orthodontic appliances.

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 appliance may be fixed in various ways according to the needs of the

patient. 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. 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 patient to open and move their jaw freely. The Forsus™ spring is supplied in four different lengths: 28 mm, 31 mm, 34 mm and 37 mm, in each case for right and left fitting. Measurements are made in habitual occlusion mesially from the headgear tube of the upper first molar distally to the bracket of the lower canine. 12 mm is added to this measurement (4 mm play, 4 mm headgear tube, 4 mm activation) and this gives the length of the module to be used.

A ball pin serves to attach it to the maxillary headgear tube. A bayonet bend is placed in the mandibular arch distal to the canine bracket and a ball stop is pushed onto it to form a stop for the Forsus™ spring. The ball pin and ball stop are both made of stainless steel. The bracket on the lower first premolar is removed so that the spring can slide along the whole archwire.

INSTRUCTIONS FOR USE

SPRING MODULE INSTALLATION

Insert "L" ball pin into spring module distal-end pin hole.

Figure 2. Insertion of L ball pin in module

Pull "L" ball pin through headgear tube from distal to mesial

Figure 3. L ball pin passing through headgear tube

Bend pin around headgear tube as shown.

Option 1: pin bent occlusally.

Figure 4. Pin bent occlusally

Option 2: pin bent gingivally.

Figure 5. Pin bent gingivally

(Note: To allow for pin adjustments and avoid restricted movement, leave 1 to 2 mm clearance between distal end of tube and pin ball).

Cinch archwire to secure lower arch teeth positioning. For increased anchorage on lower arch, use second molar attachment if appropriate.

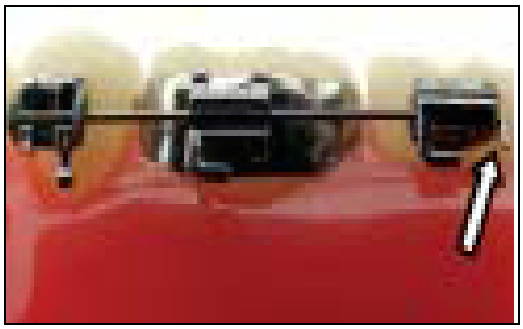

Figure 6: Second molar attachment for increased anchorage

(Note: Use full size rectangular stainless steel wire on both arches to further secure teeth positioning).

In order to avoid elastic ligature breakage and to secure cuspid bracket to archwire, use stainless steel ligature tie.

Figure 7. Stainless steel ligature tie to secure bracket to the arch wire

OPTIONAL

To avoid contact with cuspid bracket, place a stop such as a Gurin lock distal of the canine.

Figure 8.Gurin lock

To increase anchorage on the lower arch and prevent lower anterior flaring, lace the entire lower arch and increase labial root torque on lower anteriors.

Figure 9. Lacing of the entire lower arch

Push Rod Installation

Measure from distal end of upper molar tube to a point distal to cuspid bracket (or to chosen stop) while in centric occlusion. Use Forsus™ guide

Figure 10.Forsus guide

Select a push rod from the available sizes to fully compress the spring without immediately reposturing the mandible.

Figure 11. Push rods of different lengths

(Note: Right and left configuration)

Place push rod loop between cuspid and first bicuspid, have patient open mouth, compress spring, and insert push rod. If push rod protrudes distal of spring module in centric occlusion, it is too long.

Figure 12. Increased length of push rod

Crimp push rod mesial end by closing loop around archwire.

Figure 13. Crimping of push rod hook distal to the canine

FINAL ASSEMBLY

Note: If patient bites on spring assembly, adjust "L" ball pin or entire assembly with a buccal offset

Figure 14. Final assembly: Buccal off set given to prevent the biting over the spring.

RE-ACTIVATION

Crimp split ring bushings on push rod distal of stopper by compressing the spring as needed (usually 2 or 3 mm at a time to achieve midline correction and advancement).

Figure 15.Crimp split ring bushings added for reactivation

Precise Insertion of the Forsus Fatigue Resistant Device[9]To ensure a symmetrical installation on the left and right sides when using the L-pin attachments (as opposed to the EZ modules), their are following recommendation for the procedure: 1. Mark the leg of one of the L-pins provided with the Forsus kit at a point 2mm away from the L-bend, measuring with a vernier or other precision caliper This space provides an adequate amount of play for the spring after activation. 2. Insert the marked pin into the headgear tube of a spare prewelded molar bracket, so that the mark lies immediately distal to the tube. Make a second mark on the pin just mesial to the molar tube. Remove the pin from the tube and transfer the same markings to the second pin . The mesial marks on the right and left sides will be visible during installation of the Forsus, so the pins can be bent precisely and symmetrically at these marks. So taking a few extra steps makes insertion of the Forsus appliance with L-pins much easier. Later reactivation using the manufacturer's crimpable stops will also be more precise if these steps are followed.

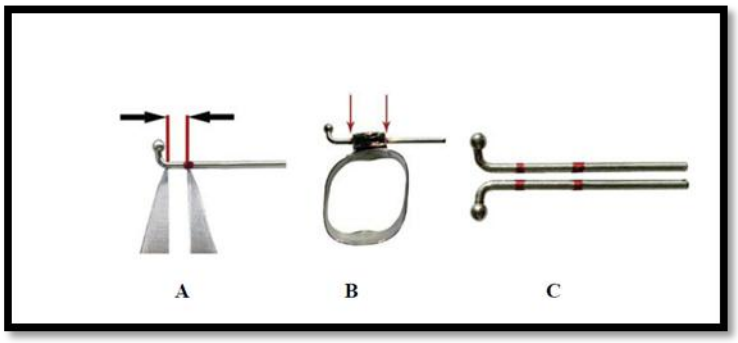

Figure 16.Marking on L pin for precise insertion of Forsus

Rotation Wedges for Forsus Treatment[10]**:** AMesial rotation of the mandibular canines is commonly encountered during treatment with the Forsus FRD, due to the constant force exerted by the push rods. This force can also cause canine bracket failure or breakage of the elastomeric ligature as it is pinched between the push rod and the bracket. A damaged or broken elastomeric ligature can result in proclination of the lower anterior segment if it is not replaced immediately. To overcome these problems, we can engage standard rotation wedges on the distal tie wings of the lower canine brackets prior to placement of the archwire and Forsus modules. Only the mesial tie wings are ligated to the archwire. The rotation wedges prevent direct contact of the push rods with the canine brackets and elastomeric ligatures. Their shock-absorber effect helps avoid undesired tooth movement or bracket debonding and also assists somewhat in activation of the appliance. This modification has proven so beneficial that it is routinely employed for all Forsus cases in our practice.

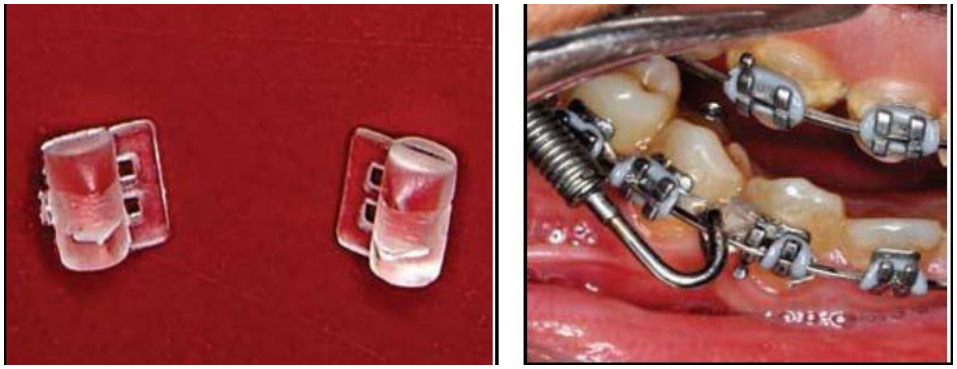

Figure 17. Rotational wedge during Forsus Treatment

Another device from the same company is the **FORSUS™ NITINOL FLAT SPRING**[13] which presents a Nitinol flat wire instead of the coil. The appliance's 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.

ForsusNitinol Flat Spring requires no laboratory setup, making chairside installation quick and easy.

1. The ForsusNitinol 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 ForsusNitinol Flat Spring is slim, flat and made of Super-Elastic Nitinol.
2. Nitinol is always at work, delivering consistent forces. Force levels remain constant from the initial setup to the time of removal.
3. The result is faster, more efficient treatment.

IV. CLINICAL STUDIES

El-Sheikh MM, Godfrey K, Manosudprasit M and Viwattanatipa N (2007)[7] carried out a study (1) to measure the mean force delivered at different amounts of deflection; (2) to determine and compare the mean stiffness between loading and unloading; and (3) to determine the resilience of the fatigue-resistant device springs by testing the fatigue-resistant device springs with a universal testing machine with the load cell of 100 N. Force-deflection data during loading and unloading were recorded at 2-mm intervals up to 12 mm compression.The results showed that (1) The mean force-deflection loading and unloading curves generally were linear, with a small area of hysteresis; (2) the loading mean stiffness (19.4 g/mm) was significantly greater than the unloading mean stiffness (18 g/mm), although this is clinically insignificant; (3) fatigue-resistant device springs exhibited good resiliency.

Jones G, Buschang PH, Kim KB and Oliver DR (2008)[8]evaluation of Forsus Fatigue Resistant Device (FRD) as a compliance-free alternative to Class II elastics showed significantly greater lower molar mesial movements and total molar correction in the Forsus group with a general trend for mesial movement of the maxilla, mandible, and dentition during treatment for both groups. The mandibular skeletal advancement and dental movements were greater than those in the maxilla, which accounted for the Class II correction. Lower incisor proclination was evident in both groups. Vertically, the maxillary and mandibular molars erupted during treatment in both groups, while lower incisors proclined.

Franchi L, Alvetro L, Giuntini V, Masucci C, Defraia E and Baccetti T (2011)[6]assessed the dental, skeletal, and soft tissue effects of comprehensive fixed appliance treatment combined with the Forsus Fatigue Resistant Device (FRD) in Class II patients with the help of lateral cephalograms. The FRD group showed a significant restraint in the sagittal skeletal position of the maxilla (also at the soft tissue level), a significant increase in mandibular length, and a significant improvement in maxillo-mandibular sagittal skeletal relationships. The treated group exhibited a significant reduction in overjet and a significant increase in molar relationship. The lower incisors were significantly proclined and intruded, while the lower first molars moved significantly in a mesial and vertical direction. It led to the conclusion that the FRD protocol is effective in correcting Class II malocclusion with a combination of skeletal (mainly maxillary) and dentoalveolar (mainly mandibular) modifications.

Aras A, Ada E, Saracoglu H, Gezer NS and Aras I (2011)[9] **had taken** lateral cephalometric radiographs of patients at or just before the peak phase of pubertal growth (peak pubertal group) and near the end of the pubertal growth period (late pubertal group) showed statistically significant group differences in mandibular length and ramus length, with significant increases of these parameters in the peak pubertal group. No significant differences were observed between the groups concerning dental parameters, with the exception of mandibular molar vertical movements, which were significantly greater in the peak pubertal group. Analysis of the magnetic resonance images showed no positional changes of the mandibular condyle in relation to the glenoid fossa in either group. Although the articular disc was positioned more anteriorly in the peak pubertal group compared with its pretreatment position,

the position of the disc was still within the physiologic range. No significant intergroup difference was observed for disc-condyle relationship.

Sood S, Kharbanda OP, Duggal R, Sood M, Gulati S (2011)[10] had done a study on Class II Division 1 malocclusion, there was a significant decrease in the muscle activity at one month after Forsus Fatigue Resistant Device insertion during swallowing of saliva and maximal voluntary clenching which gradually returned to pre treatment levels at the end of six months.

V. SUMMARY AND CONCLUSIONS

Removable functional appliances are effective but relies heavily at the mercy of patient cooperation for achieving predictable results in reasonable time frame.

Patient cooperation is variable and is not always forthcoming. Also, even if patient is cooperative, there are occasion when the appliance cannot be worn; ex. Mastication which can make a significant difference between success and failures. Beside this there are many difficulties faced during performing other functions like speech with these appliances.

To eliminate these drawbacks, fixed bite jumping appliance have been developed.

With these appliances patient cooperation is no longer a stumbling block, the fixed functional appliance have rapidly endeared themselves to the clinician in achieving result and they should not considered at last resort appliances.

The wide variety of functional appliances that are available to posture the mandible forward for the correction or Class II skeletal discrepancies which, gives the orthodontist a wide variety of appliance selection and at the same time challenges the rationale for selecting the most appropriate appliance.

The decision as to which appliance is to be used is based primarily on the status of the dental and skeletal tissues of the patient ,the type of dental response desired ,the rate and amount of skeletal growth remaining and the degree of co-operation anticipated from the patients.

However, fixed bite jumping appliance have definite indication and contraindication, which should not be neglected. Indiscriminate use in any skeletal disorder without proper diagnostic assessment can make a difference between success and failure.

Newer innovations have come into this field, and it is up to the clinician to decide as to when, where and how to apply it.

Finally, it is not the appliance but the clinician behind the appliance who can make the difference between success and failure.

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