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RESEARCH ARTICLE

FIXED FUNCTIONAL APPLIANCES: AN OVERVIEW

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ABSTRACT

Functional appliances have been used since the 1930s. Despite this relatively long history, there continues to be much confusion relating to their use, method of action, and effectiveness. These appliances alter the arrangement of various muscle groups that influence the function and position of the mandible in order to trasmit forces to the dentition and the basal bone. Typically these muscular forces are generated by altering the mandibular position sagitally and vertically, resulting in orthodontic and orthopedic changes. Functional appliances have been broadly divided into two categories removable and fixed functional appliances. Fixed functional appliances have been used in patients who are non compliant to removable appliances and in patients after the active growth phase has been completed. The purpose of this review was to overview the different fixed functional appliances available till date for the treatment of Class II malocclusions.

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INTRODUCTION

Altering patient's facial profile has been a challenge for orthodontists over the years. Growth modification is the best way to correct a jaw discrepancy as it allows the patients to grow out of the skeletal disharmony. (Kragt and Herman S Duterloo, 1982) Functional appliances refer to a variety of appliances designed to alter the arrangement of various muscle groups that influence the function and position of the mandible in order to transmit forces to dentition and basal bone. (Kragt and Herman S Duterloo, 1982) Functional orthopedic treatment seeks to correct malocclusions and harmonize the shape of the dental arch and oro-facial functions. (Profitt and Fields, 2000) The ideal time for treatment with fixed functional appliance is permanent dentition (to ensure a stable intercuspation of teeth post treatment) and after the pubertal growth spurt (to reduce retention period). (Issacson, 1990) Fixed functional appliances are normally described as "Non compliance class II correctors" giving a false idea about the co-operation necessary during treatment, in reality when we compare them to removable appliance, we can clearly recognize fixed appliances as non compliance devices. However, for treatment to be successful good co-operation is always necessary.

Historical perspective

A major reason for development of functional appliances was recognition that function had an effect on ultimate morphologic structure of dentofacial complex. A number of fixed functional appliances have gained popularity in recent years to achieve better results in non-compliant patient. The correction consists of advancing the mandible to a forced anterior position to stimulate growth and harmonize skeletal defects. Fixed Functional Appliance was introduced first in dentistry by Dr. Emil Herbst of Germany at the 5th International Dental Congress in Berlin in 1909. Herbst (1934) presented a series of article in the "ZAHNAZTLICHE RUNDSCHAU' on his experience with the appliance, which was later rediscovered by Pancherz in the late 1970s. Hans Pancherz *et al*. (1979) investigated the effect of continuous bite jumping on masticatory muscle activity using EMG records; in class II, Division I malocclusion, treated with the Herbst appliance. James J. Jasper (1987) introduced a relatively new type of flexible, fixed tooth borne functional appliance that allowed lateral movements. Hans Pancherz (1981) showed that sagittal mandibular growth was accelerated by continuous bite jumping. During treatment mandibular length and the SNB angle increased. The influence of bite jumping on maxillary growth appeared to be reversible. SNA angle significantly reduced during treatment but during follow-up period maxillary growth caught-up and the SNA angle returned almost to pretreatment values. Clements and Jacobson (1982) introduced the MARS (Mandibular Advancing Repositioning Splint). It is a fixed functional device which is attached to the archwires of a multibanded orthodontic appliance. It forces the patient to maintain the mandible in a protruded position 24 hours a day and y*et al*lows full and complete opening and closing as well as lateral excursive movement. Jasper and

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McNamara Jr (1995) describes the use of a flexible force module (the Jasper Jumper) that can be incorporated into existing fixed appliances to correct various types of sagittal malocclusion. The flexible spring module provides greater freedom of mandibular movement than is possible with the more rigid mechanism of the Herbst appliance. Weiland and Bantleon (1995) gave a report of treatment of class II malocclusion with the Jasper Jumper. It concluded that correction was a result of skeletal (40%) and dental (60%) changes. Skeletal class II correction was predominantly restricted to mandible. Almeida *et al*. (2005) described the short term treatment effects produced by the Herbst appliance during treatment of mixed dentition patients with Class II division 1 malocclusion. The results indicated that the treatment effects produced were primarily dentoalveolar in nature. Ritto (1999) described a miniaturised telescopic device the Ritto appliance. Ashok and Ritu (2010) has shown the treatment effects of MPA-IV in the correction of class II malocclusion. They concluded that Twin-block and MPA-IV were effective in correcting the molar relationships and reducing the overjet in Class II division 1 malocclusion subjects. However, twin-block contributed more skeletal effects than MPA-IV for the correction of Class II malocclusion.

Indications of fixed functional appliances

It is a well known fact that for successful completion of functional appliance therapy patient's compliance is of paramount importance. The fixed functional appliance, being fixed to the teeth is a most important weapon against non-compliance offered by the patient.

1) The correction of skeletal abnormality in young growing individuals.

a) In skeletal class II patients with retrognathic mandible.
b) In skeletal class III patients with retrusive maxilla.

2) Making use of the residual growth left in neglected post adolescent patients who have passed the maximal pubertal growth and are too old for removable functional appliances.

3) In adults patients

a. Can be used to distalize the maxillary molars in correction of dental class II molar relationship.
b. Can be used to enhance anchorage.
c. Can be used as an mandibular anterior repositioning splint in patients having temporomandibular joint disorders.
d. Presurgical muscle conditioning of patients with class II malocclusion.
e. Post surgical stabilization of class II / class III malocclusion.

4. Correction of functional midline shifts by using the appliance unilaterally.

Classification of fixed functional appliances: By Ritto A. Korrodi (2001)

A} Rigid Fixed Functional Appliances (RFFA)

1. The Herbst Appliance and its modifications.
2. The Mandibular Protraction Appliance (MPA)
3. The Mandibular Anterior Repositioning Appliance (MARA)
4. The Ritto Appliance
5. The IST-Appliance
6. The Biopedic Appliance

B} Flexible Fixed Functional Appliances (FFFA)

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

C} Hybrid Fixed Functional Appliances (HFFA)

1. Eureka Spring
2. FORSUS- Fatigue Resistant Device
3. The Twin Force Bite Corrector.
4. Alpern Class II Closers
5. The Calibrated Force Module

Considerations for fixed functional appliances

1)Age factor: fixed functional appliances have an important advantage that they can be used in post adolescent patients in whom very less growth is remaining.

2)Growth considerations: The prognosis of the fixed functional therapy is poor in patients with hyperdivergent facial growth patterns i.e. in patients with alarge gonial angle and increased lower anterior facial height and also in patients having an open bite.

3)Esthetic considerations: Fixed functional appliances yield excellent results in patients with skeletal class II bases with retrognathic mandible who have a positive VTO (visual treatment objective). On the contrary fixed functional appliances are not recommended in patients with a negative VTO because of unsatisfactory results.

4)Compliance: Being 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

The mechanism of mandibular adaptation to the forward posturing by fixed functional appliance is the same as that seen in removable functional appliance. The appliance is tooth-borne and exerts its effects via teeth to the underlying bone by transmitting the forces developed as a result of the continuous forward posturing of the lower jaw. (Graber *et al*., 1997) Inspite of the various differences in concept, the general mode of action is one or combination of the following.

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

Typically, the results obtained by functional appliance in correction of class II malocclusion consists of combination of orthopedic (30-40%) and dentoalveolar (60-70%) effects. (Graber *et al*., 1997)

Functional appliance

↓

Increased contractile activity of lateral pterygoid muscle

↓

Intensification of retrodiscal pad by repetitive activity (bilaminar zone)

↓

Increase in growth stimulating factors
a) Enhancement of local mediators
b) Reduction of local regulating factors

↓

Additional growth of condylar cartilage and subperiosteal ossification of posterior border of ramus

↓

Supplementary lengthening of mandible

Flow chart : Showing mechanism of action of the fixed functional appliances

Biomechanical Effects of Fixed Functional Appliance on Craniofacial Structures

1) Fixed functional appliances move the entire mandible anteroinferiorly, with maximum displacement observed in the parasymphyseal and midsymphyseal regions. The anteroinferior displacement of the mandibular dentition was most pronounced in the incisor region, while the maxillary dentition was displaced posterosuperiorly.
2) The displacement was more pronounced in the dentoalveolar region as compared to the skeletal displacement.
3) All dentoalveolar structures experience tensile stresses, except for anterior nasal spine and the maxillary posterior teeth.
4) Maximum tensile stress and von Mises stresses occurred in the condylar neck and head. (Panigrahi and vineeth, 2009)

Complications with use of fixed functional appliances

Sanden *et al*. (2004) described the complications during fixed functional appliance treatment. Three types of complications were most commonly seen,

Rigid Fixed Functional Appliances

S No.	Appliance name	Introducer	year	Description
1	THE HERBST APPLIANCE[4] & Its modifications (fig 1).	Introduced by Emil Herbst Reintroduced by Hans Pancerz	1979	•The Herbst appliance is an artificial joint between maxilla and mandible. A telescope mechanism on either side of the jaw, attached to orthodontic bands, keep the mandible continuously in an anterior jumped position during all mandibular functions. •The telescopic tube was attached to the maxillary permanent first molar band and the telescope plunger to the mandibular first premolar band
	MODIFICATIONS A)Bonded Herbst Appliance. [15](fig 1 A)	Raymond P. Howe	1982	A)The principal difference between the original and the bonded appliance is that the paired telescoping elements, which has been attached to the lower bicuspid bands, are now attached to the entire lower dental arch by an acrylic bite splint.
	B)Acrylic splint Herbst appliance.[16] (fig 1 B).	James A. McNamara	1988	B)Maxillary and mandibular acrylic splints are placed. Maxillary acrylic splint is made with cusp tips perforating the acrylic. And mandibular with posterior cusp tips perforating and anterior occlusal coverage.
	C)Integrated Herbst appliance. [17](fig 1 C).	Paul Haegglund and Staffan Segerdall	1997	C)It is an integration of the herbst appliance with conventional upper and lower fixed appliances. A lower auxillary archwire with the herbst pistons attached is used to distribute the force from the appliance to the main mandibular archwire, thus reducing the possibility of bracket loosening and wire breakage
	D)Mandibular Advancement Locking Unit (MALU) herbst appliance. (fig 1 D).			D)It consists of two tubes, two plungers, two upper "Mobee" hinges with ball pins and two lower key hinges with brass pins.
	E)Flip locked herbst appliance. (fig 1 E).	TP Orthodontics		E)It Is a horse-shoe ball joint Herbst appliance. Since the ball joint is smalletr in size as compared to pervious appliances it give more patient comfort.
2	Mandibular advancing repositioning splint (MARS).[7]	Clements & Jackson	1982	•It is a fixed functional device, attached to the archwires of a multibanded orthodontic appliance. The function of the MARS appliance is similar to that of the Herbst appliance in that the mandible is maintained in a continuous protruded position via compressive struts.
3	Mandibular protraction appliance (fig 2).[18]	Coelho Filho	1995	•There are four types of MPA (I - IV). •The first type of MPA32 requires stainless steel edgewise appliance in both arches.It is used for the treatment of skeletal class II deformity. Sufficient overjet reduction has been seen in period as short as 4 months. •The result may be due to mandibular growth promotion and dentoalveolar changes. Dentoalveolar changes include distalization of maxillary molars, retraction of maxillary anteriors, mesialization of mandibular molars without retraction of mandibular anteriors. •This appliance was developed to overcome the costly laboratory procedures associated with the herbst appliance and the jasdper jumper.

Continue……..

4	Functional orthopedic magnetic appliance (FOMA).[19] FOMA II - Correction of class II skeletal relations FOMA III - Correction of class III skeletal relations	Vardimon et al.	1989	•Appliance can be classified as a fixed functional appliance using rare earth magnets in an attractive mode to constrain the mandible in an advanced sagittal posture. •The mode of force application is different from the conventiona appliances. Most of them use some form of rigid or flexible "pushing" modality to posture the mandible forward; which are termed as passive appliance. •FOMA II is an active appliance that direct is inherent magnetic forces to the jaws and thereby constrains the lower jaw forward.
4	Ritto Appliance (fig 3).[20]	Dr. A Koroddi Ritto	1999	•It can be described as a telescopic system that is both miniature and versatile. It has been developed with a goal of creating an efficient appliance of simplified intra-oral application •It is a one-piece device with telescopic action. It comes in a Jingle format which allows it to be used on both sides. •Total length of appliance when closed is 25mm and at maximum opening is 33mm.
5	Intraoral snoring therapy appliance (IST appliance). (fig 4).	Hinz		•Is a new device designed by Hinz in order to treat patients who suffers from breathing problems during sleep e.g. obstructive sleep apnea. •The IST appliance suppresses sncring by moving the lower jaw forward reducing the obstruction in the pharyngeal area.
6	Biopedic appliance. (fig 5).	Designed Collins J. and marketed by GAC	1997	•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.
7	Universal bite jumper.[21]	Xavier Calvez	1998	•It is a mandibular propulsion appliances, the UBJ uses a telescoping mechanism. In its normal configuration, the UBJ is attached to the maxillary headgear tube with a ball pin. This pin is bent so it can be tied with a ligature wire to the hook on the molar band •It can be used at any stage of treatment-In the early mixed dentition to obtain an immediate mandibular advancement before any dental alignment or in the permanent dentition for fixed functional treatment. •It is simple, sturdy, inexpensive and can be used in both class II and class III.
8	MARA (Mandibular anterior repositioning appliance)	Douglas toll	1991	•The MARA is a functional appliance because it postures the patient's lower jaw in a forward direction. •It consisted of cams on the molars that guided the patient to bite into Class I. The appliance was low in bulk and easily tolerated by the patient.
9	Rick-A-Nator Appliance. (fig 6).[22]	Rondeau B.H.	1990	•It is a simple appliance consisting of two maxillary 1st molar attached to an anterior bite plane via .036" connector wires. This inclined encourages mandible to come forward which corrects class II molar relationship to class I and eliminates overjet.
10	The ventral telescope	The Professional Positioners		•This was the first telescopic RFFA 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.
11	Magnetic telescopic device	A.K.Ritto		•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. •Main disadvantages are its thickness, the laboratory work necessary to prepare it and the covering of the magnets.
12	Cantilevered bite jumper	mayes	Mid – 1980s	•It is a rigid fixed functional appliance. •Is a Herbst-style appliance; fitted directly to the lower I molar bands through a cantilever arm.
13	Fixed Magnetic Appliance	Varun kalra	1989	•Used For patients having mandibular retrusion and increased lower facial height and large interlabial gap. •The appliance consisted of upper and lower acrylic splints that were bonded on the occlusal halves of the permanent first molars, deciduous molars or premolars, and canines.

Flexible fixed functional appliances

S No.	Appliance name	Introducer	year	Description
1	Jasper Jumper. (fig 7).[23]	Jasper & McNamara	1995	•In an attempt to overcome the rigidity problem of the Herbst Appliance, James Jasper developed a new pushing device that is flexible. It is termed as Jasper Jumper. It can be attached between the maxillary and mandibular arches to produce both sagital and intrusive forces which may be either "head-gear like", "activator-like forces" or combination of both.
2	Adjustable bite corrector.[24]	Dr. Richard west	1995	•The appliance is similar to Jasper Jumper but incorporates several useful features. It consists of a stretchable closed-coil spring with internally threaded endcaps at both ends. This allows additional range of opening with no risk of breaking the appliance or accidentally changing its length.
3	Churro Jumper. (fig 8).[25]	Ricardo castanon et.al.	1998	•The name has been taken from a Mexican cinnamon twist. It functions more like the Jasper Jumper. •In the class II mode, each jumper attaches to the maxillary molars by a pin that passes first through a circle on the distal end of the jumper and then through the distal end of the headgear tube. It is secured by bending the pin down on the mesial end of the tube
4	Amoric torsion coils	Amoric N.	1994	•Made up of two intermaxillary springs, one of which goes inside the other. •It is marketed in one size only and are bilateral.
5	Scandee tubular jumper	Saga dental AS, 2201, Kongsvinger, Norway		•This is a coated inter-maxillary torsion spring sold in a kit which includes the spring, the covering, the connectors, the ball pins and the glue. There is no distinction between left and right. •The covering can be of different colors making it more attractive for patients.
6	The Bite fixer	ormco		•It is a flexible fixed functional appliance. •Is a intermaxillary spring coil. The spring is attached and crimped to the end fitting to prevent breakage between the spring and the end fitting.
7	Super Spring II. (fig 9).[26]	Lewis Klapper	1999	•The super spring II is a flexible spring that attaches between the maxillary molar and mandibular canine. It is designed to rest in the vestibule, making it impervious to occlusal damage and allowing for good hygiene •Uses: The spring can be used in entire range of class II cases, from vertical facial patterns with shallow overbites to brachyfacial patterns with deep overbites. It can be used with fully bracketed appliance.

Hybrid fixed functional appliances

S No.	Appliance name	Introducer	year	Description
1	Eureka spring. (fig 10).[27]	John Devincenza	1997	•This is also a fixed intermaxillary force delivery system similar to fixed Herbst appliance, used in non compliant class II patients. •Advantages of eureka spring are that Minimal patient co-operation is required. •The Eureka spring because of its small size and lack of protruberances into the buccal vestibule is almost invisible. Hence its esthetic acceptability is high. And it is Resistant to breakage. And causes minimal tissue irritation.
2	Forsus (fatigue resistant device). (fig 11).	*William Vogt marketed by* (3M Unitek Corporation)	2006	•The Forsus (also known as the Forsus Fatigue Resistant Device [FRD]) is a semirigid telescoping system incorporating a superelastic nickel-titanium coil spring that can be assembled chair-side, and it can be used in conjunction with complete fixed orthodontic appliances. •The Forsus (FRD) can be used instead of Class II elastics in mild cases and instead of Herbst appliances in severe cases. Forsus springs work best in patients with convex profiles, but they are indicated in any Class II patients except those with normal mandibles and protrusive maxillae, or with protrusive or overly large mandibles relative to the other cranial structures
3	Alpern Class II corrector	(GA C International Inc)		•This appliance was designed as a substitute for elastics. It consists of a small telescopic appliance with an interior copil spring and two books for fixing. •It functions in the same way as elasticds and is fixed to the lower molar and to the upper cuspid.
4	Calibrated force module	The Cor Mar Inc.	1988	•It was a fixed appliance designed to substitute class II elastics. •It is 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 150-200 gm.
5	Power scope. (fig 12).	Dr. Andy Hayes (Marketed by American orthodontics)		•Indicated for use in treating Class II Malocclusions during orthodontic treatment of both growing and non-growing patients with full permanent dentition. Use standard treatment protocols for Class II Correction when using appliance. •PowerScope 2 Class II Corrector is contraindicated for use with patients who have a history of severe allergic reactions to nickel.

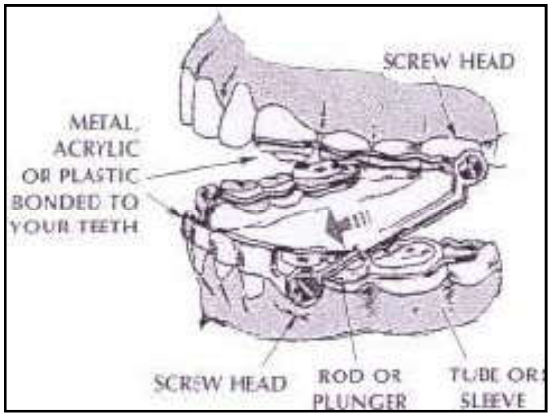

Fig. 1. The herbst appliance

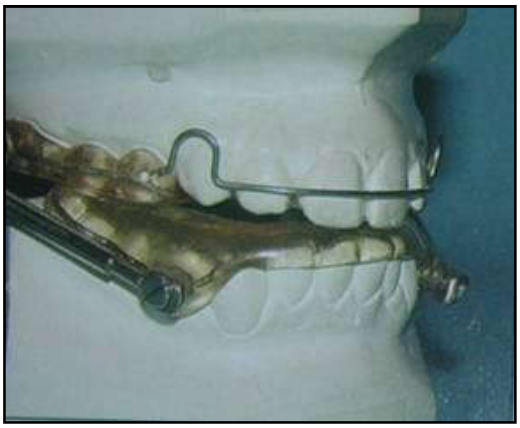

Fig. 1. A bonded herbst appliance

Fig. 1B. Acrylic splint Herbst appliance

Fig. 1C. Integrated Herbst Appliance

Fig. 1. D Components of MALU Appliance

Fig. 1. E Flip locked Herbst appliance

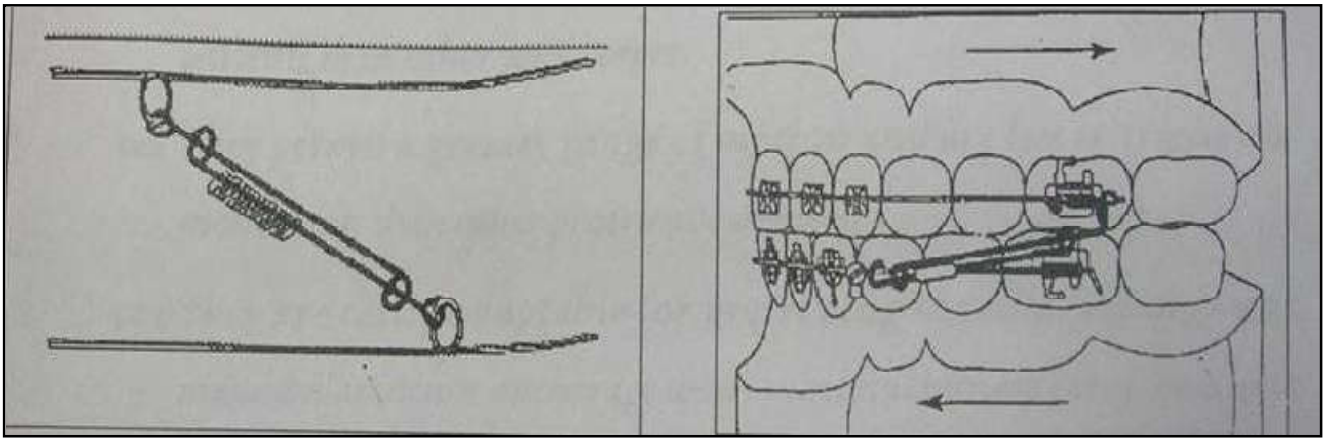

Fig. 2. Mandibular protraction appliance (MPA)

Fig. 3. RITTO APPLIANCE

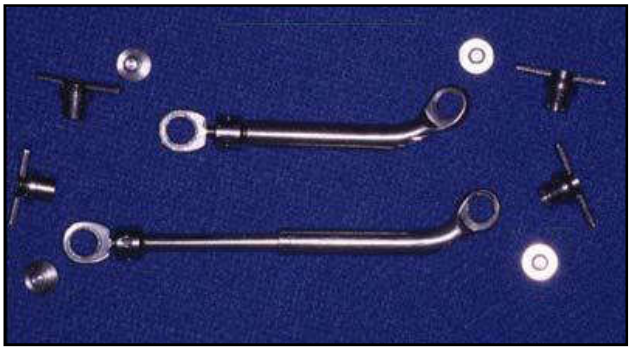

Fig. 4. Intraoral snoring therapy appliance

Fig. 5. The Biopedic Appliance

Fig. 6. Rick-A- Nator appliance

Fig. 7. Jasper Jumper

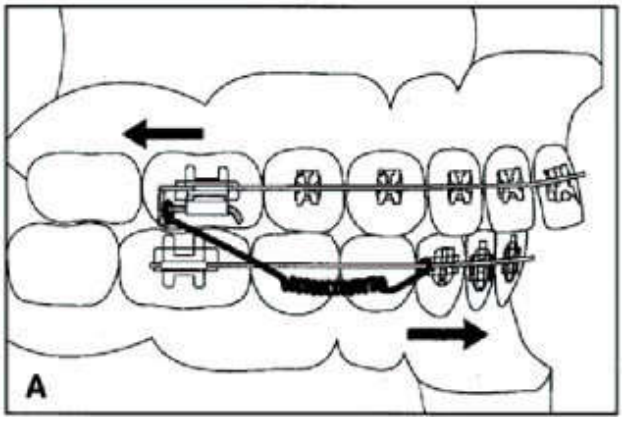

Fig. 8. Churro Jumper

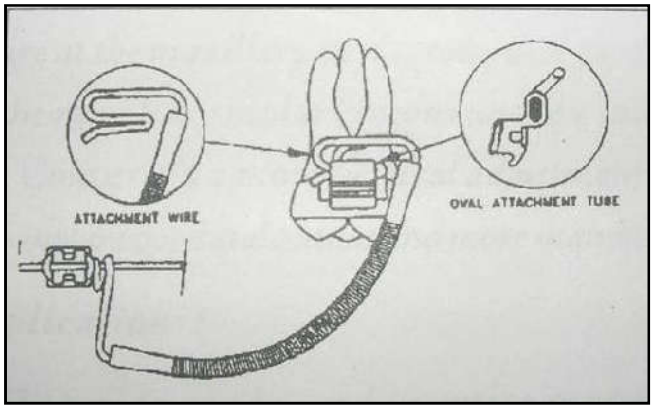

Fig. 9. Supper spring (Klapper spring)

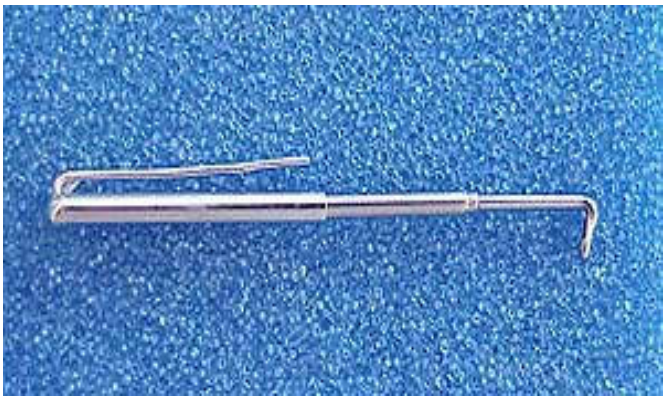

Fig. 10. Eureka Spring

Fig. 11. Forsus fatigue resistant device

Fig .12. Power Scope

1. Breakage of bands or splints.
2. Breakage of telescoping mechanisms.
3. Loosening of bands or splints.
4. Trauma to buccal mucosa

There were no significant differences in complications of treatment between male and female patients.

Conclusion

Removable functional appliances are effective but rely heavily at the mercy of patient cooperation for achieving predictable results in a reasonable time frame. Patient cooperation is variable and is not always forth coming, with appliances such as headgear or removable functional appliances.

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