IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 18, Issue 5 Ser. 4 (May. 2019), PP 65-68
www.iosrjournals.org

Functional Appliances: Origins, the Present & the Future

Sofitha M D[1], M.D.S; Mohamed Iqbal J[2] M.D.S
[1.] *Associate Professor of Orthodontics; Department of orthodontics, Tamilnadu Government Dental College.*
[2.] *Senior Assistant Professor of Orthodontics; Department of Orthodontics, Tamilnadu Government Dental College.*

Corresponding Author- Dr. Mohamed Iqbal J
Senior Assistant Professor Department of Orthodontics Tamilnadu Government Dental College and Hospital Chennai, Tamilnadu India.

Abstract
Orthodontic treatment to correct malocclusion had been to a large extent taken to mean correcting the dentition in all three planes using a fully strapped fixed appliance. The realization that sagital correction of dentition alone, over a skeleton that has a sagital discrepancy, is ineffective led to the focus shifting to correcting the skeletal bases. Two modalities were identified viz: surgical and functional. Functional jaw orthopaedics has seen widespread use in correcting skeletal malocclusion in the growing age. Various appliances have been advocated with some being used by a large section while others not being in vogue. However there is still ambiguity in literature as to the effectiveness of functional appliances and whether it is a sound practice to pull the mandible out of the fossa. This article reviews the concept of functional jaw orthopaedics and presents the current best evidence.

Key Words-*Functional appliances, Growth modification, Supplementary mandibular growth, Current evidence.*
Word count- 2321 words.

Date of Submission: 29-04-2019 Date of acceptance: 13-05-2019

I. Introduction

Functional appliances represent a wide range of appliances that primarily alter the position of the mandible, both sagittally and vertically, to stimulate an increased condylar cartilage growth resulting in supplementary lengthening of the mandible [(1-2)]. They find application in the correction of skeletal class II malocclusions with mandibular retrusion. Though a skeletal Class II malocclusion can also be due to a prognathic maxilla, mandibular retrusion has been shown as the major contributing factor [(3)]. The advantage, according to the proponents of functional appliances, of early treatment in the mixed dentition is that the orofacial environment is improved to receive the permanent dentition. By lengthening the mandible during the active growth period the need for complex intervention involving extractions or surgical correction is minimized [(4)]. However current evidence points out that mandibular lengthening achieved by functional appliances is clinically insignificant[(5)] and there is no advantage of early two phased treatment, over a single phase treatment started at a later age[(6)].

II. History

Wilhelm Roux's (Fig 1) work on tail fins of Dolphins in the year 1883 sowed the seed for the concept of function influencing form. He described functional stimuli as capable of building, molding, remolding and preserving tissue. Robin and Andresen at different periods applied Roux's hypothesis. In 1885 Julius Wolff (Fig 2) published his book "Law of the transformation of bone" in which he stated that function brought about changes in form [(7)]. Much later Karl Hauple used Roux's hypothesis to explain how functional appliances bring about change through the activity of orofacial muscles [(8)]. Though functional appliance is identified as a European treatment philosophy, it was Norman W.Kingsley (Fig 3) who first advanced the mandible forward in the treatment of malocclusion [(9)]. The predominant use of removable functional appliances in Europe was more out of necessity brought about by the Second World War (1939-1945), while across the globe, in the United States, fully banded fixed appliance was the orthodontic treatment mainstay. Edward Angle used Wolff's hypotheses to his own end as reinforcement for his conviction that expanding arches brought about new bone formation. In the year 1933, when Oppenheim published his work on the potentially damaging effects of heavy orthodontic forces [(10)] as used in fixed fully strapped up appliances, it turned out to be an impetus to the advocacy of functional appliances.

Pierre Robin became the first to use functional jaw orthopaedics to treat a malocclusion in 1902. He used Monobloc, a modification of Kingsley's appliance, to treat children with the glossoptosis syndrome. However the impact of functional appliances was effectively made by Viggo Andresen (Fig 4), when in 1909 he accidentally found that a retainer he gave to his daughter with a lingual horseshoe flange had corrected her Class II malocclusion. Andresen's design was a finer modification of Robin's Monobloc. But he recorded that he had no knowledge of that and it is plausible considering the state of information transfer during that era. For a long time Andresen's appliance was just a plate with a design to bring the mandible forward. However in 1925, while he was a director of Orthodontic department in Oslo, on a government assignment to design a cost effective appliance to treat Norwegian children, Andresen for the first time registered the mandible in an advanced position using a wax bite. In a sense this marked the beginning of functional appliances in the form that we know now. Karl Hauple (Fig 5) a periodontist at the same institution saw Andresen's work and became an advocate of the appliance which by now was widely referred to as "Norwegian system". Karl Hauple was as dogmatic in his views of the Activator (Fig 6) as Angle was of non extraction fixed appliance treatment in the United States. As fallout, European orthodontics became synonymous with functional jaw orthopaedics to the exclusion of all other treatment modalities [(11)].

The first detraction to the use of functional appliances came in 1951 when Reitan in his doctoral dissertation, showed that functional appliance too produce histological changes similar to fixed appliances. Human studies on the efficacy of functional appliances were cautious at best compared to earlier animal studies which led to a wave of functional appliance use. Rolf Frankel introduced his appliance which had the oral vestibule as the area of operation. The Frankel Regulator [(2)] (Fig 7) introduced in 1957 was complimented by Melvin Moss's (Fig 8) Functional matrix theory [(12)]. For a complex vestibular appliance, Frankel's regulator had many enthusiasts due largely to Rolf Frankel's courses and presentations. Frankel was able to do what other Functional appliance practicing European orthodontists couldn't- he convinced American orthodontists to practice Functional appliance treatment. However limited exposure and insufficient grasp of the concept soon discouraged many. Another view is that the interest showed by the American orthodontists to Frankel was the result of them being "unbusy" due to effects of community water fluoridation[(9)]. The Herbst appliance originally introduced by Emil Herbst in 1905 and revived by Hans Pancherz (Fig 9) was a fixed functional appliance for non compliant patients [(13)]. William J.Clark introduced his Twin block as a 24 hour two element appliance with the advantage of comfort and exploitation of functional forces continuously [(14)]. While several other functional appliances have been introduced, those which had an impact and were practiced popularly include Activator, Frankel functional regulator, Herbst and presently the use of Twin Block is synonymous with functional appliances.

Basis of Functional Appliance Treatment

Two concepts that form the basis for the philosophy of functional appliance treatment are, the functional matrix theory of Melvin Moss [(12)] and the ability of the condyle to adapt to various topographical and functional relationships during the growth period [(15)]. Functional matrix hypothesis claims that the origin, growth and maintenance of skeletal tissues and organs are always secondary, compensatory and mechanically obligatory responses to temporally and operationally prior events and processes occurring in related nonskeletal tissues, organs and functional spaces. Frankel functional regulator works on the premise that abnormal forces generated by an inequillibrium between the buccal musculature and tongue results in the features of malocclusion. The appliance, by eliminating the abnormal forces, provides a better environment for the jaw bases to grow.

Condylar cartilage is a secondary cartilage and hence is influenced by local factors. It is possible to modulate both the amount and direction of condylar cartilage therapeutically [(15)].

A focussed research by Petrovic and co-workers [(16)] resulted in the recognition of the role of Lateral Pterygoid muscle (LPM) in modifying condylar cartilage growth rate. LPM plays a regulating role in the control of the condylar cartilage's growth rate. The retrodiscal pad on the other hand has the role of the mediator to the efforts of the LPM in controlling condylar growth. The influence of retrodiscal pad on mandibular growth has been explained by two effects. In the "blood circulating effect", intensification of activity as in mandibular advancement results in increased blood and lymph flow. This causes an increase in nutritive and growth stimulating factors supply, like STH-stomatomedin, Testosterone, and Prostaglandin F2. At the same time there is a decrease in the locally produced metabolites. This essentially leads to supplementary growth of condylar cartilage and increased endochondral ossification rate. In the "biochemical effect", intensification of activity leads to piezoelectric changes resulting in increased bone apposition on the posterior ramus and increased bone resorption in the anterior ramus. The result is supplementary lengthening of the mandible and posterior growth rotation.

Scientific enquiry into the efficacy of functional appliances has been mainly to ascertain whether the supplementary lengthening achieved is clinically significant and whether the regimen is effective in avoiding later phase treatment in terms of time and cost.

Evidence On Functional Appliances

Literature on functional appliances is predominantly in the form of prospective studies and case reports with scant randomization. Initial animal studies, the results of which led to widespread use of functional appliances, were followed by human studies with less enthusiastic results. The advent of Evidence based practice [(17)] led to the identification of studies which were sound in their design and methodology and hence can be considered good evidence. Unfortunately very few studies meet the criteria even to be included in a systematic review or Meta-analysis. Chen et al [(5)] in their systematic review for the period 1966-1999 found only 17 randomized trials of which only 6 met their selection criteria (Table 1). Marsico et al [(19)] in their systematic review for the period up to September 2009 found only 32 randomized trials of which only 4 met their selection criteria (Table 2). The major drawbacks of studies on functional appliances seem to be that there is wide variability in the measurement of effective mandibular length. While some studies have used Condylion (Co)-Pogonion (Pg), others have used Articulare (Ar)-Pogonion (Pg) as reference points in the measurement of effective length of mandible [(5, 19)]. Secondly variations were found among the subject groups. The range was wide (7-13yrs) and only chronological age was taken as criteria. Chen et al [(5)] argue that growth does not occur at a constant rate and children of same chronological age might not have equal skeletal maturity or growth potential. Treatment duration also differed widely among the studies ranging from 6 months to 24 months.

On the basis of the systematic reviews and meta-analyses conducted till date, the best evidence suggests that the effect of functional appliances on mandibular growth is clinically insignificant [(5, 6, and 19)]. Early treatment with functional appliances followed by a second phase of fixed appliance compared to a single phase treatment at a later age has no significant advantage either with respect to jaw relationships and occlusion or treatment time and cost [(20)]

Conclusion

Functional appliances still find their place in the orthodontic practice even in the wake of increasing evidence questioning the validity of their effectiveness and advantages. The current evidence is based on studies considered to be of good design and methodology, which unfortunately are few. One systematic review [(5)] highlights the need for more randomized control trials to reduce methodological errors and minimization of confounding errors such as discrepancies in age and treatment duration. According to Popper science is not a static acceptance of truth but rather the permanent search of truth. More randomized controlled studies of high evidentiary value are required to validate or refute existing information.

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Sofitha and Iqbal. "Functional Appliances: Origins, the Present & the Future." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 18, no. 5, 2019, pp 65-68.