

## **Functional appliances: The activator and the functional regulator- A review**

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### **ABSTRACT**

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In this review of literature we are discussing the effects of functional appliances on the dentofacial structures in the treatment of Class II malocclusions. Despite recent questions on the effectiveness of early treatment, it is generally recognized that the use of growth modification still has a place in modern orthodontic practices. The aim of this review is to study growth modification of the mandible by two appliances: the activator and the functional regulator. Mechanism of action, design, effect on dentofacial structures, etc. of activator and

the functional regulators are discussed here. Regardless of the appliance used, there are a large amount of variations in individual patient response to treatment. A second stage of treatment with a fixed appliance is necessary in most cases to ensure proper alignment and interdigitation of the dentition. Regardless of the appliance used, the success of treatment is dependent on patient cooperation.

**Key words:** Activator, functional regulator, myofunctional appliances.

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## INTRODUCTION

“Functional appliance” refers to a variety of *removable and fixed* 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 the dentition and the basal bone. Typically, these muscular forces are generated by altering the mandibular position sagittally and vertically, resulting in orthodontic and orthopedic changes. Functional appliances have been used since the 1930s. Despite this relatively long history, there continues to be much controversy relating to their use, method of action, and effectiveness. Although there are a number of functional appliances used by clinicians, this review will emphasize the activator, and the functional regulator used to correct Class II malocclusions.

### The activator



**Figure 1.** Activator.

#### *Mechanism of action and design*

The original monoblock designed by Robin in 1902 was a one-piece removable appliance [1]. Andresen and Haupl, who introduced the use of the activator, believed that the repetition of the new mandibular closure pattern induced a musculoskeletal adaptation and resulted in the reeducation of the orofacial musculature. Since it was designed to be loose fitting and required the patient to actively hold the appliance in place, it was often described as an exercise appliance. Although the original activator was made of rubber, the appliance currently is made of acrylic. The muscular forces generated by the forward mandibular positioning were transferred to the maxillary and mandibular teeth through the acrylic body and the labial bow, which contacted the maxillary incisors. In theory these forces were transmitted through the teeth onto the periosteum and bone, where they produced a restraining effect on the forward growth of the maxilla, while stimulating

mandibular growth and causing maxillary-mandibular dentoalveolar adaptations. Interocclusal acrylic guide planes were provided to direct the dentoalveolar adaptations in a desirable direction. For a Class II correction, the mandibular posterior segments were directed to erupt vertically and mesially, while the maxillary teeth were directed distally and buccally. Vertical eruption of the maxillary teeth was impeded by the acrylic occlusal stops and the intrusive forces generated by the appliance [2,3]. Incisal acrylic coverage was intended to inhibit the eruption of the maxillary and mandibular anterior teeth while reducing the flaring of the mandibular anterior teeth. Uncontrolled incisor flaring could result in a rapid correction of the overjet, which would minimize the orthopaedic effects of the appliance on the maxilla and mandible. Most present day activators are a modification of the Andresen-Haupl appliance, which was designed for nighttime use [4,5].

#### *The construction bite*

Since the most variable aspect of appliance design is the vertical dimension of the construction bite, the effects of treatment could be evaluated on this basis. The construction bite determines the sagittal and vertical displacements of the mandible and therefore the degree and direction of appliance activation.

Andresen increased the vertical dimension between the molars by 3 to 4 mm. Harvold used a construction bite that increased the vertical dimension a minimum 5 to 6 mm beyond the average 4 to 5 mm rest position. He also increased the horizontal displacement of the mandible beyond the advancement to a Class I molar relationship that was used by Andresen to an end-to end incisor relationship.

### The functional regulator



**Figure 2.** Functional regulator.

### *Mechanism of action and design*

Frankel believed that a poor postural behavior of the orofacial musculature is the primary etiologic factor in Class II malocclusions. He believed that the correction of a Class II malocclusion is achieved by permanently advancing the position of the mandible through muscular exercise. Since the Functional regulator is to a great extent a tissue-borne appliance, it facilitates active muscular training. It attempts to strengthen the mandibular protractors by advancing the mandible in a slow, stepwise fashion during a long period of time. Frankel advocates advancing the mandible 2 to 3 mm every 4 to 5 months [6]. This stepwise advancement of the mandible can be obtained by use of the split buccal vestibular shields, which allow the mandibular labial lip pads and mandibular lingual shield to be advanced. The advanced position of the mandible is maintained by the lingual acrylic shields, which contact the lingual alveolar mucosa below the lower incisors without touching them. As the mandible attempts to drop back, the shield puts pressure on the alveolar processes; this is supposed to induce a proprioceptive response that repositions the mandible forward. The muscles are allowed to adapt to each new mandibular position before further advancement is performed. This prevents the muscles from being over activated or overstretched, which could lead to muscle fatigue that is undesirable because it will result in contact of the lingual shield with the lingual surface of the anterior alveolus causing mandibular incisor flaring [7]. Frankel believes that the 2 to 3 mm incremental advancement will decrease the risk of muscular fatigue and that each new forward position of the mandible results in renewed growth stimulation of the condyle.

Another feature of the FR is its ability to facilitate maxillary arch width expansion. The expansion is believed to be the result of two mechanisms: 1. the buccal and labial shields relieve the muscle pressure on the teeth causing the crowns to tip buccally; 2. the buccal shields are positioned to the maximum depth of the vestibule, thus producing an outward pull on the periosteal tissue. This force is transmitted through the muscle fibers and connective tissue onto the alveolar bone where it induces lateral movement of the alveolus. This movement is supposed to counteract the lingual root movement so that a bodily buccal tooth movement is produced. It is suggested that for this expansion to be stable, treatment should be initiated in the mixed dentition. [2]. Though the FR is supposed to be tissue-borne, it is designed to have wires that seat into maxillary molar and canine rests to ensure proper maxillary anchorage. It has been argued that the most common cause of failure is inadequate maxillary anchorage

preparation. Without this anchorage, the appliance tips lingually, contacting the lower incisors, and causing labial gingival abrasion [8]. The FR also has a labial wire that can produce a lingual force on the maxillary arch if it is allowed to contact the teeth. The appliance is worn on a full-time basis.

### **Effects of various appliances on the dentofacial structures**

#### A. Effects of activator therapy

1. Effects on the mandible. Birkebaek, Melsen, and Terp [9] in an implant study that featured laminographs of the temporo-mandibular joint, concluded that the major effects of activator treatment were an increased amount of condylar growth and a remodeling of the articular fossa. The combination of these effects resulted in the permanent anterior displacement of the mandible. Using the implants for cephalometric superimpositions, they determined that the appliance did not inhibit the growth of the maxilla, but that it did cause the maxilla and mandible to rotate in a downward and backward direction. They also found that treatment resulted in a slightly forward displacement of the glenoid fossa as compared with the slightly backward displacement in the controls. In addition the anterior facial height increased by 1.1 mm and the mandibular plane angle was increased by 2.5 degree. The mandibular plane angle slightly decreased in the controls. Other investigators also found 1.0 to 2.0 mm incremental increases in the growth of the mandible after the use of activators [10-13]. Pancherz [14] evaluated 30 Class II, Division 1 children in the mixed dentition who were treated successfully with activators. The controls were persons of the same sex and similar ages with excellent occlusion. The activator was worn at night for an average of 32 months. He found that mandibular growth increased by 0.3 mm per year, but this was not statistically significant. He concluded that the magnitude of mandibular growth was not affected by activator treatment [15].
2. Effects on the maxilla. Several investigators have shown that it is possible to clinically alter the growth direction of the maxilla [4,14,16-18] Williams and Melsens [13,19] demonstrated that an increased posterior maxillary vertical height resulted in a backward rotation of the mandible and pogonion. Forerg and Odenrick [20] noted a significant decrease of the SNA angle. Vargervik and Harvold [18] found that the activator inhibited the horizontal growth of the maxilla by 2 mm; Pancherz [14] found it was restricted by 1.7 mm.

3. Effects on the dentition. Bjork [19], Pancherz [14] and Wieslander and Lagerstrom, observed significant dentoalveolar change. A Class I occlusion was achieved through distal tipping of the maxillary teeth and a mesial, vertical movement of the mandibular dentition. Harvold and Vargervik [18] observed that the appliance also caused 1.4 mm of maxillary incisor lingual tipping and 0.5 mm of mandibular incisor labial tipping. They concluded that the appliance achieved a Class I occlusion by inhibiting maxillary dentoalveolar vertical development, while encouraging mandibular dentoalveolar mesial and vertical development. Pancherz found that more than 70% of the overjet was corrected by incisor tipping. Approximately 50% (2.5 mm) of the overjet was reduced by lingual movement of the maxillary incisor, while 22% (1.1 mm) was reduced by mandibular incisor flaring.
4. Effects on soft tissue. Forsberg and Odenrick [20] observed that upper lip retrusion was significantly more prevalent in the treated Class II group than the control group. The nose showed equal forward growth in both groups, but the soft-tissue pogonion was significantly further anteriorly in the treated group.

#### **Effect of the functional regulator on the dentofacial structures**

1. Effects on the mandible. Frankel and Reiss [21] reported a forward displacement of pogonion and point B at a rate of 4 mm per year in 6- to 9-year-old children and 6 mm per year in children 9 to 13 years of age. McNamara [6] found that the FR resulted in an average increase of 1.2 mm per year in mandibular growth. Righellis [22] also found that the FR increased mandibular length by 1.8 mm per year.
2. Effects on the maxilla. Righellis [22] found no significant horizontal effect on the maxilla in patients treated with the FR as compared with untreated Class II subjects.
3. Effects on the dentition. Frankel indicated that the FR could not cause flaring of the mandibular incisors since the appliance does not contact them. This assertion was supported by Nielsen who found that the FR did not induce proclination of the mandibular incisors relative to the cranial base. However, other investigators concluded that FR induced a significant amount of incisor proclination [23-25]. McNamara, Bookstein, and Shaughnessy [23] believed that improper placement of the lower labial pads either too far occlusally or labially would result in a lip bumper effect rather than a restriction of mentalis activity.

This incorrect placement would contribute to the additional proclination that was found. Although there is disagreement on the effect of the FR on the mandibular incisors, there is greater agreement, in the literature, as to its effect on the maxillary incisors. They are tipped lingually an average of 2.3 to 2.7 mm. According to McNamara [6], the failure to notch the maxillary teeth allows the appliance to rock posteriorly and inferiorly, causing lingual tipping of the maxillary incisors and downward and backward rotation of the maxilla.

4. Effects on the soft-tissue profile. Nielsen examined Class II, Division 1 patients treated with the FR. Although all patients showed an improvement in their soft-tissue profile because of an improved lip position, seven of the ten showed no change in facial convexity.
5. Effect on arch width. A significant amount of expansion in arch width was observed by McDougall, McNamara and Dierkes during treatment with the FR. Less expansion was noted in the lower arch and was attributed to dental up righting. Long-term stability of the dental arch expansion after all retention appliances have been removed has not been sufficiently documented. In summary, with the functional regulator, the overjet correction is achieved through dental tipping (63%) and skeletal orthopedic changes (37%).

#### **Comparisons of the effects of functional appliances and other methods of treatment**

##### *Activator vs. fixed appliance therapy*

Class II malocclusions successfully treated with either an activator or extraoral traction were compared to untreated controls by Baumrind and associates [25,26]. They found that mandibular length, measured from the condyle to pogonion, increased by 2.8 mm in the activator group and 2.7 mm in the headgear group, while the controls increased by 2.1 mm. They also concluded that the activator did not significantly affect the mandibular plane angle or the anterior facial height.

Mecha cephalometrically compared 76 Class II, Division 1 patients treated with extraoral force and activators and found that the activators favorably influenced the bony profile by positioning pogonion in a relatively more forward direction [27-28].

##### **Functional regulator vs. fixed appliance therapy**

1. Effects on the maxilla. Creekmore and Radney [29] compared the treatment results obtained by

the FR to those obtained with a standard edgewise treatment and extraoral traction. Both groups were also compared to an untreated control group. They observed that both treatment modalities were effective in the correction of a Class II malocclusion. Although both treatment modalities significantly reduced the anterior growth of the maxilla, the fixed appliance therapy with extraoral forces retarded the forward growth of the maxilla by an additional 1 mm. Fixed appliances also were associated with 1.1 mm greater lingual movement of the maxillary incisors.

2. Effects on the dentition. Differences in the magnitude of labial tipping of the mandibular incisors were dependent on whether Class II elastics were used during fixed appliance therapy. The FR caused 0.8 mm less mandibular incisor flaring than fixed appliances and Class II elastics. On the other hand, the FR flared the incisors 3.7 mm more when Class II elastics were not used during fixed appliance therapy. Compared with fixed appliances, the FR typically induced 1.4 mm of additional mesial movement of the mandibular molars. Remmer and associates [27] found that fixed appliances resulted in more bodily retraction of the maxillary incisors, relative to a predominant lingual tipping action produced by the FR.
3. Effects on the mandible. Gianelly, Arena, and Bernstein [28] compared the effects of nonextraction treatment on Class II, Division 1 malocclusions using either edgewise mechanics and headgear, Begg mechanics with Class II elastics, or the FR. The FR group consisted of 16 of the most successfully treated cases from a sample of 53. The maxillary teeth were notched as advocated by Frankel. The cephalogram of the FR patients were taken in centric relation using a leaf gauge. Gianelly and associates found that there were no significant differences between the appliances with respect to the skeletal and dental changes that occurred to achieve successful results. In addition, they concluded that there were no significant differences in the amount of mandibular growth among the three modalities. They concluded that the Class II correction was achieved through a combination of orthodontic and orthopaedic effects, with the predominant change being a dentoalveolar effect. They believed that all of these treatment modalities would probably influence the average growing face in a similar manner. In another study designed to evaluate the ability of the FR to increase mandibular growth, Gianelly and associates examined 10 Class II, Division 1 patients treated for 1 year with the FR [28]. These patients were compared to 15 patients with Class

II, Division 1 malocclusions who were treated with a cervical pull headgear and edgewise mechanics. A leaf gauge was used to ensure a centric relation position in both groups. No significant differences in mandibular growth as measured from articulare to gnathion were found between the groups during the first year of treatment. Although both groups showed an average mandibular growth of 2.4 mm, there was a large amount of individual variation. Mandibular growth ranged from 0.8 to 3.5 mm in the FR group and from 0.8 to 4.1 mm in the edgewise group. The authors emphasized that most studies that evaluate functional appliances do not ensure that a true centric relation position is obtained. Therefore they believe that much of the claimed additional mandibular growth could actually be a forward posturing of the mandible.

4. Effective changes at pogonion. Creekmore and Radney [29] found no significant difference in the forward displacement of pogonion with the FR. Since the additional 1.2 mm of mandibular growth was expressed primarily vertically and not horizontally, they concluded that treatment with the FR resulted in a longer face, with minimal (0.5 mm) additional anterior displacement of pogonion as compared with the untreated controls. Similar conclusions were found by McNamara, Bookstein, and Shaughnessy [23]. They observed that in children older than 10 years, despite a 3.6 mm increased mandibular length, only 1.3 mm was expressed horizontally. In younger children (2 age=8.8 years), the mandibular length increased by 2.4 mm, but resulted in only a 0.7 mm anterior displacement of pogonion. The primary result of treatment with the FR was an increased lower anterior facial height of 2.1 mm in the older group and 3.1 mm in the younger group. They concluded that since the increased mandibular length resulted in a vertical translation of the mandible, little improvement in the profile was achieved.

#### **Indications and advantages of functional appliances**

Although functional appliances have been designed to treat all types of malocclusions, they are most effective in treating dental and skeletal Class II malocclusions, particularly cases with mandibular deficiency.

Other indications of functional appliance therapy inquired to investigate, evaluate, and formulate conclude prevention and correction of oral habits. It is interesting to note that the conclusions drawn thumb/lip sucking, mouth breathing, and other

oral by the various authors often differ significantly while functional aberrations.

### **Limitations of functional appliances**

1. Functional appliances are typically associated with maxillary and mandibular molar extrusion. Although this is helpful in eliminating a deep overbite, it also can result in an unfavorable increase in lower anterior facial height, which explains why any additional mandibular growth is primarily expressed vertically and not horizontally. Therefore, functional appliances are contraindicated in backward mandibular rotators with minimal overbite.
2. Individual tooth movements are difficult with functional appliances. Therefore, a final phase of fixed appliance therapy should be considered to achieve bodily and rotational tooth movements and optimal functional occlusion.
3. The results of treatment are totally dependent on patient cooperation.
4. These appliances are of very limited use in the correction of anteroposterior discrepancies in no growing persons.

### **Timing of treatment**

The age at which functional appliance therapy is instituted is of major importance for the successful correction of Class II malocclusions. Functional appliance treatment should be coincident with periods of active growth. Most agree that it should be initiated during the middle to late mixed dentition. It can also be used earlier if the patient can cooperate in wearing the appliance.

### **CONCLUSIONS**

1. Any appliance is only a tool available for the clinician. Functional appliances are one of many effective modalities used to treat persons with Class II malocclusion.<sup>4</sup>
2. There is a place for functional appliances in our armamentarium. The ideal types of cases for such treatment are nonextraction Class II, Division 1 malocclusions, with procumbent maxillary incisors, lingually tipped mandibular incisors, a deep overbite, a flat to average mandibular plane inclination, and mandibular skeletal retrusion.
3. The success of treatment is totally dependent on patient cooperation and timing the treatment during periods of growth.
4. The appliance needs to be worn for a prolonged period of time, usually 1.5 to 2 years to ensure complete condylar adaptation following its initial

displacement from the fossa. The potential of a dual bite requires careful evaluation. A leaf gauge should be used to determine mandibular position so that a potential relapse can be avoided.

5. Regardless of the type of functional appliance used, the correction of the malocclusion is generally achieved in a similar manner-that is, (1) optimizing mandibular growth, (2) redirection of maxillary growth, (3) lingual tipping of the maxillary incisors, (4) labial tipping of the mandibular incisors, (5) mesial and vertical eruption of mandibular molars, and (6) inhibition of mesial movement of the maxillary molars. A combination of orthodontic (60% to 70%) and orthopaedic (30% to 40%) movements provide the correction necessary for successful treatment. The choice of appliance should be based on the proper diagnosis of the different aspects of the malocclusion and not because a particular appliance is thought to have a greater influence on mandibular growth. Clinicians should be thoroughly familiar with the appliances they are using, including their potential benefits and limitations. Clinicians also should be aware of the effects of these appliances on the dentofacial structures when formulating a treatment plans for everyone patient.
6. Regardless of the appliance used, there is a large and similar amount of variation in individual patient response to treatment. A second stage of treatment with a fixed appliance is necessary in most cases to ensure proper alignment and interdigitation of the dentition.
7. Further investigation of the effects of the combined use of extraoral forces with functional appliances, especially high-pull traction, is needed. The combined effect with high-pull traction could result in improved control over maxillary vertical growth, which could subsequently improve the horizontal mandibular growth.
8. The long-term stability of the dental arch expansion using functional appliance therapy still needs to be evaluated.

### **Conflicts of Interest**

None

### **REFERENCES**

1. Robin P. Demonstration pratique sur la construction et la mise en bouche d'un nouvel appareil de redressement. *Rev Stomatol.* 1902;9(3):561-90. (French)

2. Graber TM, Neuman B. Removable orthodontic appliances. Philadelphia: WB Saunders, 1984.
3. Graber TM, Rakosi T, Petrovic AG. Dentofacial orthopedics with functional appliances. St. Louis: The CV Mosby Company, 1985.
4. Harvold EP, Vargervik KS. Morphogenetic response to activator treatment. *Am J Orthod.* 1971 Nov;60(5):478-90.
5. Woodside DG. The activator. Salzmann JA, (ed.) Orthodontics in daily practice. Philadelphia: JB Lippincott, 1974.
6. McNamara JA. On the Frankel appliance. Part I. Biological basis and appliance design. *J Clin Orthod.* 1982 May;16(5):320-37.
7. McNamara JA, Hulse SA. The Frankel appliance (FR-2): model preparation and appliance construction. *Am J Orthod* 1981 Nov;80(5):478-95.
8. Bernstein L, Ulbrich R, Gianelly A. Orthopedics versus orthodontics in Class II treatment. An implant study. *Am J Orthod.* 1977 Nov; 72(5):549-.59.
9. Birkebaek L, Melsen B, Terp S. A laminographic study of the alterations in the temporomandibular joint following activator treatment. *Eur J Orthod.* 1984 Nov; 6(4):257-66.
10. Cohen AM. Skeletal changes during treatment of Class II/I malocclusions. *Br J Orthod* 1983Jul; 10(3):147-53.
11. Demner LM, Kolotokov AP, Basharova ON. Cephalometric analysis of changes arising during treatment of prognathism. *Stomato-logica (Moskva)* 1961 Jan; 48(2):57-61.
12. Marschner JF, Harris JE. Mandibular growth and Class II treatment. *Angle Orthod.* 1966 Jan; 36(1):89-93.
13. Williams S, Melsen B. Condylar development and mandibular rotation and displacement during activator treatment. *Am J Orthod.* 1982 Apr;81 (4):322-6.
14. Pancherz H. A cephalometric analysis of skeletal and dental changes contributing to Class II correction in activator treatment. *Am J Orthod.* 1984 Feb;85(2):125-34.
15. Elder JR, Tuenge RH. Cephalometric and histological changes produced by extraoral high-pull headgear to the maxilla in *Macaca mulatta*. *Am J Orthod.* 1974 Dec;66(4):599-617.
16. Nanda R. Biomechanical and clinical considerations of a modified protraction head-gear. *Am J Orthod.* 1980 Aug;78(2):125-39.
17. Pfeiffer JP, Grobety D. Simultaneous use of cervical appliance and activator: an orthopedic approach to fixed appliance therapy. *Am J Orthod.* 1972 Apr;61(4):353-73.
18. Vargervik K, Harvold EP. Response to activator treatment in Class II malocclusions. *Am J Orthod* 1985 Sep;88(3):242-51.
19. Bjork A. The principle of the Andresen method of orthodontic treatment: a discussion based on cephalometric x-ray analysis of treated cases. *Am J Orthod.* 1951 Jul;37(7): 437-58.
20. Forsberg CM, Odenrick L. Skeletal and soft tissue response to activator treatment. *Eur J Orthod.* 1981;3(4):247-53.
21. Frankel R, Reiss W. Zur Problematik der Unterkiefermacheat wicklung bei Distal-bissfallen. *Forstschar kieferorthop.* 1970: 31;345-55. Cited in Mills JRE, Clinical control of craniofacial growth; A skeptik's viewpoint. In Macnamara JA Jr, Ribben KA and How RP, (eds.) Clinical alteration of the growing face Monograph. An Arbor; 1983, 17-39.Center for Human growth and development, University of Michigan.
22. Righellis EG. Treatment effects of Frankel, activator and extraoral traction appliances. *Angle Orthod.* 1983Apr;53(2):107-21.
23. McNamara JA Jr, Bookstein FL, Shaughnessy TG. Skeletal and dental changes following functional regulator therapy on Class II patients. *Am J Orthod.* 1985 Aug;88(2):91-110.
24. Robertson NR. An examination of treatment changes in children treated with the functional regulator of Frankel. *Am J Orthod.* 1983 Apr; 83(40):299-310.
25. Baumrind S, Kom EL, Molthen R, West EE. Changes in facial dimensions a: sociated with the use of forces to retract the maxilla. *Am J Orthod.* 1981Jul; 80(1):17-30.
26. Baumrind S, Molthen R, West EE, Miller DM. Mandibular plane changes during maxillary retraction. *Am J Orthod.* 1978 Jul;74(1):32-9.
27. Remmer KR, Mamandras AH, Hunter WS, Way DC. Cephalometric changes associated with treatment using the activator, the Frankel appliance, and the fixed appliance. *Am J Orthod.* 1985 Nov;88(5):363-72.
28. Gineally AG, Arena SA, Bernstein. A comparison of class-II treatment changes noted with the light wire, edgewise and Frankel Appliances. *Am J Orthod.* 1984 Oct; 86(40):269-76.
29. Creekmore TD, Radney LJ. Frankel appliance therapy: orthopedic or orthodontic? *Am J Orthod.* 1983 Feb;83(2):89-108.