SPECIAL ARTICLE

Orthodontics in 3 millennia. Chapter 9: Functional appliances to midcentury

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The history of the functional appliance can be traced back to 1879, when Norman Kingsley introduced the "bite-jumping" appliance. In the early 1900s, parallel development began in the United States and Europe in fixed and functional techniques, respectively, but the Atlantic Ocean was a geographic barrier that restricted the sharing of knowledge and experience in these philosophies. The only exception to this was the fixed functional appliance designed by Herbst. The monobloc, developed by Robin in 1902, is generally considered the forerunner of removable functional appliances, but the activator developed in Norway by Andresen in the 1920s was the first functional appliance to be widely accepted, becoming the basis of the "Norwegian system" of treatment. Both the appliance system and its theoretical underpinnings were improved and extended elsewhere in Europe, particularly by the German school led by Häupl, Bimler, and Balters. It would be after midcentury before functional appliances were reintroduced into American orthodontics. (Am J Orthod Dentofacial Orthop 2006;129:829-33)

For many years, the exclusive province of dentofacial orthopedics was Europe, while North America was firmly rooted in Angle's fixed-appliance philosophy, yet it was Norman W. Kingsley who first (1879) used forward positioning of the mandible in orthodontic treatment. Kingsley's removable plate with molar clasps might be considered the prototype of functional appliances, having a continuous labial wire and a bite plane extending posteriorly. As he described it, "The object was not to protrude the lower teeth, but to change or jump the bite in the case of an excessively retreating lower jaw." Edward H. Angle used a pair of interlocking rings, soldered to opposing first molar bands, much along the lines of today's mandibular anterior repositioning appliance (Fig 1), to force the mandible forward. The Oliver guide plane was another functional adjunct from this side of the Atlantic serving that purpose (Chapter 5).

As a result of studies on a dolphin's tail fin, Wilhelm Roux is credited as the first to study the influences of natural forces and functional stimulation on form (1883) (Wolff's law, Chapter 4). His work became the foundation of both general orthopedic and functional dental orthopedic principles. Later, Karl Häupl saw the potential of Roux's hypothesis and explained how functional appliances work through the activity of the orofacial muscles.[1]

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Submitted and accepted, March 2006.
0889-5406/$32.00

doi:10.1016/j.ajodo.2006.03.019

The monobloc

The first practitioner to use functional jaw orthopedics to treat a malocclusion was Pierre Robin (1902). His appliance influenced muscular activity by changing the spatial relationship of the jaws. Robin's monoloc was actually an adaptation of Ottolengui's removable plate, which, in turn, had been a modification of Kingsley's maxillary plate. It extended all along the lingual surfaces of the mandibular teeth, but it had sharp lingual imprints of the crown surfaces of both maxillary and mandibular teeth. It incorporated an expansion screw in the palate to expand the dental arches.

Robin designed his monobloc specifically for children with the glossoptosis syndrome (ectomorphic constitution, adenoid facies, mouth breathing, high palate, and other problems). It has since been named the Pierre Robin syndrome. Treatment would obviously require a total body approach, to include psychological support, muscular and breathing exercises, and lip closure, with the monobloc indicated to stimulate the activity of the facial musculature and to normalize the occlusion.

Myofunctional therapy

Alfred P. Rogers (1873-1959; Angle School, 1903), sometimes called the father of myofunctional therapy, also recognized the importance of the whole orofacial system. In addition, he was a strong proponent of the total-child approach and advocated muscular exercises to improve neck, head, and tongue posture and encourage nose breathing. Rogers grew up on the shores of

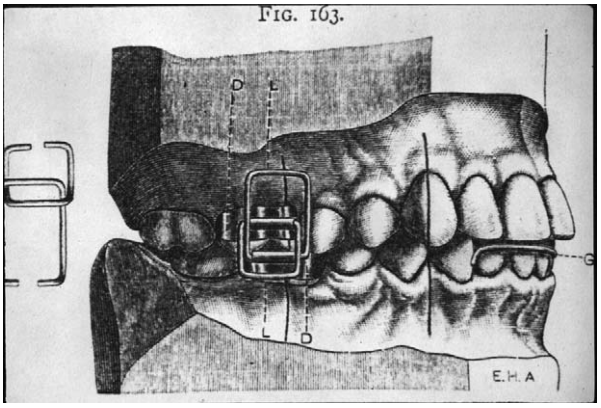

Fig 1. Angle's noncompliance, functional Class II corrector.

Fig 2. Viggo Andresen's activator was archetype of many of today's functional appliances.

Canada's Bay of Fundy and developed a lifelong interest in nature and conservationism. He was the first orthodontist in New England to limit his practice (1906). From 1918 to 1922, he directed the Harvard-Forsyth orthodontic program. Although most of his exercises have become obsolete, Rogers was the first to implicate the facial muscles for the growth, development, and form of the stomatognathic system.[2]

The activator

In 1909, Viggo Andresen (1870-1950) (Fig 2) removed his daughter's fixed appliances before she left for her summer vacation, as was customary at the time, and placed a Hawley-type maxillary retainer. On the mandibular teeth, he placed a lingual horseshoe flange that guided the mandible forward about 3 to 4 mm in occlusion. Andresen, a Danish dentist, did not start specializing in orthodontics until 1919. On his daughter's return, he was surprised to see that nighttime wearing of the appliances had eliminated her Class II malocclusion, and it was stable. Applying this technique to other patients resulted in significant sagittal corrections that he could not produce with conventional fixed appliances.[3,4]

The original Andresen activator was a tooth-borne, loosely fitting passive appliance consisting of a block of plastic covering the palate and the teeth of both arches, designed to advance the mandible several millimeters for Class II correction and open the bite 3 to 4 mm. The original design had facets incorporated into the body of the appliance to direct erupting posterior teeth mesially or distally, so, despite the simple design, dental relationships in all 3 planes of space could be changed.[5]

In designing an inert appliance that fitted loosely in the mouth and, because of its mobility, transferred muscular stimuli to the teeth, jaws, and supporting structures, Andresen had taken a decisive step in orthodontic treatment. Although he had effectively redesigned Robin's monobloc to correct Class II Division 1 malocclusions, he declared that he had no knowledge of Robin's work at the time.

Andresen's novel device was not initially well received. First, removable appliances were not much accepted at that time. Second, the profession was under the influence of Martin Schwarz, whose active plate was then a common form of removable—not functional—appliance. Finally, Andresen advocated extractions, although not necessarily in connection with activator treatment. And, in contrast to Angle's concept of ideal occlusion that was then prevalent, Andresen advocated a more realistic "individual and functional gnathological optimum." Thus he was subjected to the same type of ridicule that Tweed endured years later.[2]

In 1925, Andresen, then director of the orthodontic department at the University of Oslo, began developing for the government a simple method of treating Norwegian children. He modified his retainer into an orthodontic appliance, using a wax bite to register the mandible in an advanced position.

At the university, Karl Häupl (1893-1960) (Fig 3), an Austrian pathologist and periodontist, saw the possibilities of the appliance and became an enthusiastic advocate of what he and Andresen called the "Norwegian system." Häupl's theories were inadvertently strengthened by the findings of Oppenheim, who showed the potential tissue damage caused by the heavy orthodontic forces of fixed appliances. At that time, there was no mention of "growth stimulation."

Fig 3. Karl Häupl's advocacy of "Norwegian system" was main deterrent preventing Europeans' accepting fixed appliances.

Fig 4. Hans Bimler got his inspiration for *Gebissformer* as World War II army surgeon.

Activator use became so widespread among European practitioners that there was concern that proper diagnosis was being neglected. Unfortunately, reminiscent of Angle's following, "functional jaw orthopedics became a profession of faith, a religion, beside which no other opinion was tolerated."[6] Furthermore, Reitan, in his 1952 doctoral thesis, questioned Roux's hypothesis and demonstrated that no special histologic picture emerged from the use of functional appliances. His findings were supported by later researchers.

Andresen and Häupl later collaborated on a textbook (*Funktionskieferorthopädie*) about their system in 1936. The sixth edition included Leopold Petrik as coauthor. Although Häupl's complete rejection of fixed appliances led the profession astray for a time, had it not been for his promotional efforts, the activator might have languished in obscurity.

The advantages of the activator include: (1) treatment in the deciduous and early or late mixed dentition is possible and successful, (2) appointments can be spread out to 2 months or more, (3) tissues are not easily injured, (4) the appliance is worn at night only and is acceptable from an esthetic and hygienic standpoint, and (5) it helps eliminate pressure habits, mouth breathing, and tongue thrusting. Its disadvantages include: (1) success depends on patient compliance; (2) activators are of little value in marked crowding, so that patients must be selected; (3) the appliance does not obtain as good a response in older patients; and (4) forces on individual teeth cannot be controlled with the same degree of exactness as in fixed appliances.[7]

The Herbst appliance

The Herbst appliance (Dentaurum, Newtown, Pa) is suitable for slightly older children whose cooperation might not be dependable, because it is a fixed appliance worn 24 hours a day. The Herbst was introduced in 1905 by Emil Herbst (1842-1917), but his findings were not published until 1935. Little more was published on the appliance until the late 1970s, when Hans Pancherz, recognizing its possibilities for mandibular growth stimulation, revived interest. The typical Herbst consists of a telescoping mechanism connected to the maxillary first molars at 1 end and a cantilevered arm attached to the mandibular fist molars at the other end; it forces the mandible forward.

The Bimler appliance

Just as Andresen's discovery of the activator was an accidental outgrowth of his retainer, so was Hans Peter Bimler's (1916-2003) (Fig 4) *elastischer Gebissformer* (elastic bite former) a fortuitous development. As a surgeon treating jaw injuries during World War II, Bimler had devised a maxillary splint for a patient who had lost his left gonial angle. The splint provided a guide into which the patient could insert the remainder of his mandible. In so doing, however, the pull of scar tissue led to a slight widening of the maxillary arch. Bimler reasoned that it might be possible to expand the arch by means of crosswise mandibular movements, and the Bimler appliance was born. Bimler also developed, about 1938, the "roentgenphotogramm," by superimposing a photograph on a head plate, to show the

Fig 5. A. Martin Schwarz was one of first to separate activator horizontally, harbinger of today's Twin-block.

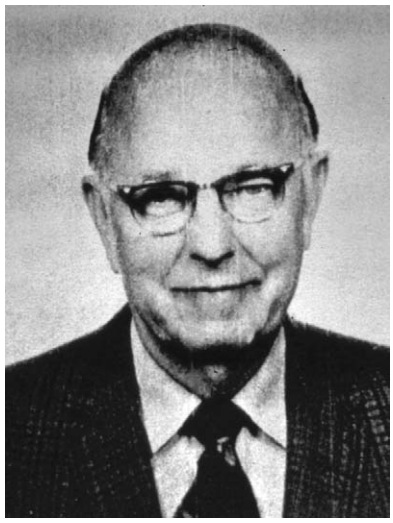

Fig 6. Harold D. Kesling, inventor of tooth positioner.

relationship between the skull, the teeth, and the soft tissues—something done today by computer.[8]

World War II brought European orthodontic progress almost to a standstill. Nevertheless, functional appliances got a boost because precious metals were no longer available for fixed appliances. In Germany, dentists were ordered to specialize in functional jaw orthopedics.[9] Still, the war brought its own brand of progress.

After several modifications, the Bimler appliance achieved its final form in 1949. Compared with previous functional appliances, its reduced size made it possible to wear all day, its elasticity allowed muscular movements to translate more effectively to the dentition, and, because the upper and lower parts were connected by a wire, gradual forward positioning of the mandible became possible. Also like Andresen, Bimler was attacked by the functional establishment, in particular Häupl, for his new ideas, but every functional appliance subsequently developed has incorporated at least 1 of his innovations.

The double plate

A. Martin Schwarz (1887-1963) (Fig 5) began his career as an ear, nose, and throat physician but was diverted into dentistry by famed histologist Bernhard Gottlieb. He became director of Kieferorthopaedia, Vienna Polyclinic, and the jaw orthopedics division of the Viennese government in 1939, where he expanded orthodontic service from 100 to more than 3000 patients. In 1956, Schwarz attempted to combine the advantages of the activator and the active plate by constructing separate mandibular and maxillary acrylic plates that were designed to occlude with the mandible in a protrusive position. The double plate resembled a monobloc or an activator constructed in 2 pieces.[5]

The function regulator

Rolf Fränkel (1908-2001) must be recognized as the inventor of an appliance that corrects malocclusions with little or no contact with the dentition. He studied in Leipzig and Marburg, Germany, receiving his Dr Med Dent in 1931 but was treating patients in his office at Zwickau with Angle's E-arch as early as 1928. In World War II, he was a military surgeon involved with jaw and facial injuries. After the war, he returned to Zwickau, only to find himself sealed off by the East German regime from mainstream orthodontics.

Recognizing that stability of treatment can occur only if the structural and functional deviations of the muscular system are corrected,[10] Fränkel designed the function regulator (FR, 1957), making the oral vestibule the operational basis for his treatment. The appliance was designated as FR-1, FR-2, and FR-3, for treating Class I, Class II, and Class III malocclusions. The appliance achieved rapid acceptance in dental orthopedics. Even so, its fabrication is complex, and few laboratories understand the critical details of its construction. The FR was welcomed by American dentists, and especially pedodontists, as a solution to their "unbusyness" brought about by the fluoridation of water.

The tooth positioner

In 1944, Harold D. Kesling (1901-79) (Fig 6) developed the tooth positioner. The technique involved

taking impressions of a patient nearing completion, denuding the plaster of appliances, and resetting the teeth into ideal positions (the "diagnostic setup"). From the new models, a rubber positioner was made that, if worn enough hours, acted as a finishing appliance.[11] It could also be used as a retainer or a recovery appliance. Later versions were made of other materials, including clear plastic. Out of these innovations developed T(ooth) P(ositioner) Orthodontics (LaPorte, Ind), which now markets them as Pre-Finishers.[12]

The Nuk Sauger

In the late 1940s, Adolph Mueller, a West German orthodontist, took early treatment to its ultimate when he designed a pacifier to promote development of babies' jaws and facial muscles With a bottle nipple duplicating the shape and texture of a mother's nipple, this pacifier would better satisfy an infant's natural sucking desire. It could also preclude development of the tongue thrust that was believed to result from a baby's attempt to block the copious flow of milk from conventional nipples. Originally marketed by Rocky Mountain Orthodontics (Denver, Colo), the Nuk Sauger (German for *suckler*) is now sold by Gerber (Fremont, Mich).[13]

The bionator and other functional appliances of the early 1950s

In 1950, Wilhelm Balters (1893-1973), in an effort to treat Class II malocclusions characterized by deficient mandibles, began to modify Andresen's activator. He gave it the name *bionator.* It is indicated for patients with favorable facial growth patterns and is designed to produce forward positioning of the mandible. As with the function regulator, the bionator is available in 3 designs. Consisting of 2 halves connected by a Coffin spring, it is less restrictive of speech than Andresen's appliance. However, the treatment also highly depends on patient compliance, especially with regard to exercising.[14]

In 1952, Hans Mühlemann created the propulsor. It was based on the activator, but it lacked the metal elements. The propulsor was later perfected by Hotz. About a year later, Leopold Petrik (1902-65) introduced an activator having greater occlusal thickness to increase the vertical dimension, and Hugo Stockfisch (1914-) came out with his kinetor. This device consisted of 2 movable plates connected by wire buccinator loops, which keep muscle pressure away from the cheeks. An unusual feature of the kinetor was the elastic tubes between the 2 plates that acted not only as shock absorbers but also as a means of broadening and optimizing orofacial muscle pressures.[15]

Classification by type

Functional appliances can be fixed (eg, Herbst, Jasper Jumper [American Orthodontics, Sheboygan, Wisc]) or removable (most). Proffit and Fields suggested a further classification, based on the appliance's platform. The largest category, passive tooth-borne appliances, includes monobloc, activator, bionator, Bimler, and Twin-block. Active tooth-borne appliances comprise tooth positioners (includes Pre-Finishers, the Ortho-Tain family [Ortho-Tain Inc, Toa Alta, Puerto Rico], and Mini-Positioners [Unitek, Monrovia, Calif]). Tissue-borne appliances are the oral screen, the Nuk Sauger pacifier, and the FR.[5] The oral, or vestibular, screen is a C-shaped plastic appliance that fits loosely in the anterior vestibule. If worn conscientiously, it is an excellent deterrent for tongue thrust and finger sucking.[16]

In later issues, we shall examine more recent appliances and see how the term "cross-fertilization" of the 1960s came to be applied to the exchange of philosophies across the Atlantic.

The author thanks Dr Lysle E. Johnston for his review of the manuscript.

REFERENCES

1. Dentofacial orthopedics with functional appliances. In: Graber TM, Rakosi T, Petrovic AG, editors. Principles of functional appliances. St Louis: Mosby; 1985.
2. Concepts of functional jaw orthopedics. In: Graber TM, Neumann B, editors. Removable orthodontic appliances. 2nd ed. Philadelphia: Saunders; 1984. p. 87.
3. Moorrees CFA. Orthodontics and dentofacial orthopedics: past, present and future. Part 2. Kieferorthop 1998;12:127-40.
4. Rakosi TR, Graber TM, Petrovic AG. Dentofacial orthopedics with functional appliances. St Louis: Mosby; 1985.
5. Proffit WR, Fields HW, editors. Contemporary orthodontics. 3rd ed. St Louis: Mosby; 2000.
6. Hotz RP. The changing pattern of European orthodontics. Br J Orthod 1973;1:4-8.
7. Salzmann JA, editor. Practice of orthodontics. Philadelphia: Lippincott; 1966.
8. Bimler B. Hans Peter Bimler at age 85. Int J Orthod 2002;13:19-20.
9. Schmuth GPF. Milestones in the development and practical application of functional appliances. Am J Orthod 1983;84:48-53.
10. McNamara JA Jr. Rolf Fränkel, 1908-2001 (in memoriam). Am J Orthod Dentofacial Orthop 2002;121:238-9.
11. Harold D. Kesling (1901-79) (in memoriam). Am J Orthod 1980;77:574-5.
12. Kesling HD. The philosophy of the tooth positioning appliance. Am J Orthod Oral Surg 1945;31:297-304.
13. Gerber Medical Marketing. Via e-mail. June 20, 2005.
14. Melo ACM, dos Santos Pinto A, da Rosa Martins JC, Martins LP, Sakima MT. Orthopedic and orthodontic components of Class II Division 1 malocclusion correction with Balters bionator. World J Orthod 2003;4:237-42.
15. Levrini A, Favero L. The masters of functional orthodontics. Milan, Italy: Quintessenz Verlag; 2003.
16. Graber TM. Orthodontics: principals and practice. 3rd ed. Philadelphia: Saunders; 1972. p. 699.