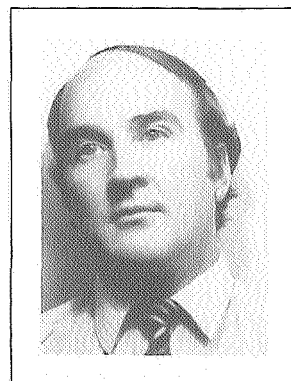


Functional appliances: Which one, When?

Part 1 – Rationale for selection

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Abstract:

One current question is whether functional appliance therapy is capable of producing clinically significant changes in the human dento-facial complex under realistic treatment conditions. Another question is whether the different designs of functional appliances have differing modes of action, and, if so, how does the clinician select the one most appropriate for the requirements of the case in hand, and when?

Current knowledge of the responses elicited by functional appliances is reviewed.

Descriptions of the "ideal" patient for each appliance is given, along with indications and contraindications. Specific associations are emphasized, such as vertical control and Teuscher, decrowding and Fränkels, Herbst and breakage prevention, retention and Bionators. Case reports are also presented to help the selection process.

Key words : functional appliances, selection, timing, activator, Teuscher, Fränkel, Herbst, Bionators

INTRODUCTION

The original objective of orthodontic treatment was to recreate normal dental occlusion. In contemporary orthodontic therapy this remains a fundamental goal, but decades of clinical research has increased rather than decreased the complexity of the problem. The three primary correlates of human dental occlusion are :

1. Dentitional development
2. Craniofacial growth
3. Neuromuscular maturation and function.

These three factors, while constantly interrelated in function nevertheless develop on different time schedules. The development of occlusion is therefore one of the most fascinating and complicated problems in all of developmental biology, presenting the orthodontist with an enormous challenge.

When clinicians focused their attention on only the first of these factors, appliance systems evolved which rendered symptomatic treatment for developmental deviations and irregularities in the oro-facial complex. In order to move teeth, the physical forces generated by orthodontic appliances were distributed to the teeth and this initiated remodelling of the dento-alveolar structures.

Extra-oral forces were added to these intraoral appliances, originally to supplement anchorage, but subsequently it was found that there was a modification of the normal growth behaviour of the maxilla. (Poulton 1967, Weislander 1974)

For a considerable period, this was regarded as the only orthopaedic possibility in orthodontic treatment.

The size and position of the mandible were generally agreed to be immutable, and discrepancies in maxillo-mandibular relationships in Class II cases were routinely treated by modifying the forward growth of the maxillary teeth and/or the maxilla. This application is appropriate for patients with prognathic maxillae, but is quite unsuited to patients with normal maxillae in combination with deficient mandibles. Moyers (1980) found that the incidence of this latter group within the Class II population is approximately 70%, a much higher figure than was formerly recognized. McNamara (1981) confirmed this finding. Within his group of 277 Class II children, only 27% had prognathic maxillae while 50% had retruded maxillae. Sixty percent of the group were found to have retruded mandibles.

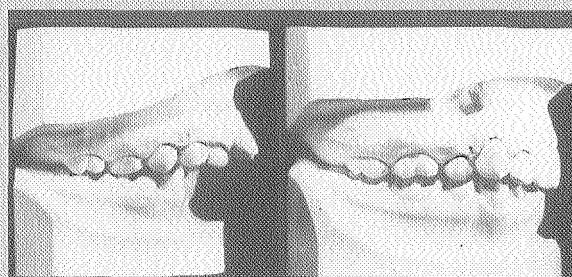
These findings highlighted the limitations of conventional orthodontic systems, and led orthodontists to re-examine the potential of functional appliance therapy. The feature of functional therapy which sets it apart from other orthodontic philosophies is that a

deliberate primary impact is delivered to the musculature with the intention of creating an improved local environment for the developing dental arches and growing jaw bones. The neuromuscular activity generated by functional appliances is tapped to alter stress on the teeth and jaws. This represents a comprehensive approach to orthodontic treatment because the three major developmental processes are subjected to some degree of control.

Many experimental studies have identified the close interaction between muscle function and the internal and external structure of bone. (Woodside et al 1983) One of their conclusions was that "chronic or continuous alteration in mandibular position within the neuromuscular environment produces extensive condylar remodelling and change in mandibular size".

The controversy which prevails is not whether

Figure 1. Changes produced in a nine year old girl by night-time wear of a single activator appliance



(a) Study models before treatment

(b) Study models at termination of activator wear



(c) Facial photograph before treatment



(d) Facial photograph after treatment

alteration in muscle function produces changes in bone morphology, but rather whether functional appliance therapy is able to produce clinically significant changes in the human dento-facial complex under realistic treatment conditions. Another question arises as to whether the different designs of functional appliance have differing modes of action, and, if so, how does the clinician select the one most appropriate for the requirements of the case at hand.

These questions will be addressed in a discussion on treatment experiences with three types of functional appliance:

1. Activator appliances
2. Fränkel appliances
3. Herbst appliance.
4. Bionator appliance

The first two and last are removable, while the Herbst appliance is fixed but they all have the effect of changing the position of the mandible within a muscle system.

It should be stated clearly that functional appliance therapy does not stand in opposition to conventional multi-band fixed appliance therapy. Rather, the two systems frequently combine to fulfill treatment objectives otherwise unattainable. However, for the sake of clarity, cases illustrated in this article have been selected because they show responses to functional appliances only, and there has been no contribution from fixed appliances to the stage shown. Subsequently of course some cases underwent final detailing with fixed appliances.

ACTIVATORS

These appliances were so named because they were felt to activate the muscles, which in turn, activated the appliance.

There has been a resurgence of interest in the activator in the last decade or two, encouraged by the attainment of favourable occlusal and facial changes (Figure 1).

Andresen's original design of 1908 is still in common use although subsequent innovations have attempted to either reduce the bulk of the appliance to enable longer wearing times, or to supply elastic elements which reinforce or extend the range of muscular impulses. The application of directionally controlled extra-oral force adds an element of sophistication in terms of management of the maxilla and, in vertically growing cases, this has a favourable impact on the development of the mandible, as will be discussed later.

Mode of Action

The mode of action of the activator appliances is controversial, but some of the proposed mechanisms of action are summarized below;

1. Re-education of the musculature.

Andresen hypothesized that by continually holding the mandible forward in Class II cases the muscles would be obliged to learn a new functional pattern. Gradually the teeth and jaws would adapt to the new jaw relationship prescribed by the appliance.

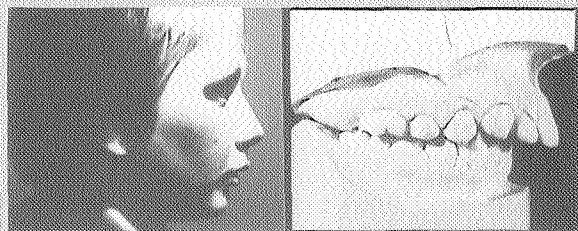
2. Lateral pterygoid muscle stimulation.

Obligatory mandibular protrusion has been found, in experimental animals, to be associated with increased electromyographic activity in the superior head of the lateral pterygoid muscle. Coordination of electromyographic readings with measurements of condylar growth reveals a close relationship, indicating that skeletal adaptation proceeds until muscle activity is restored to normal levels. (McNamara et al, 1975).

3. Decreased biochemical feedback.

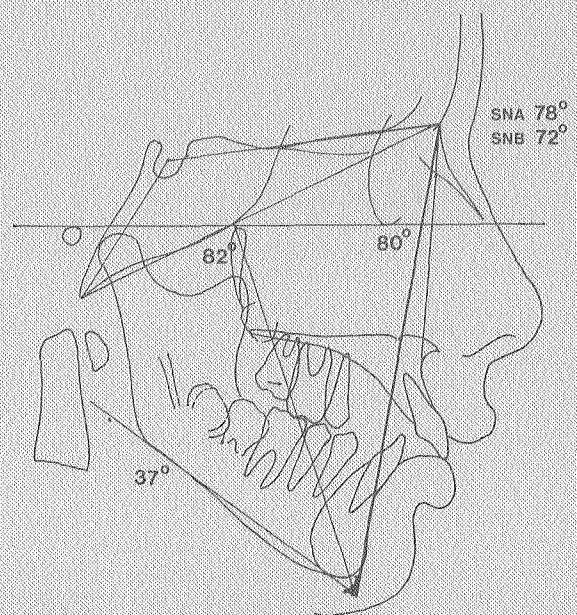
Stutzmann and Petrovic (1979) found that the zone of functional chondroblasts in the rat condyle normally secretes a substance which retards mitotic activity of the stem cells. When the lateral pterygoid is activated by an appliance, the functional chondroblasts mature more quickly, consequently secreting less "negative feedback" substance. By removal of this biochemical "brake", acceleration of condylar growth is permitted.

Figure 2. Case 1: Activator treatment for a twelve year old boy

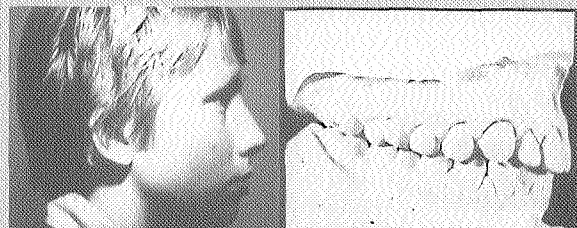


(a) Facial profile before treatment

(b) Study models showing Class II division I malocclusion before treatment

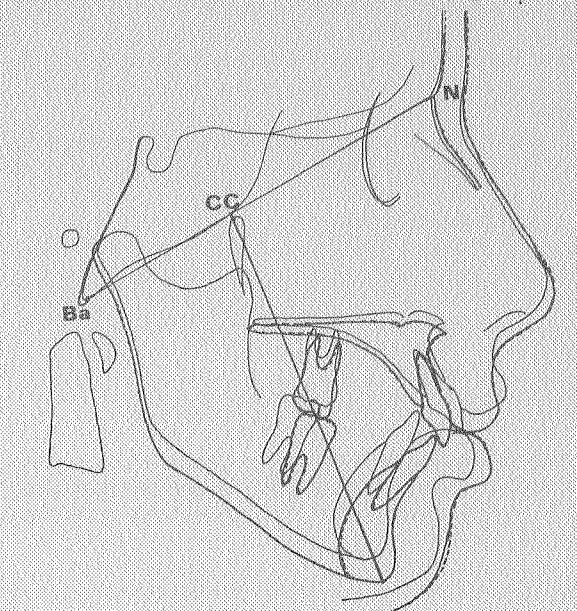


(c) Pre-treatment cephalometric tracing



(d) Facial profile at termination of activator wear

(e) Study models depicting the sagittal change in dental arch relationship



(f) Superimposition of pre- and post-treatment cephalograms

4. Unloading of the mandibular condyle.

The mandibular condyle is normally subjected to pressure which is one component of the local homeostatic mechanism controlling its growth. When an appliance is used which distracts the condyle from the fossa this pressure restraint is removed, thereby facilitating an increased rate of growth.

5. Transduction of visco-elastic force.

Some authorities are skeptical of the efficacy of the muscle generated forces created by increased biting and swallowing when an activator is in place. Instead, they harness the passive tension arising from the inherent elasticity in muscle, skin and tendinous tissues and transmit this to the maxillary teeth engaged in the appliance. Accordingly, extreme vertical registrations are frequently employed. (Woodside, 1977)

6. Differential Eruption.

Harvold (1974) has shown that the divergent directions of eruption of the maxillary and mandibular molars can be altered by the appliance to create the molar relationship desired. For example, in Class II treatment, the acrylic platform can be adapted to arrest maxillary molar eruption, yet allow concomitant mandibular molar eruption into Class I relationship. In Class III activator treatment, the converse would be applied.

Clinical Studies

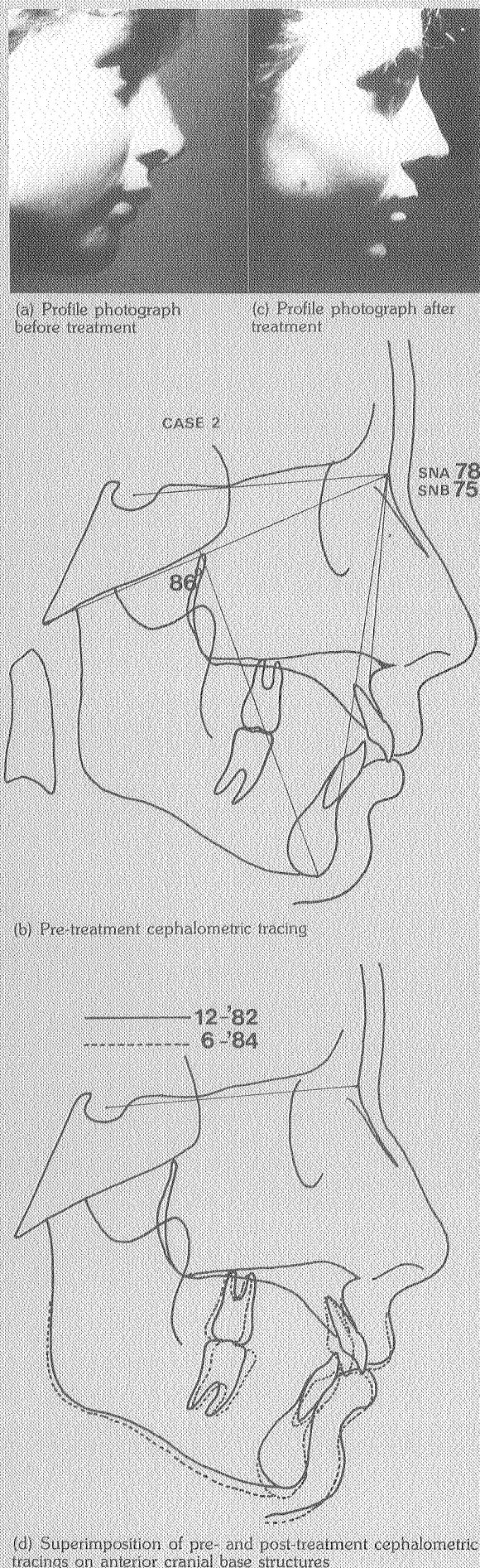
There are a number of reports concerning the effects of the activator on the growing human dento-facial complex.

Marschner and Harris (1966) published results which suggested that activator therapy permitted a more rapid rate of mandibular growth in the treated sample. Meach (1966) found a significant increase in the facial angle in his activator group. Freunthaller (1967) claimed that activator treatment produces an increase in mandibular growth as evidenced by a greater opening of the angle between the palatal plane and the facial plane. Demisch (1972) reported that the forward movement of the upper arch is stopped or reversed by the activator therapy, while half of his cases showed an increase in the growth rate of the mandible. Hausser (1973) found an increase of the Basion to Pogonion distance in activator patients. He concluded that the activator "can exercise a lasting influence on the sagittal development of the lower jaw when it is used early enough in the treatment of Class II malocclusion" and that the results of treatment "arise mainly from mandibular transformation."

Luder (1981) appears to have been the first to report a sex difference in the response to activator treatment. This may explain the variable results from mixed studies. Boys showed increased condylar growth expressed in a modified direction, with no posterior rotation. Girls experienced a change in the direction of condylar growth, with no change in the amount of growth.

Baumrind et al (1981) contrasted the treatment effects of cervical and high-pull headgears with those of the activator. They found that the condyle to pogonion distance increases relative to the Sella-nasion distance at a more rapid rate in the activator group. A conclusion put forward was that "these findings argue strongly that the activator does, in fact, produce biological activity in the region of the condyle." In a later study (Baumrind et al, 1983 a) they found that of the total displacement of the maxillary molar, half of the change was orthodontic and half was orthopaedic. Restraint of the normal displacement of the anterior nasal spine was also reported. In their most recent study (Baumrind et al 1983b) these workers reported specifically on the movement of the chin point in response to the three forms of therapy. When the effects of normal growth were subtracted to leave treatment effects only, it was revealed that the largest displacement of pogonion actually occurred in the cervical headgear group. However the direction of displacement was primarily vertical, in contrast to the

Figure 3. Case 2: Activator treatment initiated after period of maximal facial growth in a 14 year old girl



activator group where the growth was expressed in a more horizontal direction.

Van Beek (1982) used Harvold's parameters of facial growth to express his findings. The difference between the effective mandibular length and the effective maxillary length increases at a normal rate of 1mm per year. In Van Beek's activator patients, this distance increased at a rate of 3mm per year. Birkebaek (1984) recently measured remodelling changes in the fossa as well as those involving the condyle. She found that the activator cases experienced an increase in the amount of condylar growth and an anterior remodelling of the fossa.

In summary, *the reported anteroposterior effects of the activator are:*

1. A forward displacement of the lower arch
2. A distal movement of the maxillary arch
3. An inhibition of the forward growth of the maxilla
4. A stimulation of condylar growth
5. A remodelling of the mandibular fossa
6. An elimination of interferences which guide the mandible distally during closure.

The vertical effects of activator treatment have been studied by Andersson and Ahlgren (1977). Successful overbite reduction was found to be accompanied by:

1. Inhibition of lower incisor eruption.
2. Facilitation of molar eruption.
3. Encouragement of forward mandibular rotation.
4. An increase in lower face height.

CASE REPORTS

Case 1 (Figure 2(a)) was a twelve year old boy when he presented with a full unit Class II malocclusion *Figure 2(b)*. Analysis of the cephalogram, *Figure 2(c)*, suggested that forward movement of the mandible, together with upward rotation would be a much more appropriate treatment than retraction of the maxilla to the existing mandibular position. Hence functional appliance therapy was prescribed rather than extra-oral traction to the maxillary teeth. Since the permanent dentition was established, an activator was selected rather than a Frankel appliance.

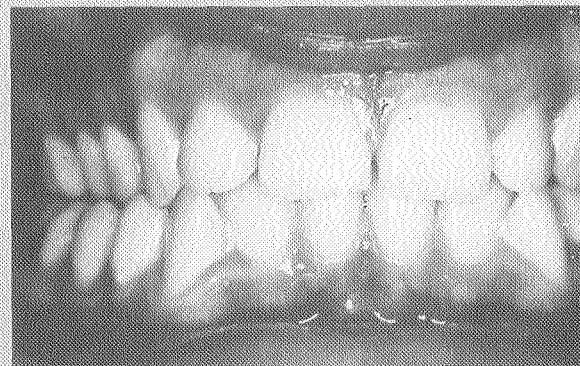
After 15 months of night timewear, the changes produced are shown in *Figure 2 (d),(e) and (f)*. Favourable dental and facial changes have been produced. Serial superimposition of the pre- and post-treatment cephalograms shows that there has been 6 mm of condylar growth, which has been expressed along the facial axis. Superimposition on Ba-N registered at N shows that the maxilla has been displaced downwards and backwards. In retrospect, this unwanted change could have been negated by the use of Teuscher's (1978) appliance design, and this would have allowed the mandibular development to be expressed in a more anterior direction.

It should be emphasized that functional appliance treatment, when indicated, should be instituted during the growing period. The following case is presented to illustrate the limited response available in non-growing patients.

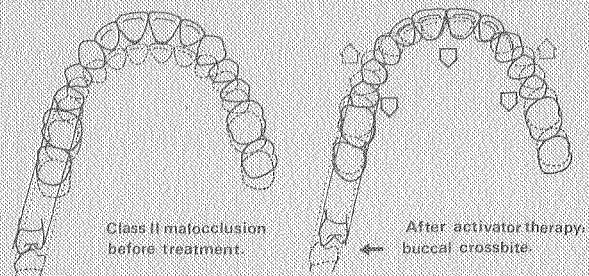
Case 2 (Figure 3(a)) presented at age 14, requesting a reduction in her overjet, but specifying that fixed appliance therapy in any form was excluded from the option list! An activator appliance was constructed. The changes after eighteen months of appliance wear are shown. Cephalometric measurements fail to show any change in the antero-posterior positions of the mandible and maxilla, although there has been a slight posterior rotation of the mandible. The occlusal correction is due entirely to dento-alveolar change, and the long term stability is uncertain.

One feature of the activator response which deserves mention is shown in *Figure 4*. Favourable antero-posterior corrections are sometimes accompanied by the development of posterior crossbites, due to the

Figure 4. Crossbite development



(a) Development of a posterior crossbite during activator treatment



(b) Diagram illustrating the mechanism of cross-bite development during activator therapy. This problem may be circumvented by (i) favourable intercuspation, (ii) pre-treatment maxillary arch expansion or (iii) the incorporation of a midpalatal screw in the appliance

geometry involved in relocating an unexpanded maxillary arch in relation to an unchanged mandibular arch. Although this is an unwanted effect, (and specific steps may be required to overcome it), it can be used to advantage in scissor bite cases (*Figure 5*).

Profile of an "Ideal" Activator Patient

The "profile" of a patient for whom Andresen-type activator therapy would meet currently accepted treatment objectives would include the following features:

1. Skeletal features:

- (a) There should be significant amounts of facial growth remaining.
- (b) The maxilla may exhibit mild prognathism but must not show any features of vertical maxillary excess.
- (c) The mandible should show mild to moderate skeletal retrusion.
- (d) The vertical facial proportions should err on the side of decreased lower face height.
- (e) The facial axis should be equal to, or greater than, 90 degrees.

2. Dental features:

- (a) The dental arches should be free of crowding and individual tooth irregularities such as rotation and poor axial inclination.
- (b) A deep incisor overbite is preferable to an open-bite tendency.
- (c) The mandibular dental arch should be retruded on the basal bone and preferably should show spacing rather than crowding.
- (d) The maxillary incisors should be slightly proclined.
- (e) A slight scissor bite tendency is favourable.

3. Social-behavioural features:

As with other systems of orthodontic treatment, a well adjusted, motivated and cooperative patient will be more likely to enjoy a successful resolution of their problem.

Indications

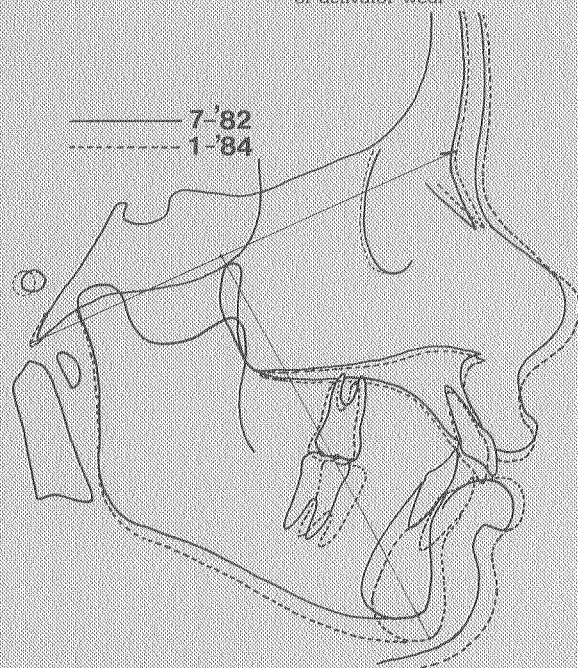
In addition to patients fulfilling the preceding requirements, a number of specific morphological groups should be considered for activator therapy.

Figure 5. Case 3: "Incidental" correction of a bilateral scissor bite during treatment with an activator



(a) Study models showing bilateral scissor bite before treatment

(c) Intra-oral photograph showing correction of scissor bite at termination of activator wear



(b) Superimposition of pre- and post-treatment cephalometric tracings

1. Dento-alveolar Class II malocclusions. The activator is employed as a form of Class II intermaxillary traction to initiate dento-alveolar remodelling.

2. Moderate skeletal dysplasias between the midfacial area and the mandible, where moderate amounts of maxillary incisor retraction and moderate amounts of mandibular growth would combine to yield a successful result.

3. Class II malocclusions resulting from environmental influences such as thumb sucking and chronic mouth breathing, providing some growth still remains and the oral habit can be eliminated.

4. Non-extraction deep overbite cases in which it is desirable or permissible to exert a forward pull on the lower dental arch. Many Class II division II cases belong in this category.

5. Class II cases complaining of temporomandibular joint pain and dysfunction associated with posterior displacement of the condyles.

Contraindications

The Andresen-type activator is contraindicated in the following situations:

1. Non-growing patients.
2. Vertical growth patterns.
3. Intractable mouth breathing or digit sucking.
4. Poor cooperation.
5. Cross bite tendency.
6. Gross intra-arch irregularities and rotations.
7. Marked spacing of the upper incisors. Activators are not capable of parallel space closure.
8. Retroclined upper incisors.
9. Activators, along with other functional

appliances, should not be used by clinicians who will not use cephalometric analyses to assist in establishing the nature of the facial morphology to be treated.

Limited orthopaedic effect

The limited orthopaedic effect reported by several investigators of activator therapy (Ahlgren 1976, Pancherz, 1984, Weislander, 1979) may be the result of several factors:

1. *The bulk of the appliance renders full-time wear difficult*, and with night-time wear only, the threshold for adaptive remodelling at the condyles may not be reached in all cases. Apart from a reduction in the time of application of the stimulus, there is reduced protractor muscle activity during sleep (Witt, 1973) and there may also be reduced mitotic activity in condylar prechondroblasts. (Petrovic, 1975). The increasing clinical use of minimal bulk activators, such as the Bionator, which can be worn on a full-time basis, may furnish evidence of a truly orthopaedic effect.

2. Since the *activator is tooth-borne, in contrast to the Functional Regulator*, tooth movement may lead to occlusal correction before the desired skeletal changes have been achieved. Continued pursuit of the skeletal goals would produce a Class III dental malocclusion.

3. Inappropriate case selection or improper appliance manipulation can lead to a posterior rotation of the mandible. This leads us to a discussion of Teuscher's approach.

Management of Class II problems with increased vertical height

The untoward vertical effects of activator treatment can be eliminated or even reversed by the incorporation of directionally controlled extra-oral force, as described by Teuscher (1978). Teuscher points out that normal occlusal development depends on harmonious coordination between:

1. Condylar growth
2. Posterior displacement of the mandibular fossa
3. Downward and forward displacement of the nasomaxillary complex
4. Vertical development of the maxillary and mandibular dento-alveolar structures.

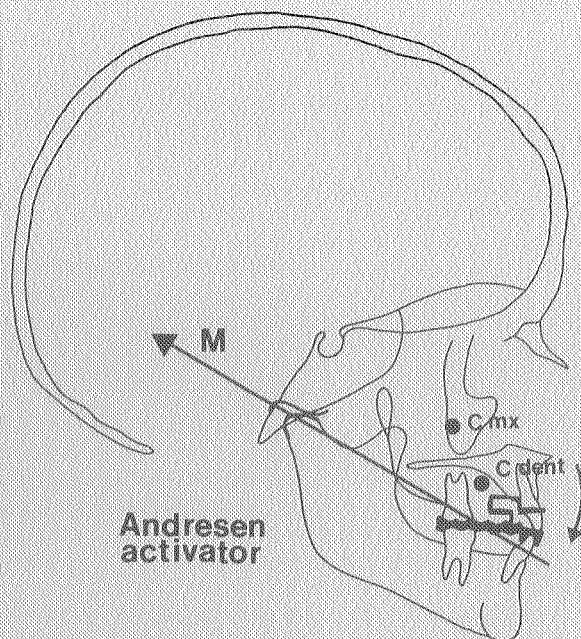
From the geometric aspect this balance is very sensitive, since minor variations in the degree of development and movement of these separate units would lead to full intermaxillary dis-coordination. Teuscher demonstrated that a number of orthodontic force systems deliver undesirable vectors to the naso-maxillary complex. In the case of the activator alone, the force vector from the musculature passes below both the centre of resistance of the maxillary dentition and also that of the maxilla, tending to produce a posterior maxillary rotation similar to that seen in the patient in Figure 2. Unless a patient experiences exceptional condylar growth, the mandibular development is deflected into a downward and backward direction, detracting from the profile change expected in Class II correction. However, the Teuscher activator (Figure 6) through the medium of extra-oral force attachment, allows the clinician to control the vector of force so that it passes between the centres of resistance of the maxillary dentition and the maxilla. A positive control of sagittal maxillary development is thus obtained, ensuring that the mandibular response will be expressed horizontally rather than vertically.

THE FRANKEL APPLIANCES

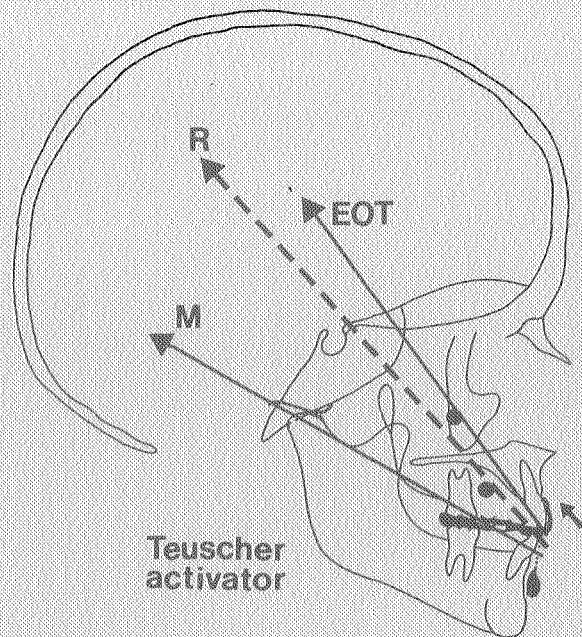
A new orthodontic philosophy and system of removable appliance therapy was developed in East Germany in the late 1950's by Professor Rolf Fränkel.

Although there are four fundamental designs of the Fränkel appliance, they are often grouped together for description as the Function Regulator or FR. The FR is not just another appliance suitable for indiscriminate or routine use, but an exercising device demanding thorough

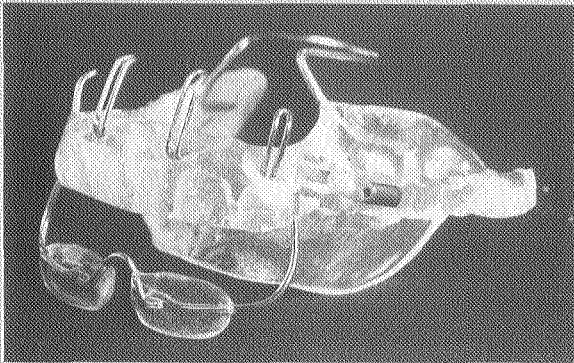
Figure 6. Teuscher Activator Therapy



(a) Diagram showing the force vector (M) arising from muscular reaction against a conventional activator



(e) Diagram showing the force vectors arising from muscular reaction (M) and extra-oral traction (EOT), and the resultant (R) acting during Teuscher activator therapy



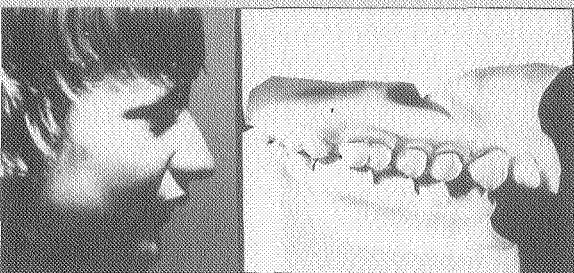
(b) The Teuscher appliance



(f) Extra-oral force assembly

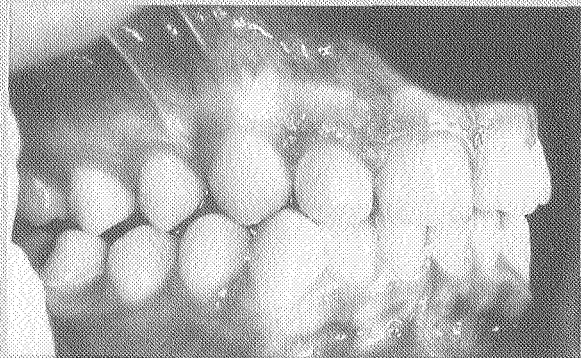


(g) Facial profile at termination of Teuscher appliance



(c) Facial profile of a 12 year old boy before Teuscher activator therapy

(d) Study models of the Class II division I malocclusion before treatment



(h) Intra-oral photograph of occlusion prior to fixed appliance phase

grounding in orofacial physiology, growth and development, as well as orthodontic diagnosis. Moorrees (1984) rightly states; "The FR is not an appliance in the conventional sense, and it requires a reschooling of orthodontic thinking if one is to understand its indication, potential handling, and construction as a physiotherapeutic device during daytime function."

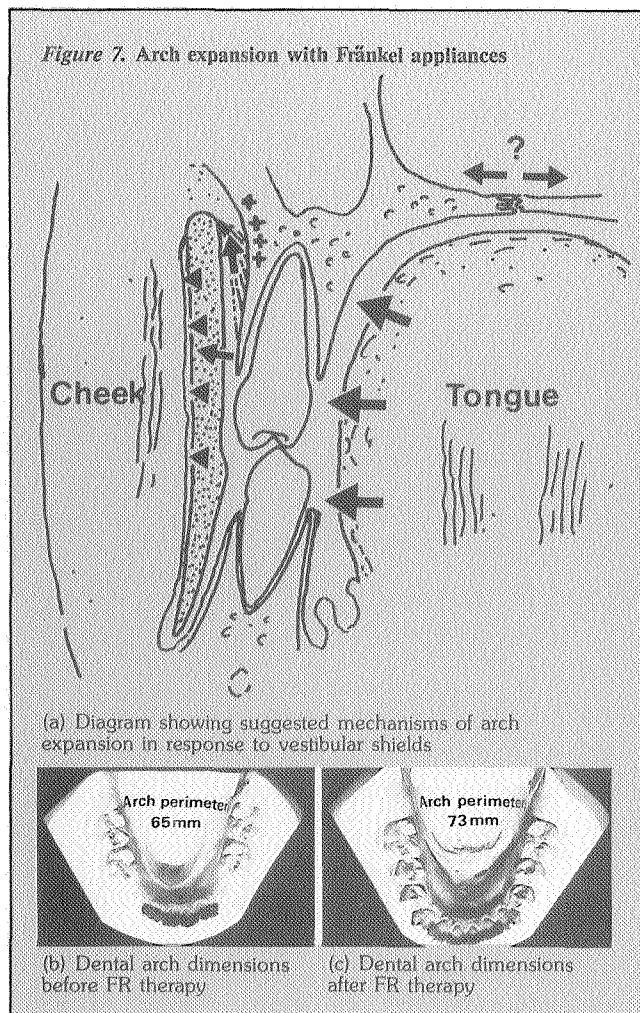
Rationale

Fränkel's approach is based on the importance of the form-function relationship in craniofacial morphogenesis. In general orthopaedics it has been claimed that of all of the functional factors which play a part in the aetiology of skeletal deformities, aberrant postural performance is the most important. Recent experimental evidence supports

the view that this applies also to the craniofacial region. Harvold (1968), Harvold et al (1973), and Tomer and Harvold (1982) have shown that experimentally induced alterations in the postural activity of the muscles suspending the mandible result eventually in measurable changes in mandibular shape and position. In Fränkel's view, the main aim of functional therapy is to identify a faulty postural performance of the orofacial musculature and to correct it by orthopaedic exercises. The essential problem for him was to design and construct an "exercise device" that would interfere directly with the functional environment and result in the correction of the poor postural behaviour.

Faulty muscle posture is seen as having an adverse environmental effect on:

Figure 7. Arch expansion with Fränkel appliances



1. The spatial relationships of the maxilla and/or the mandible, that is, the sagittal, vertical and transverse basal arch relationships.

2. The development in space of the dento-alveolar structures.

Fränkel applies the functional matrix concept and terminology of Moss (1970) to explain the basis of design of his appliances. When faulty muscle posture is deemed to have compromised the spatial relationships of the maxilla and mandible in a growing child, the appliance is designed to alter the biomechanical conditions in the *periosteal functional matrices* of these bones.

(a) In the case of a deficient mandible the cause is considered to be a postural imbalance between the retractor and protractor muscles. The FR1 and FR2 appliances are constructed so that the patient is obliged to posture the mandible forward in order to achieve a comfortable jaw position. In this way the periosteal tissues related to the mandibular condyle are subjected to a biomechanical stimulus which favours an increased rate of bone deposition until a position of stability is reached, with the mandible relocated in a more anterior position. (b) In the case of a deficient maxilla, the FR3 appliance is constructed so that periosteal tension is produced at the superior sulci. The vestibular shields and upper lip pads counteract the restricting effect of aberrant posture within the labial muscle groups and normal maxillary growth is restored.

(c) In skeletal open bite development, clinical relevance is placed on the poor postural performance of the muscles forming the external soft tissue capsule and of those suspending the mandible. Accordingly, therapy with the FR4 is directed at restoring a competent anterior oral seal and establishing a more superior postural position of the tongue and of the mandible. Subsequent skeletal and

dento-alveolar remodelling mediated via the periosteal matrices will favour acceptable vertical, dental and facial relationships.

The second of Moss's concepts concerns the *capsular functional matrix*. Fränkel sees the muscular portions of the walls of the oral and nasopharyngeal spaces as forming a capsular matrix, the volume of which has an important morphogenetic influence on the development of the dentoalveolar structures.

Specifically, he claims that an aberrant postural pattern of the external muscular environment may unfavourably influence the eruptive path and restrain the normal physiologic process of decrowding and uprighting of the teeth during eruption. By means of the vestibular shields of the functional regulators, the erupting dentition is protected from the adverse forces generated by the existing perioral musculature, allowing for spontaneous decrowding of the teeth.

Decrowding during eruption

Decrowding is a feature of all of the Fränkel appliances and therefore will be discussed first, before proceeding to an outline of the individual features of the four types of appliance. The distinguishing characteristic of the Fränkel appliances is the use of the oral vestibule as the operational base. Acrylic vestibular shields are located bilaterally in the buccal vestibule and anteriorly in the labial vestibule. This is in contrast to the acrylic palatal or lingual baseplates employed in conventional activators and one arch removable appliances. The oral vestibule is seen as the interface between the facial capsule and the developing dento-alveolar structures and its use is felt to offer an opportunity for an interceptive treatment program.

There are *several possible modes of action of the vestibular shields*:

1. The vestibular shields eliminate perioral soft tissue pressure which arises from:

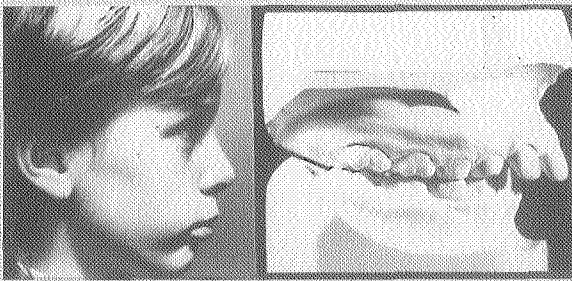
(a) muscular forces associated with aberrant postural patterns in the orofacial muscles, (b) sub-atmospheric pressure generated in the oral cavity which acts to suck the lips and cheeks against the teeth and into the inter-occlusal space. Elimination of these restraining muscle pressures allows the inherent bone inducing potential of the erupting tooth to be expressed in a more buccal direction. The potential significance of this effect can be understood when it is realized that the apical base in the mandible translates vertically through some 11mm during the eruption of the permanent dentition. The implication for vestibular screen therapy is that treatment should commence early in the transitional dentition and be sustained until eruption of the second permanent molars.

2. The periphery of the vestibular shield is deliberately extended into the vestibular reflection so that tension is produced in the soft tissues. This pull on the soft tissue is transferred to the periosteum, with two possible effects:

(a) The tension in the periosteum may contribute mechanically to an outward bending of the thin buccal plate, thereby facilitating outward drift of the teeth. (b) Direct tension in the periosteum is known to stimulate deposition of new alveolar bone (Donnelly et al, 1973) and this is claimed to occur on the facial aspect of the alveolus in response to FR treatment. The work of Brieden et al (1984) supports this hypothesis. A comparable widening of the apical base could not be expected in conventional appliance therapy because the expansion force is delivered to the tooth crowns, and the apices are deflected in a lingual direction.

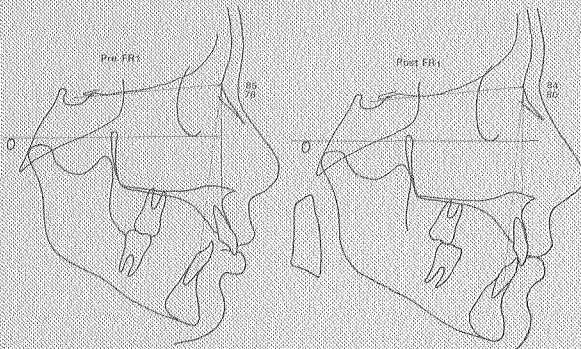
3. The outer surfaces of the vestibular shield are presented to the musculature as a correct configuration of the dento-alveolar process. The orofacial musculature is trained to function in harmony with the dental arches as they attain correct width and shape.

Figure 8. Case 4: Treatment of a 9 year old girl with the FR1 appliance



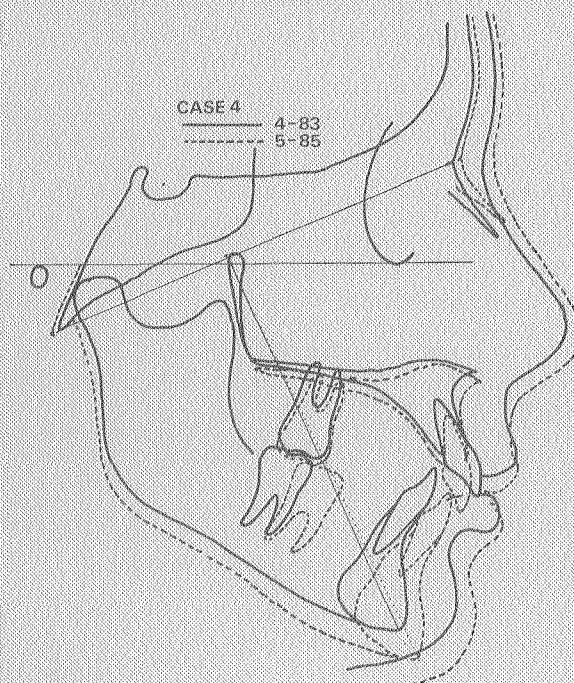
(a) Facial profile before treatment

(b) Study models before treatment

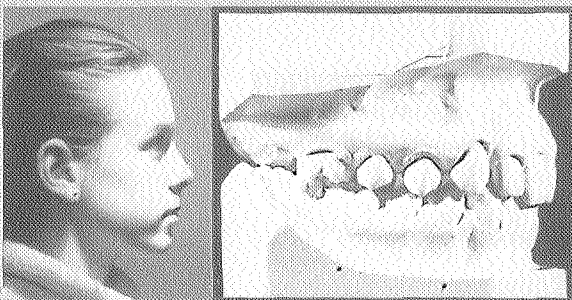


(c) Pre-treatment cephalometric tracing

(g) Post-treatment cephalometric tracing

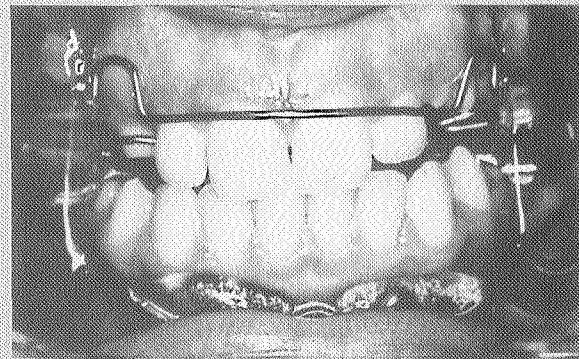


(d) Superimposition of pre- and post-treatment cephalometric tracings



(e) Facial profile after treatment

(f) Study models showing sagittal change in dental arch relationship



(h) The FR1 appliance in place

4. The projecting vestibular screens stretch the perioral soft tissues. After removal of the appliance, the peri-oral soft tissue pressure will continue to be reduced while the tongue pressure is increased because it is elevated into a palatal position. This favours long term stability of arch expansion.

5. Bilateral tension on the maxilla at the level of the sulcus is claimed to stimulate widening of the midpalatal suture. The evidence for this is not yet conclusive. Ghafari (1984) reported sutural changes in rats in association with the placement of Fränkel-type vestibular shields but no implants were used. Brieden (1984) studied the effect of FR-induced widening of the maxillary dental arch, buccal alveolus and the midpalatal suture in children. Although the treatment group had tantalum implants, the control group did not, and it was therefore not possible to ascertain what proportion, if any, of the significant arch widening was due to sutural expansion.

6. In contrast to most other functional jaw orthopaedic appliances, the FR interferes very little with tongue position, and the tongue is free to exert more force in an anterior and lateral direction.

Despite these claims, the number of systematic studies on arch expansion is very limited. Fränkel (1971) reported limited data on the upper arch only in 400 FR patients. The mean expansion between the maxillary first permanent molars, first bicusps or first deciduous molars was 4.5mm. McDougall et al (1982) published detailed studies on 60 FR patients. Only those patients who had worn the appliance over a three year period experienced expansion across the molars of the order of 3.5 to 4.2mm. However, the authors acknowledged that their appliance design at that time did not meet Fränkel's specifications with respect to vestibular extension.

Figure 7 shows the pretreatment and post treatment casts of a patient who wore an FR1 appliance.

FR1

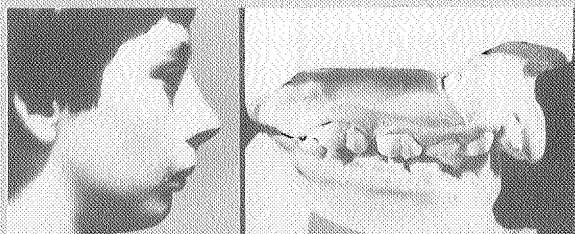
The FR1 appliance is recommended in cases ranging from Class I malocclusions characterized by crowding and increased overbite and overjet, to severe Class II division I malocclusions associated with normal maxillae and retrognathic mandibles. Vertical dysplasias are frequently unsuitable for this particular design, although minor vertical discrepancies such as over-eruption of incisors can be resolved by pre-functional fixed appliance treatment.

The principles of FR1 treatment include mandibular advancement, arch expansion, overbite reduction and muscle re-education.

1. Advancement of the mandible

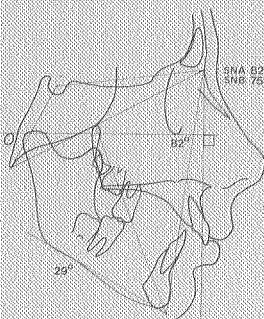
McNamara (1981) and Moyers (1980) showed that a large number of Class II children possess normal maxillae in combination with retruded mandibles. Therefore the clinical problem is to eliminate the antero-posterior discrepancy by stimulation of condylar growth alone. There must be no retraction of the maxilla or of the

Figure 9. Case 5: Treatment of a 10 year old boy with the FR1 appliance

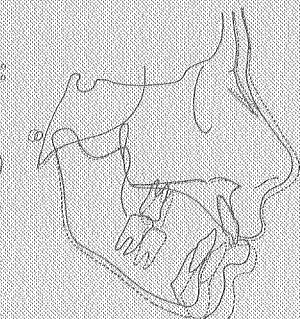


(a) Facial profile before treatment

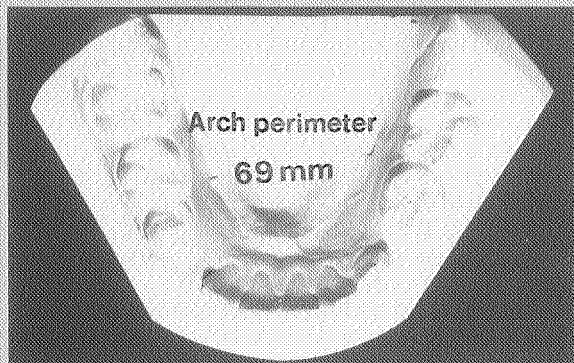
(b) Study models before treatment



(c) Cephalometric tracing before treatment



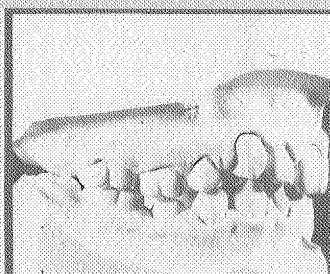
(d) Superimposition of pre- and post-treatment cephalometric tracings



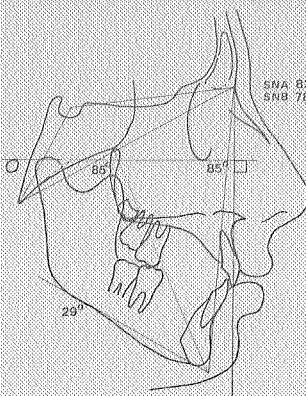
(e) Mandibular arch before treatment; note space loss at 34



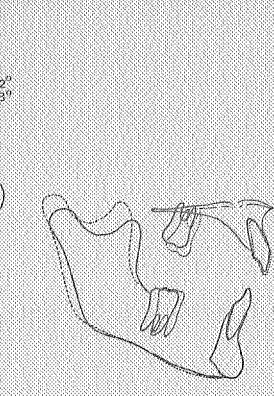
(f) Facial profile after treatment



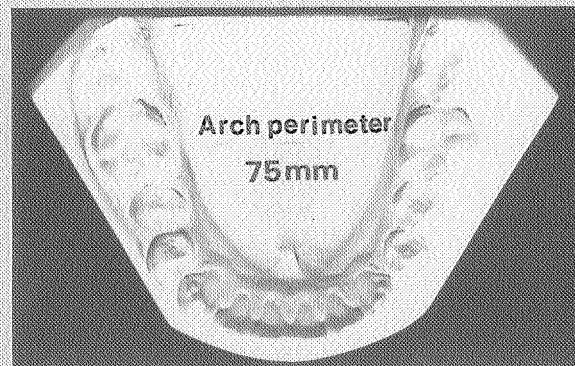
(g) Study models at termination of FR1 therapy



(h) Post-treatment cephalometric tracing



(i) Superimposition on internal structures of the maxilla and mandible



(j) Mandibular arch after treatment; note recovery of space for 34

maxillary teeth. Fränkel considers that activators fail to meet these requirements because there is some orthopaedic maxillary retraction and also because the dental system reacts so rapidly that there is no prolonged effect on the temporomandibular joint. Cemented splints produce successful changes in experimental animals but are not practical in growing children. The FR1 solves this clinical problem by means of the lingual shield and lower lip pads, which oblige the patient to produce an anterior displacement of the mandible yet ensure that there is no appliance contact with the mandibular teeth. Thus, changes observed during treatment in the antero-posterior occlusion of the buccal teeth cannot be explained by mesial movement of mandibular buccal segments, just as the correction of the overjet cannot be explained by proclination of the lower incisors (Petrovic et al, 1982).

If a patient wearing an FR1 allows the retractors to bring the mandible back to its position of centric relation, the lingual shield comes into contact with the alveolar gingiva and pressure will be felt. The sensory input provoked by the lingual shield may activate the nociceptors in the periosteum and stimulate the protractors to eliminate the disturbing signal. Constant protractor activity appears to stimulate the compensatory growth processes in the mandibular condyles. Since patients are unable to engage the FR1 firmly with their mandibular teeth, they are unable to apply forces of any magnitude to the maxilla or its teeth.

Notwithstanding these considerations, several studies have been reported in the literature in which changes in arch relationship produced by Fränkel appliances have been shown to be almost entirely dento-alveolar in origin. This finding is obviously related to violation of the following principles of treatment:

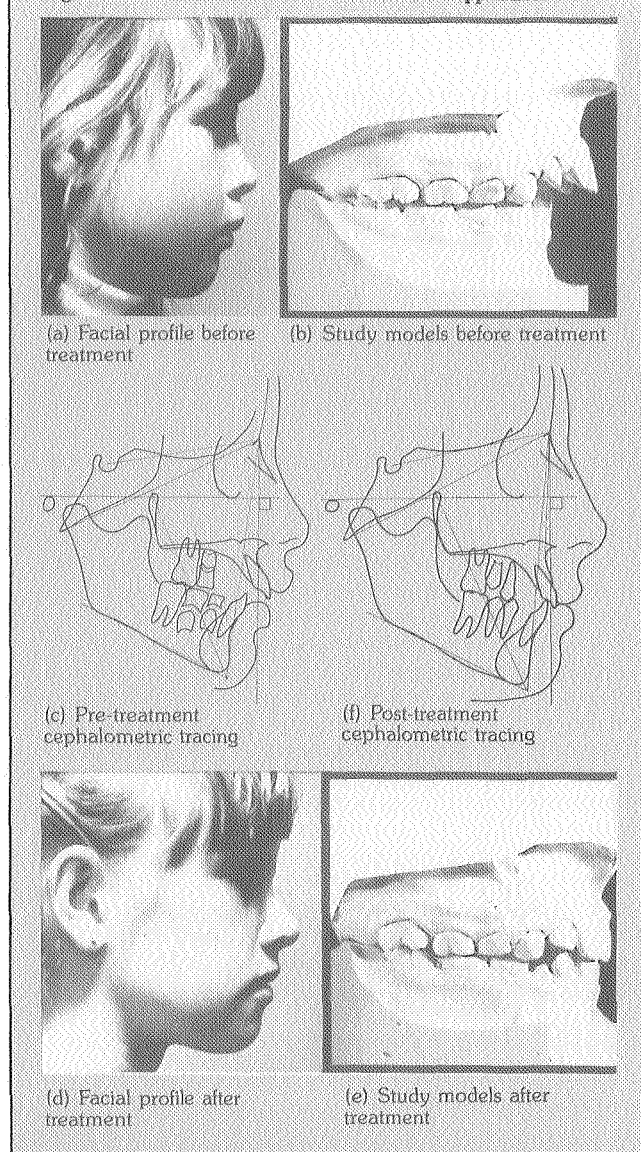
(a) Notching of maxillary deciduous teeth

The FR1 must have a firm registration against the maxilla so that it is stable during use. If the appliance is free to slide posteriorly, the labial bow will come into contact with the maxillary incisors and cause their retroclination together with unfavourable vectors which would deflect the maxilla from its normal growth direction. Maxillary anchorage is secured by lodging the interproximal sections of the palatal connector and the cuspid wires in notches cut on the distal aspect of the maxillary second deciduous molars and between the first deciduous molars and cuspids respectively. This is an essential procedure in the construction of the FR1 (and FR2) but was disregarded in the clinical trials reported by Creekmore (1982) and Robertson (1983).

(b) Sequential mandibular advancement

In the early period of the development of his functional concept, Fränkel found that proclination of the lower incisors did occur, and that it was associated with the relatively large mandibular advancements of 5-6mm registered in the construction bites taken at that time. It appears that the protractors are unable to sustain these

Figure 10. Case 6: Treatment with the FR1 appliance



extreme forward positions and when the suspending muscles relaxed, the mandible slid downwards and backwards to provide an opportunity for contact between the incisors and the lingual shield. This mistake led to the conclusion that the initial construction bite must be taken

with the mandible protruded by no more than 1-2mm. As training and adaptation occurs, the anterior segment of the FR1 containing the lip pads and the lingual shield can be gradually advanced (by using screws and/or splits in the vestibular shields) until the desired orthopaedic effect has been obtained.

(c) Gradual training

The FR1 should be worn for only a few hours per day for the first month. It is a serious mistake to expect the child to commence night time wear immediately, because the protractors will not be sufficiently trained and their relaxation may lead to incisor proclination as described above. Preliminary lip seal training is an essential facet of Fränkel therapy, but no attention was paid to this in the studies mentioned above.

(d) Treatment timing

Treatment with the FR1 should commence at around the age of 9 years, if the clinician is to capitalize fully on the potential for sagittal skeletal change and transverse arch expansion. Some studies have suggested that the juvenile growth spurt is of greater clinical utility in terms of orthopaedic change than the pubertal growth spurt. (Riolo et al, 1974; Kerr, 1979; Lewis et al, 1982; Weislander, 1984). The ages of the patients employed in a number of studies on the efficacy of the FR would seem to be beyond this range. (Robertson, 1983; Nielson, 1984; Gianelly, 1984). McNamara (1984) reported that the wearing of the FR2 in adult patients produced no skeletal changes and only minimal dental adaptations. Orthopaedic possibilities with the FR appliances diminish in proportion to the residual facial growth.

2. Arch expansion

The possible mechanism of arch expansion with the FR1 was previously discussed. The rationale for expansion is: (a) In the treatment of Class II cases by mandibular advancement, there is a tendency for the development of a buccal crossbite (Figure 4) unless the maxillary arch undergoes concomitant expansion. The vestibular shields are very effective in this regard.

(b) To relieve existing or predicted crowding.

(c) To counteract progressive reduction in mandibular arch length, which is a feature of normal human development, and is often interpreted as post-treatment relapse. Unfortunately this aspect has not been evaluated because adequate long term material is not yet available outside the German Democratic Republic.

3. Overbite reduction

Overbite reduction is accomplished by buccal segment eruption in harmony with the vertical component of facial growth. The FR1 is not capable of active intrusion of incisors, and if this movement is required, another

Figure 11. Treatment of Class II division II malocclusion with the FR2 appliance

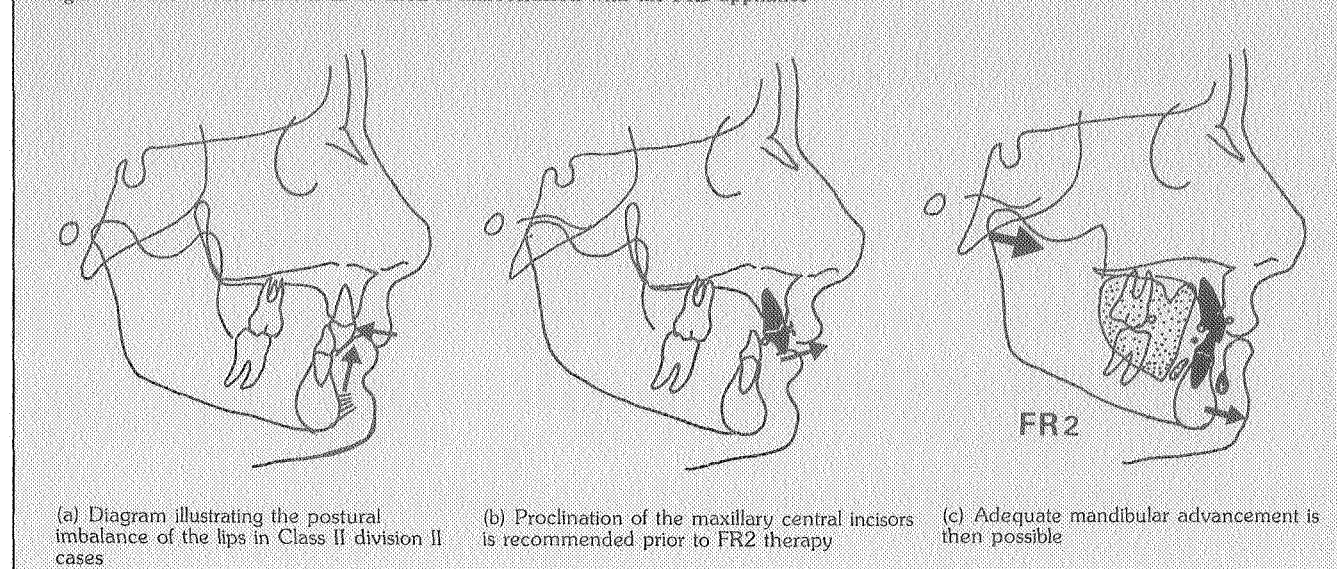
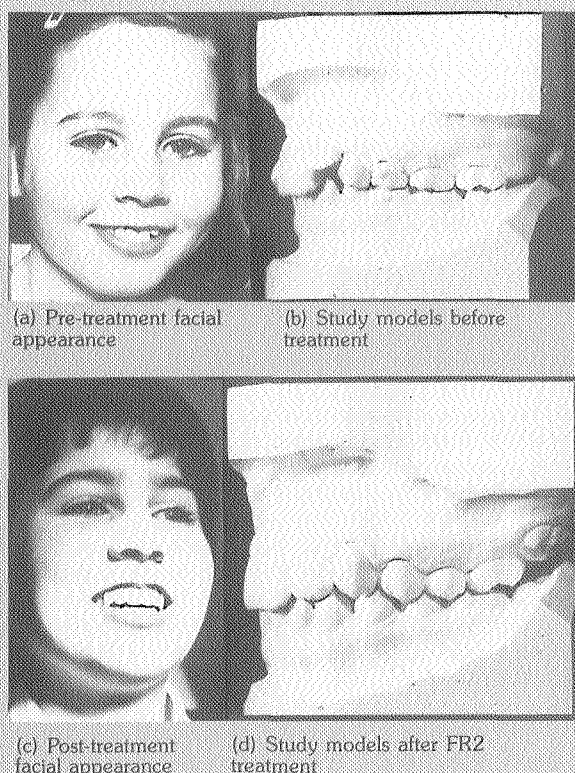


Figure 12. Case 7: Treatment of a 9 year old girl with an FR2 appliance



appliance system should be employed. That the Fränkel appliance is very effective in promoting molar eruption was shown by Rhigellis (1983).

4. Muscle re-education

Function regulator treatment is claimed to accomplish its skeletal and dental corrections by modifying behaviour aberrations involving the oro-facial musculature. Freeland (1979) compared the muscle patterns in a group of patients before and after treatment with the FR1 to those of a control group, and concluded that the FR did indeed affect muscle activity.

An ideal patient for treatment with the FR1 (and FR2) appliance would have the following features:

Skeletal features:

- (a) Normal maxillary position in the sagittal and vertical dimensions.
- (b) Retrognathic mandible.
- (c) Normal or reduced lower face height.

Dental features:

- (a) Normal relationship of the maxillary denture to the maxilla in the sagittal and vertical dimensions.
- (b) Normal relationship of the mandibular denture to the mandible in the sagittal and vertical dimensions.
- (c) Mild crowding in the mandibular arch or in both arches is acceptable, but axial rotations and bodily displacements of individual teeth require a separate phase of fixed appliance treatment.

Maturation:

Early mixed dentition, 7-9 years.

Teuscher (1983) has indicated that disappointment with the profile change in conventional Class II treatment is directly proportional to the degree of therapeutic midface restraint, and inversely proportional to the amount of condylar growth experienced by the patient. Correctly managed FR1 treatment offers an excellent potential for profile improvement in Class II treatment because there is no midface restraint and there is increased condylar growth. Fränkel's long term studies have shown that the

average anterior movement of the maxilla in FR1 treated cases is 3.4mm compared to 2.5mm in untreated Class II subjects. (Fränkel 1983). Although this difference is not statistically significant, it is clear that the FR1 is superior to the activator and Herbst appliances in terms of avoiding reciprocal orthopaedic side effects on the position of the maxilla.

CASE REPORTS : Figures 8–10

FR2

Fränkel designed the FR2 for the early orthopaedic treatment of Class II division II malocclusions, although others have adopted this appliance for the treatment of Class II division I problems (McNamara and Huges, 1981).

Fränkel cites a study of 114 untreated Class II division II cases in which serial radiography of the erupting central incisors showed that the bony layer covering the labial surface became progressively thinner as eruption advanced and disappeared completely some time before clinical emergence. Concomitantly the incisors became increasingly retroclined even before clinical eruption. Fränkel suggests that the tight lower lip and high lip line, which are characteristic of Class II division II, may account for this retroclination. If lip seal in normal individuals is established by the elevation of a relatively passive lower lip by mentalis muscle activity (Simpson, 1976) then Fränkel postulates that hyperactivity of the typically well developed mentalis muscle seen in Class II division II patients causes excessive postural elevation of the lower lip so that it intrudes beneath the upper lip. (Figure 11(a)). The resulting perioral pressure is said to have a strong morphogenetic effect on the developing premaxillary dento-alveolar structures. Leighton (1983) supported these concepts in a study comparing the eruptive behaviour of central incisors in Class I, Class II division I and Class II division II cases. The initial tooth germ orientation was similar in all groups before root formation occurred. Thereafter the Class II division II cases showed progressive retroclination of the erupting incisors and also of the labial alveolar plate. Leighton suggested that the eruptive path of the incisors is controlled by the sagittal shape of the labial alveolar process which, in turn, may be determined by the

Figure 13. Case 8: Treatment of a 10 year old boy with an FR2 appliance

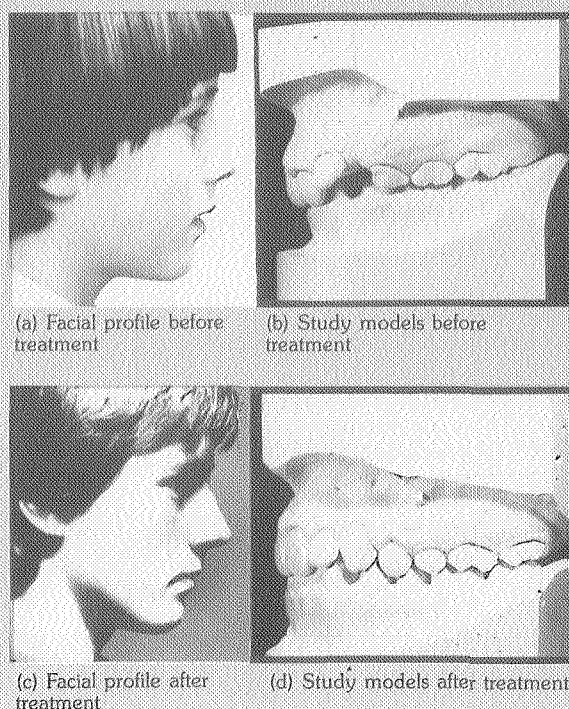
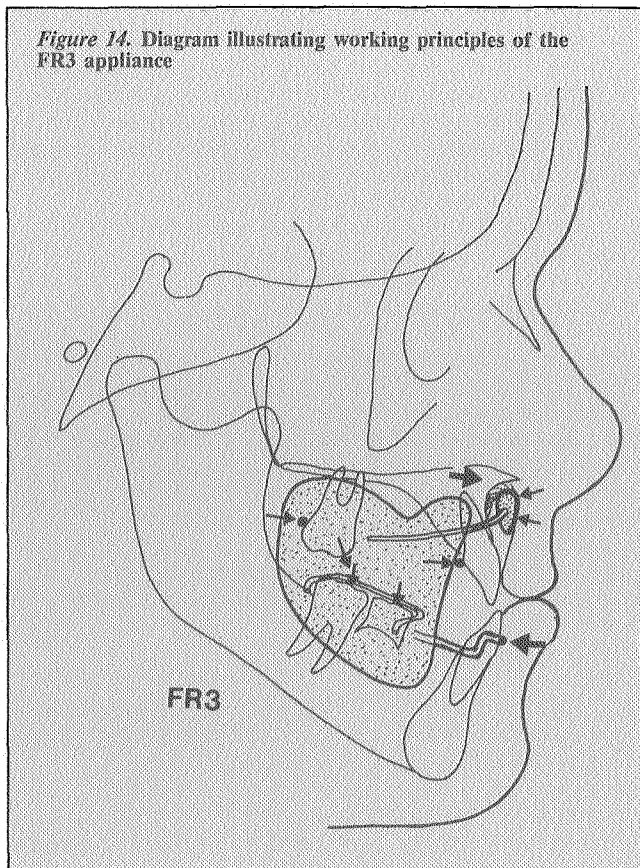


Figure 14. Diagram illustrating working principles of the FR3 appliance



perioral musculature. He suggested that the retroclination of the central incisors in Class II division II cases is environmentally induced and is therefore amenable to interception. The incisor inclination may have a restrictive effect on mandibular development and the lack of vertical support may facilitate a forward mandibular rotation. The typical features facing the clinician are incisor retroclination, a deep overbite, mild mandibular retrognathism and a decreased lower face height. Prior to the construction of the FR2 the central incisors should be proclined (*Figure 11(b)*) so that when the construction registration is made, the incisors meet edge-to-edge and there is sufficient mandibular protrusion to initiate the biological changes involved in forward transformation of the mandible (*Figure 11(c)*). Buccal segment eruption will maintain the increased vertical dimensions. If there is a scissor bite tendency, this would be accentuated by the expansion normally induced by the vestibular shields, and it may therefore be more appropriate to use a conventional activator. Slagvold (1977) makes the observation that many Class II division II cases are actually more suited to activator therapy than Class II division I malocclusions. The treatment of two cases is illustrated in *Figures 12 and 13*.

FR3

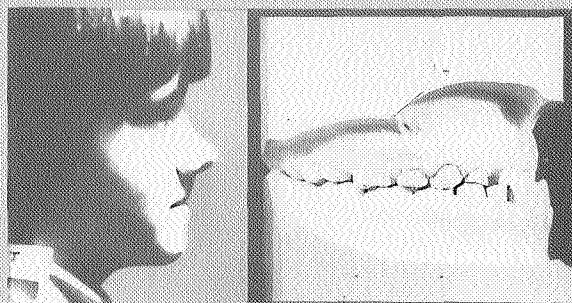
In functional orthopaedic philosophy, mandibular retrognathia is interpreted as a manifestation of failure of volumetric expansion of the inferior part of the oro-facial capsule. In contrast to this, maxillary retrognathia is viewed as a consequence of failure of expansion of the superior part of the oro-facial capsule. Delaires' (1978) dissections of normal and cleft-lip cadavers led him to postulate that the nasogenal muscles have a direct influence on maxillary growth, and that functional aberrations of these muscle groups may play an important role in restricting maxillary development.

The FR3 is constructed to interfere directly with the structural and postural deviations of the external soft tissue capsule. The vestibular shields stand away from the maxilla and lie close to the mandible, the objective being

to stimulate maxillary development and to restrict mandibular development. The upper lip pads supply a direct intervention at the muscle-tendon junction at the frontal sulcus and lead to an altered biomechanical loading of the maxillary structures and nasal cartilages. The teeth are not notched and it is important that none of the wire components of the FR3 contact any maxillary teeth in such a way as to inhibit forward movement of the maxilla. In contrast to the action of the FR2, where the skeletal and dental changes are entirely functionally induced, the FR3 imparts both functional and mechanical effects;

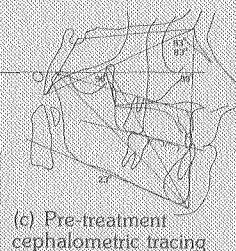
(a) The functional aspects include stimulation of forward growth of the maxilla, deposition of new bone on the facial aspect of the maxilla, of the order of 2mm at A point, (Fränkel, 1983), and possibly increased growth of the anterior cranial base (Fränkel, 1970).

Figure 15. Case 9: Treatment of a 7 year old girl with an FR3 appliance

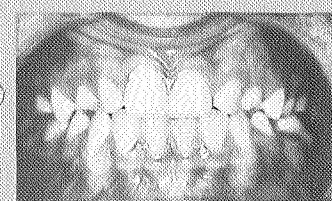


(a) Facial profile before treatment

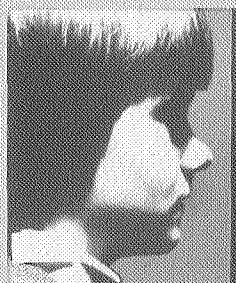
(b) Study models showing Class III malocclusion before treatment



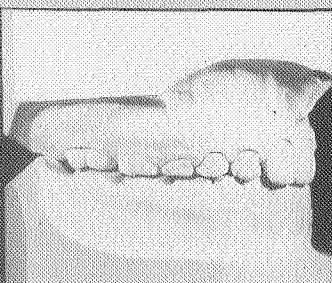
(c) Pre-treatment cephalometric tracing



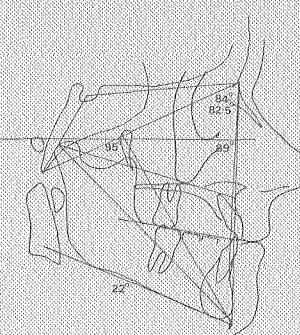
(d) Intra-oral photograph 5 years after cessation of appliance wear



(e) Facial profile after treatment



(f) Study models after treatment



(g) Post-treatment cephalometric tracing



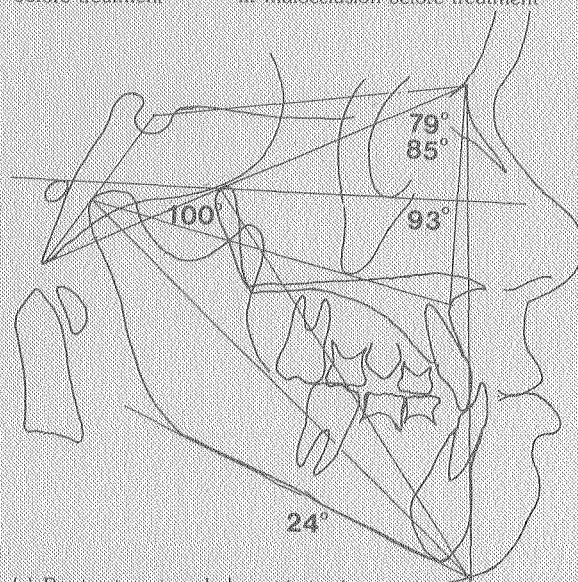
(h) Facial profile 5 years after withdrawal of the FR3

Figure 16. Case 10: Treatment of a 10 year old boy with the FR3

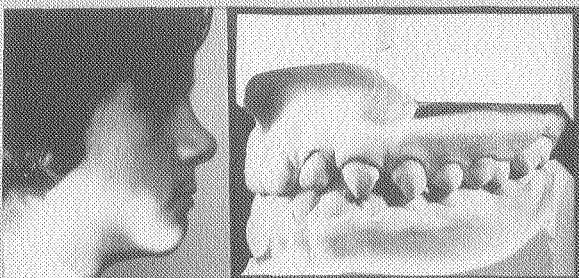


(a) Facial appearance before treatment

(b) Study models showing Class III malocclusion before treatment

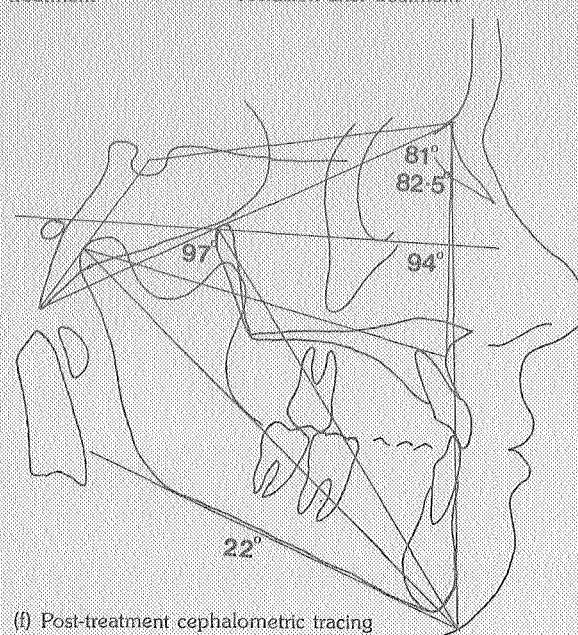


(c) Pre-treatment cephalometric tracing



(d) Facial profile after treatment

(e) Study models showing the occlusion after treatment



(f) Post-treatment cephalometric tracing

(b) The mechanical aspect of FR3 treatment is mediated by contact of the lower labial connector with the labial surfaces of the mandibular incisors. Lip pressure against the upper lip pads is transferred to the lower incisors (Figure 14) causing retroclination of these teeth and frequently a posterior rotation of the mandible. This latter effect is particularly appropriate in Class III malocclusions associated with reduced lower face height.

Since the FR3 seeks to pre-empt abnormal development and to restore normal growth rather than to correct fully established malformation, it is important that treatment be initiated as early as possible. The appliance can be readily used in the complete deciduous dentition, if necessary. Because of the induced adaptations in both hard and soft tissues during treatment, the ultimate balance between function and form should favour long term stability of the result. Freeland (1979) reported that changes in patterns of activity of the oro-facial muscles did occur after the wearing of the FR3 for 12 months. In comparison to the other function regulators the FR3 is relatively easy to construct and to manage clinically (Eirew, 1976) and maxillary orthopaedic change is therefore more likely to be a routine cephalometric finding. (Robertson 1983)

CASE REPORTS: Figures 15–17

FR4

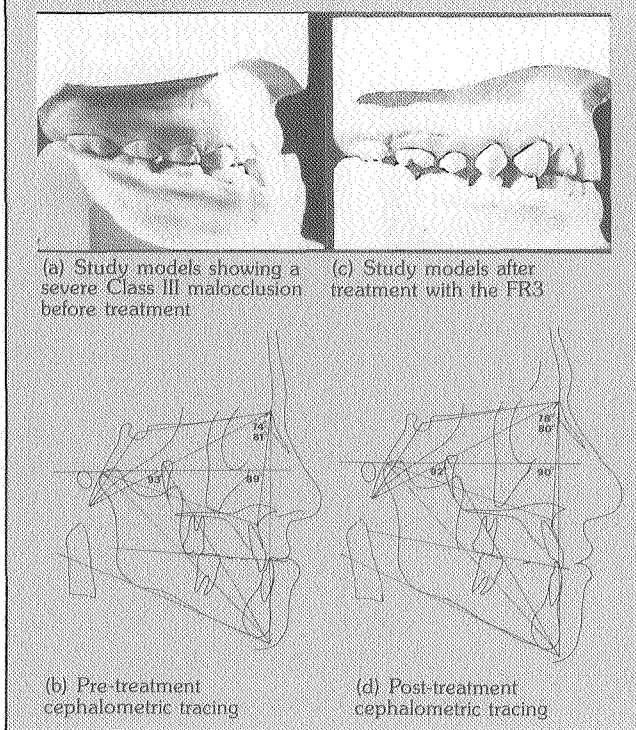
The FR4 has been used in the treatment of bimaxillary protrusions and has been found to be particularly effective in the treatment of open-bite problems. Fränkel developed this design after observing inconsistent responses to the use of "tongue habit" appliances formerly employed in the treatment of so called "tongue thrust" open bites. Analysis of refractory cases revealed a marked discrepancy between lip length and lower face height. The associated deficiency of an oral seal was attributed to a poor postural behaviour of the facial musculature, particularly in the lip area. This led Fränkel to institute functional therapy using vestibular shields in conjunction with lip seal training for anterior open-bite relapse patients.

The clinical observation that an open-bite can be closed without using any device which interferes with tongue movements or tongue posture confirmed that tongue thrust alone may not be the primary cause of that malocclusion, and that there may be a functional relationship between the postural behaviour of the tongue and the lips. It was considered that faulty interdental posture of the tongue was adopted as a compensatory or adaptive behaviour which established an anterior oral seal when the lips were incapable of doing so.

Harvold's work is of significance in this context. In a series of experiments (Harvold et al 1973, Harvold 1979, Tomer and Harvold 1982, Vagervik et al 1984.) it was shown that closure of the nasal airway in growing monkeys induced changes in neuromuscular recruitment patterns which were necessary to establish and maintain an oral airway. The muscle groups most actively involved were those of the tongue and suprahyoid area. The animals developed progressive alteration of their soft tissue and skeletal morphology, eventually corresponding to the clinical picture of skeletal open-bite. Following removal of the nasal airway obstruction, reversals in skeletal remodelling were observed, but the muscle patterns and the malocclusions tended to persist. Since condylar and alveolar growth are not "interstitial" or "expansive" but rather "appositional" in nature, it is likely that the altered direction of condylar growth and the excessive alveolar growth associated with skeletal open-bite development are a result rather than a cause of posterior mandibular rotation.

Fränkel reasoned that if alterations in the postural activity of the oro-facial musculature can lead to skeletal open-bite, then correction of faulty postural behaviour might help to correct the associated skeletal deformity. A fundamental aim of his therapy was to overcome the

Figure 17. Case 11: Treatment of a 9 year old boy with the FR3 appliance



deviant pattern of mandibular rotation through re-establishment of nose breathing by correcting the lip-apart condition and faulty tongue posture. In fact, lip-seal training alone, in the absence of any appliance treatment, has been shown to result in closure of open bites (Fränkel, 1980). However, voluntary training exercises without an appliance are difficult to sustain for adequate daily periods throughout the duration of the growth phase. Furthermore, the FR4 appliance has additional working principles which contribute to the desired skeletal remodelling changes (Figure 18). Correct extension of the posterior margins of the vestibular shields determines the location of a new centre of rotation for the mandible. From receptors in these areas sensory feedback is said to cause reflex distraction of the condyle from the mandibular fossa, while the chin is rotated upwards by the strengthened anterior vertical muscle chain. Compensatory translative growth may restore the normal condyle-fossa relationship and increase ramus height.

This hypothesis is supported by an 8-year evaluation of thirty skeletal open-bite cases treated with the FR4 (Fränkel and Fränkel 1983). The treated group experienced an increase in ramus height, a decrease in the gonial angle, a decrease in anterior face height and an improvement in the ratio of anterior face height to posterior face height. The respective values for the untreated control group of eleven subjects remained unchanged or became worse.

An important question concerning skeletal open-bite development is the role of neuromuscular maturation. Functional disorders in the oro-facial area may be attributed to a failed or incomplete maturation of postural performances, for which an adverse psychosocial environment may constitute an important contributory factor (Fränkel, 1983).

Treatment with the FR4 is not commenced until the patient has shown evidence of good co-operation with lip-seal exercises during a probationary period of 3-4 months. As with the other function regulators, therapy should be initiated in the mixed dentition and lengthy treatment and retention periods are frequently necessary in the management of these patients.

Figure 19 and Figure 20 show the responses obtained in two patients treated with the FR4.

THE HERBST APPLIANCE

This appliance was introduced in 1905 by Professor Emil Herbst, was widely used in Europe for a number of years and then was largely forgotten until Pancherz revived interest in this approach to treatment in 1979.

The Herbst appliance (Figure 21) consists of a bilateral telescope mechanism attached to orthodontic bands cemented to the maxillary and mandibular teeth. The length of the telescope tube is adjusted so that the mandible is mechanically held in a continuously protruded position, usually an edge-to-edge incisal relationship.

The Herbst appliance is analogous to the activator insofar as the change in jaw relationship is accomplished by the interposition of a rigid structure between the teeth in each jaw, but the Herbst mechanism is not removable by the patient and therefore the impact on the musculature is continuous and not intermittent in nature. The clinical situation thus corresponds more closely to the conditions established in animal experiments (McNamara, 1975) and this may explain why the condylar changes reported in studies on Herbst treatment are both appreciable and consistent (Pancherz, 1982; Weislander, 1984).

Placement of a Herbst appliance creates a primary and significant change in the intermaxillary relationship, and the expectation is that favourable skeletal and muscular adaptation will occur so that the new jaw positions are permanent. This contrasts with the principle of Function Regulator therapy, where a primary attempt is made to normalize the muscular environment of the developing stomatognathic system so that desirable secondary changes occur in basal jaw relationships.

The sliding hinges of the Herbst appliance are anchored on the maxillary molars and, using the mandibular first bicusps as "handles", the mandible is locked in a protruded position and the condyles are distracted from the fossae. Provided that there is some growth potential remaining, the condyles "grow back" into the fossae within 6-8 months, thereby stabilizing the artificially created mandibular position. Concomitant changes in muscle activity would minimize any relapse tendency.

Pancherz (1980) has shown that the E.M.G. patterns of the masseter and temporalis muscles, which are abnormal in Class II cases before treatment, are, in fact, normalized by Herbst treatment.

The proportion of change attributed to function per se is difficult to establish. Distal movement of maxillary molars results from muscle-generated forces transmitted through the plunger attached to the

Figure 18. Diagram illustrating the working principles of the FR4 appliance

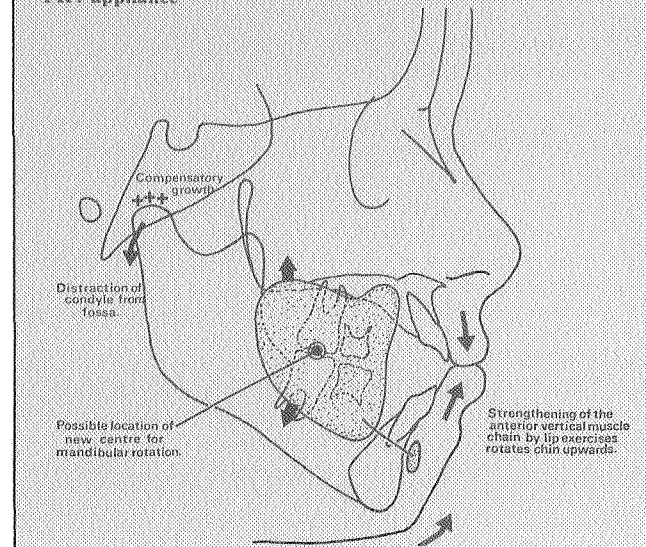
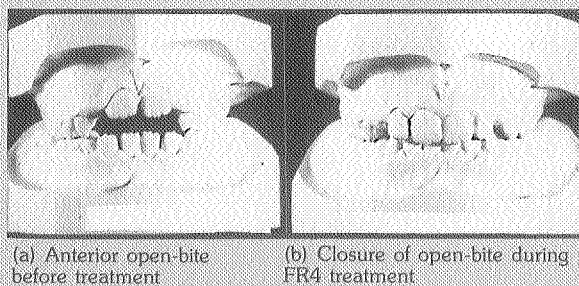


Figure 19. Case 12: Treatment of a 9 year old girl with the FR4 appliance



mandibular bicuspid. There is, usually, reciprocal mesial movement of the anterior mandibular anchorage unit which contributes to overjet reduction. The mechanism involved in condylar remodelling has not been elucidated. It is not known whether simple "passive" distraction of the condyles from the fossae constitutes an adequate biomechanical stimulus for proliferative change, or whether functional movements in the "new" position are important. In addition, reflex contractions of the lateral pterygoid muscles as a response to disturbance signals from periodontal receptors may make an important contribution to condylar remodelling, as claimed by McNamara (1975) and Petrovic (1975).

Treatment effects

The treatment effects of the Herbst appliance have been reported (Pancherz, 1982; Weislander, 1984).

There may be some minor variations depending on the appliance design. For example, the dental response may vary in accordance with the number of teeth incorporated in the anchorage unit. The reported effects are:

- (1) Proclination of mandibular incisors (6 degrees).
- (2) Distal movement of maxillary molars (2-3mm).
- (3) Mesial movement of mandibular molars (1mm).
- (4) Restraint of maxillary growth (reduction in SNA of 0.5 degrees).
- (5) Stimulation of mandibular growth (increase in SNB of 1.5 degrees, increase in effective mandibular length of 3-4mm).
- (6) Reduction in overbite (3mm).
- (7) Increase in lower face height (1.8mm). This appears to be temporary.
- (8) An anteroinferior translation of the mandibular fossae, at least in mixed dentition cases (Weislander, 1984)

An ideal patient for treatment with the Herbst appliance would have the following features:

Skeletal features:

- (a) Normal or slightly prognathic maxilla. In cases where the amount of maxillary correction required exceeds the orthopaedic capabilities of the Herbst appliance, directional extraoral traction can be applied to the upper component.
- (b) Retrognathic mandible.
- (c) Anterior growth direction of the mandible (facial axis more than, or equal to, 90 degrees).
- (d) Normal or reduced lower face height.

Dental features:

- (a) Class II dental arch relationships with increased overjet and normal or increased overbite.
- (b) Well aligned maxillary and mandibular dental arches which occlude well when advanced to a Class I relationship.
- (c) Minor crowding in the maxillary incisor segment is quite acceptable because space is made available by distal movement of the upper buccal segments.
- (d) A Class II division II configuration of the maxillary incisors is not a contraindication, provided that orthodontic alignment is carried out prior to the orthopaedic phase with the Herbst appliance.

Maturation:

Treatment during the pubertal growth period is favoured by Pancherz (1985) but Weislander (1984) has demonstrated that the mandibular response in the early mixed dentition is, if anything, slightly superior.

Indications

In comparison to removable functional appliance therapy, Herbst treatment is relatively invasive and should not be instituted without adequate patient preparation. However, there are some patients in every day orthodontic practice for whom this fixed functional appliance offers the only possibility for the attainment of an "ideal" result. The outcome of conventional orthodontic treatment would be, at best, a compromise.

These patients are grouped thus:

- (1) Patients who meet the above criteria but for whom treatment options are not considered until they have passed their maximum pubertal growth. Removable functional appliances, which require 2-3 years of "growing time", are no longer appropriate, but treatment with the Herbst appliance, which can be completed within 6 to 8 months, makes it possible to use the residual growth available in these older patients.
- (2) Patients whose skeletal, dental and maturational features qualify them for FR or activator therapy, but where proper wearing of the appliance is unlikely to be satisfactory, either because of nasal airway obstruction or poor co-operation.
- (3) Patients in the mixed dentition who display maxillary prognathism in conjunction with mandibular retrognathism. Weislander's Herbst-head gear approach

Figure 20. Case 13: Treatment of an 8 year old girl with an FR4 appliance

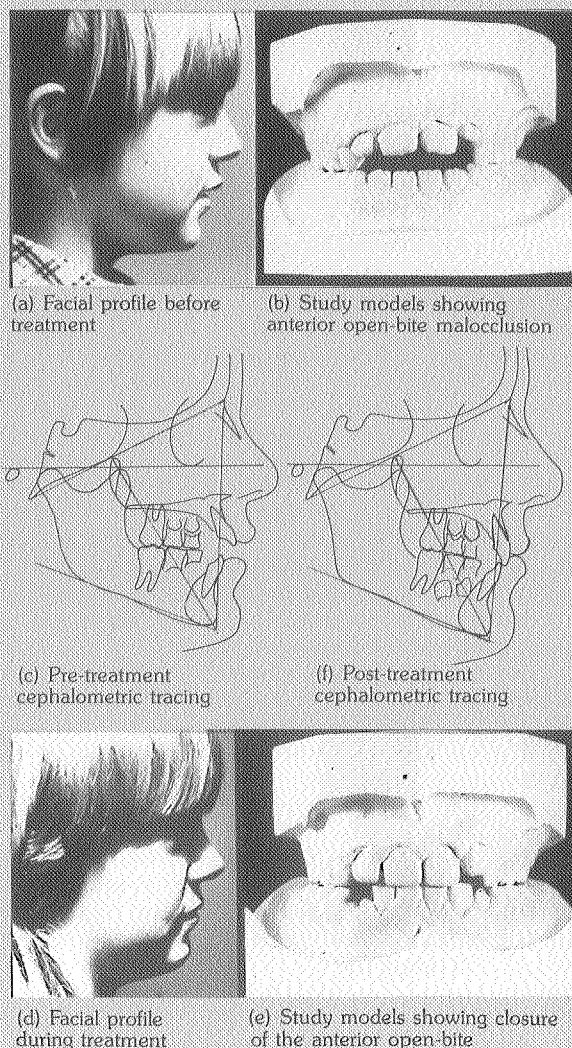
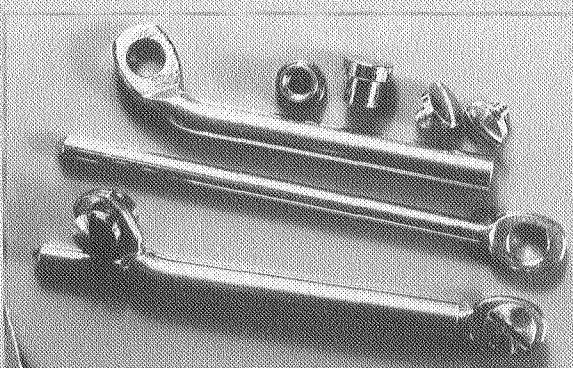
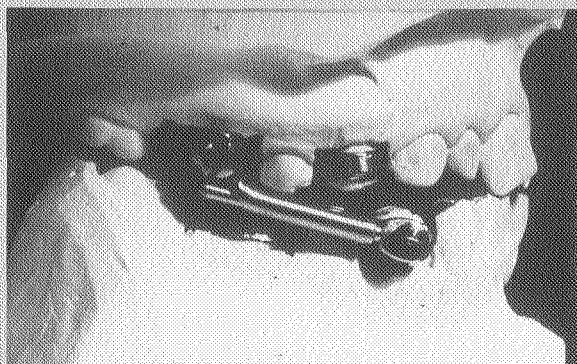


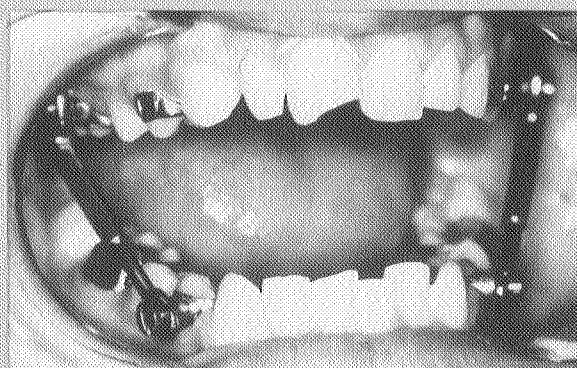
Figure 21. The Herbst appliance



(a) Components: plungers, tubes, pivots and screws



(b) Herbst appliance assembled on articulator



(c) Herbst appliance in place in the mouth

may not be the only alternative available, but may prove to be the most efficient method of restoring skeletal and muscular balance for these children.

Contraindications

(1) *Non-growing subjects.*

Skeletal alterations are minimal and treatment effects are confined to the dento-alveolar area. There may be a risk of developing a "dual bite".

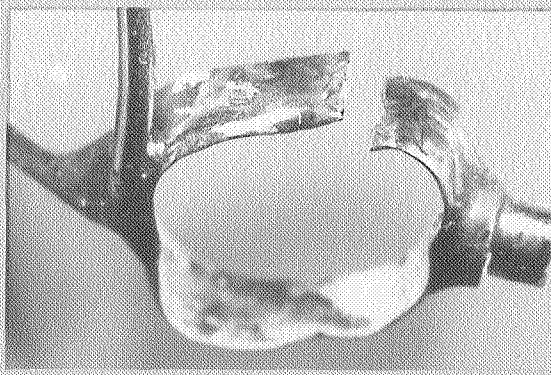
(2) *Open-bite patients.*

There are at least two reasons why the Herbst appliance should not be prescribed for these patients:

(a) Some incisal support and guidance seems to be necessary for the patient to feel comfortable during treatment.

(b) Because of the steep occlusal plane in skeletal open-bite patients, protruding the mandible to an edge-to-edge incisal relationship may generate only a mild anterior condyle translation. Woodside et al (1983) indicated that mandibular advancement per se is not a necessary prerequisite for condylar remodelling, and that vertical distraction from the fossa may be important. In other words, for these patients, the Herbst appliance is incapable of repositioning the mandible within its muscle

Figure 22. Ruptured molar band



system so that an adequate and appropriate stimulus for remodelling is obtained.

(3) *Appliance- "wreckers".*

Even in the most cooperative of patients the strain on parts of the Herbst appliance is considerable (Figure 22) and specific steps should be taken to counteract breakages. Prefabricated bands are too weak and should be strengthened by the soldering of a 1.0mm "staple" on the distal aspect of the mandibular first bicusps and on the mesial aspect of the maxillary first permanent molars (Figure 23). Alternatively, individual bands may be formed using heavy gauge orthodontic band material.

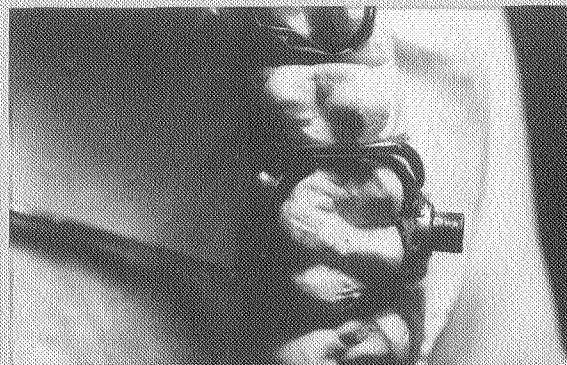
Wilful appliance breakage creates insurmountable management problems and precludes attainment of the desired skeletal changes.

Figures 24 and 25 show cases treated with the Herbst appliance.

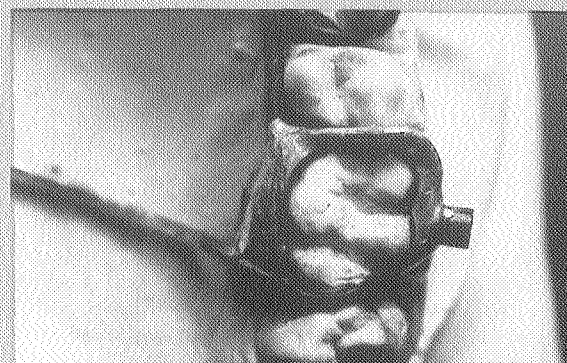
THE BIONATOR

The Bionator was developed by Balters and has much in common with the Andresen-type activator, although it has several distinguishing features:

Figure 23. Prevention of breakages in the Herbst appliance

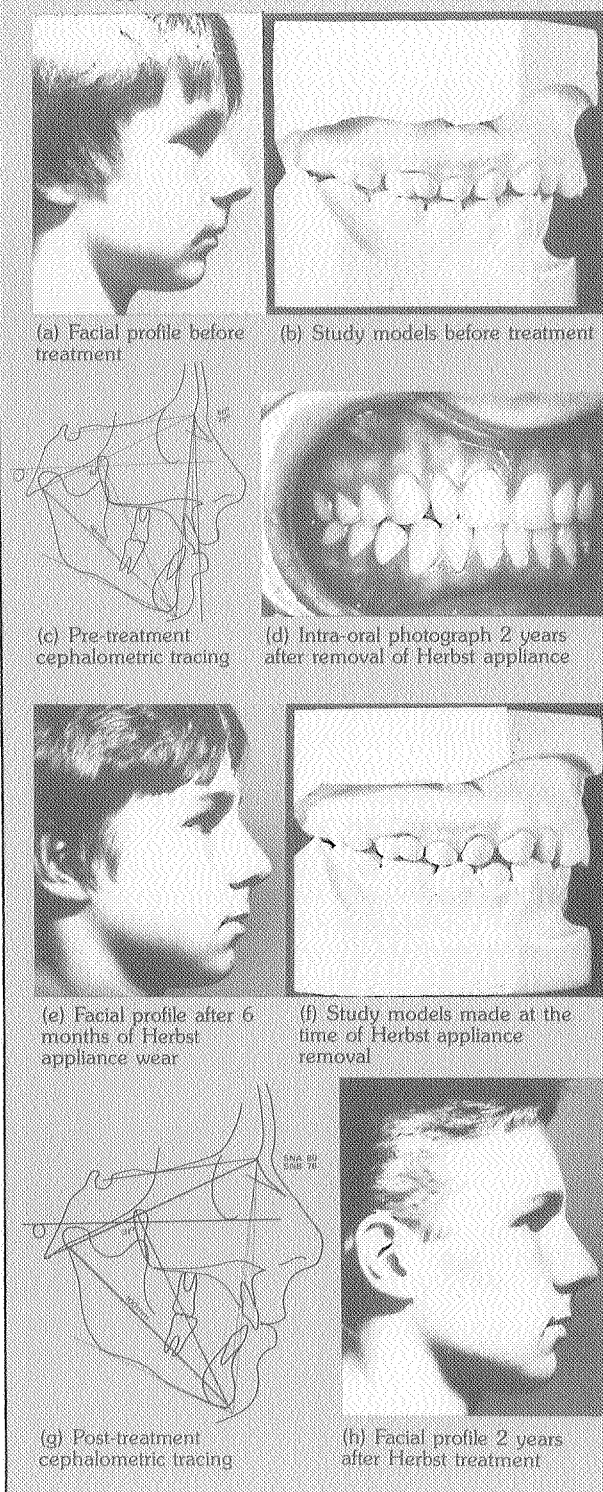


(a) 1.0mm wire staple in position



(b) Solder flowed over staple to provide strengthening of this part of the appliance

Figure 24. Case 14: Treatment of a 14 year old boy with a Herbst appliance



(a) It is considerably less bulky than the activator rendering normal speech possible and facilitating full-time wear.

(b) Freedom of movement in the oral cavity is important and fixation by clasps or extra-oral attachments would be detrimental to the mode of action.

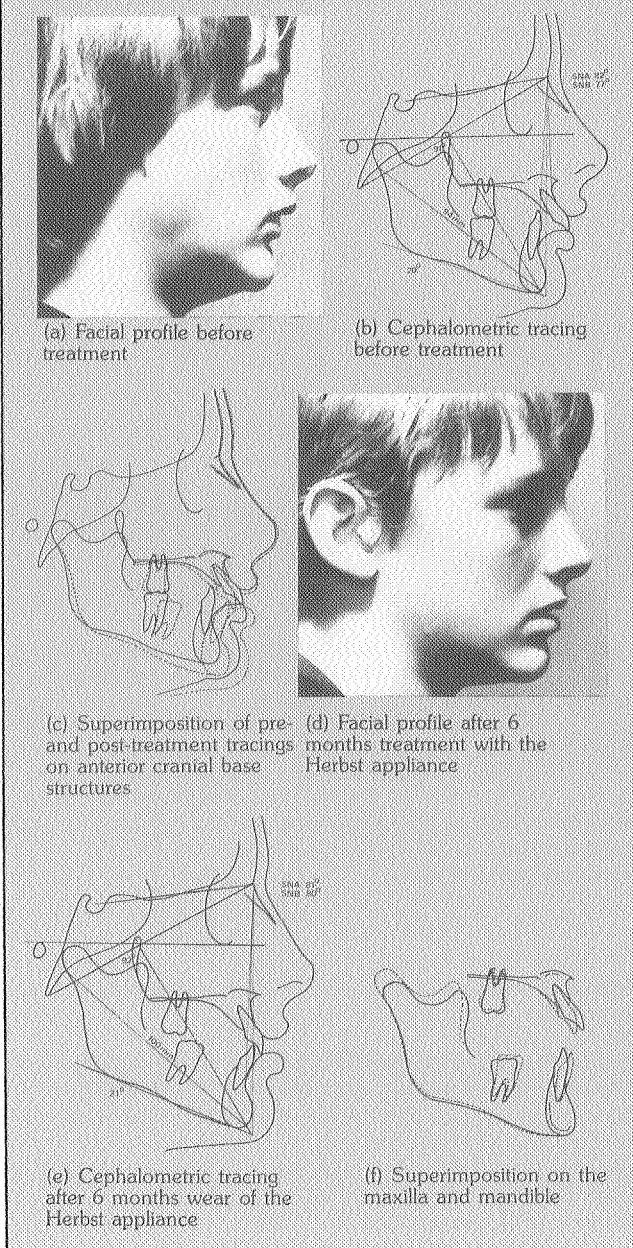
(c) It is *designed to have a specific effect on tongue function*, which is viewed by Balters as the primary morphogenetic influence on the growth, development and relationship of the dental arches.

The Bionator consists of a flange of acrylic covering the lingual aspects of the mandibular dental arch, but only small palatal areas of the maxillary molars and bicusps. The traditional palatal plate of acrylic is replaced by a palatal wire, the configuration of which is

claimed to be important for the correct function of the appliance, and differs according to the nature of the malocclusion under treatment. According to Balters' philosophy, Class II malocclusions are the result of a backward position of the tongue, which, in turn, generates faulty deglutition and mouth breathing. The main objective of Class II treatment with the Bionator is to bring the tongue forward. This is achieved partly by stimulation of the distal aspect of the dorsum of the tongue by the posteriorly directed palatal arch wire, and partly by anterior development of the mandible induced by the edge-to-edge construction bite. Class III malocclusions, conversely, are ascribed to a forward position of the tongue and therefore, in the Class III Bionator the palatal arch is inverted, with the round bend directed anteriorly. The rationale of this is to train the tongue by proprioceptive stimuli to remain in a more retracted position.

The other wire element is the vestibular arch, which has a labial segment and bilateral buccinator bends. The buccinator bends are intended to perform functions similar to the vestibular shields of the Frankel appliances: (a) They prevent the soft tissues of the cheeks from intruding into the inter-occlusal space, thereby facilitating

Figure 25. Case 15: Treatment of a 12 year old boy with the Herbst appliance



eruption and occlusal plane levelling in the buccal segments.

(b) They hold the internal surfaces of the oro-buccal capsule laterally, encouraging transverse expansion of the maxillary dental arch.

Whether or not the Bionator is capable of inducing clinically significant orthopaedic change in the mandible remains to be shown. Electromyographic and force-transducer studies by Witt (1973) suggested that mandibular elongation could be expected insofar as full-time wear of the Bionator induced active muscular protrusion of the mandible, in contrast to conventional activators which held the mandible forward mechanically. However, a recent detailed study on the efficacy of the Bionator (Janson, 1983) concluded that this appliance produces primarily dento-alveolar changes.

Indications

1. The Bionator is useful in the treatment of Class II division I malocclusions in the mixed dentition, particularly those associated with habits and abnormal tongue function.

2. The Bionator has an important role as a retention appliance;

(a) Following correction of a Class II malocclusion in the mixed-dentition with a Bionator, the same appliance is used for night time retention.

(b) After correction of Class II malocclusions by conventional fixed appliance therapy, the Bionator maintains and protects the dento-alveolar changes against disruption by post-treatment growth. The Bionator has greater patient acceptance in this application than the activator, which, because of its bulk, looms as a major treatment phase.

(c) In Herbst appliance treatment, the rapid sagittal changes may partially relapse through dental changes or unfavourable post-treatment growth. Pancherz (1985) has stated that a stable cuspal interdigitation will counteract an occlusal relapse. If treatment is performed in the mixed dentition, retention is necessary until permanent teeth have erupted to stabilize the occlusion. Furthermore, the musculature may require a training period in excess of six months to accommodate to the new mandibular position. The Bionator is a suitable retention device following Herbst treatment.

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This article is based on a paper presented to the 10th
Australian Orthodontic Congress, Melbourne (1984)

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