THE FRÄNKEL APPLIANCE, WITH
PARTICULAR REFERENCE IN THE TREATMENT
OF CLASS II, DIVISION 1 MALOCCLUSION -
A REVIEW OF LITERATURE

A treatise submitted in partial fulfilment of the requirements
for the degree of Master of Dental Surgery at the University
of Sydney.

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1984
ACKNOWLEDGEMENTS

I wish to thank Associate Professor Keith Godfrey for his advice, guidance and continuing support throughout my programme. To my parents for their tolerance, support and encouragement.
This treatise is dedicated to my parents who made my education possible.
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CHAPTER ONE

INTRODUCTION

The correction of Class II, Division 1 malocclusion as an orthodontic problem has been widely discussed. The various approaches available have included such modalities as extra oral traction, bioprogresive mechanics, intermaxillary elastics, extraction of various teeth, and an endless variety of other fixed and removable appliances.

Early interceptive treatment, such as serial extraction has produced a good response in some cases and poor in others. The limitation of these approaches to Class II therapy leads to a current interest in new approaches to Functional Jaw Orthopaedics, which the Fränkel appliance represents.

Orthodontic approach to Class II, Division 1 malocclusion using the Fränkel appliance is different, as it induces a self correction of malocclusion by modifying the muscular and skeletal environment of the developing dentition (Fränkel, 1969a).

Hence, this form of treatment differs radically from orthodontics as we generally practise it, in that, we have hitherto concerned ourselves with moving teeth into positions which we deemed to correct, by means of more or less ingenious mechanical devices designed to put pressure on the teeth. Angle in his textbook titled, "The Treatment of Malocclusion of the Teeth: Angle's System" (1907, page 140) has expressed
this approach as "set the teeth where they belong and the soft tissue parts will follow".

In Fränkel's method, on the other hand, the apparatus displaces the soft tissue such as lips and cheeks away from the dento-alveolar processes. Freeland (1979) stated the biomechanical principles of the Fränkel appliance relates to the elimination of aberrant muscle patterns, thus creating the correct environment in which the denture bases can exist and develop. The above situation is created by the appliance through various wire elements and acrylic flanges.

Klaasen (1981) claimed that it is possible to treat anomalies of the oral structures and deficient muscle activity simultaneously, using the Fränkel appliance. This appliance, as pointed out by McNamara and Hugê (1981) has two treatment effects. First, it serves as a template against which the craniofacial muscles function. The framework of the appliance provides an artificial balancing of the environment, thereby promoting different patterns of muscle activity. The second effect of the Fränkel appliance is its influence on skeletal and dental development. The Fränkel appliance removes muscle forces in the labial and buccal areas that are claimed to restrict skeletal growth, thereby providing an environment which promotes or maximizes mandibular growth. In short, overall facial balance can be potentially obtained. It is claimed that the result would be similar to that achieved by mandibular surgery. (Fig.1)

It is the aim of this treatise to review the Fränkel appliance therapy especially
Potential facial improvement from successful functional jaw orthopedics utilizing the Fränkel appliance. Fig.1, from Owen 1983 a).

In relation to the treatment of Class II, Division 1 malocclusion. Various aspects of the Fränkel appliance will be presented.

The next two chapters will deal with the historical background and design of the apparatus, thus allowing the readers to become familiar with the appliance before its theoretical concept is discussed.

Past studies of mandibular adaptation to anterior positioning of the mandible will be reviewed, especially in relation to the Fränkel appliance.

The construction of the appliance is then described as a logical sequence to gain an appreciation of the rationale of the various parts of the appliance. Then follows discussion of clinical management and various therapeutic potential
effects on basal bone (including mandibular condyles), dento-alveolar structure and muscle; treatment timing and the appliance advantages and disadvantages are presented to enhance successful treatment outcome.
CHAPTER TWO
HISTORICAL BACKGROUND

Terminology:

The Fränkel appliance is one of the latest developments of functional jaw orthopaedics. Adams (1979 page 102) stated that functional jaw orthopaedics is the "system of orthodontic treatment which makes use of forces which act in and about the human dentition during the activities of the masticatory face".

Evolution of Functional Therapy:

Historically, myofunctional therapy introduced by Rogers (1918) has an important bearing in the evolution towards functional appliance therapy. This therapy, in its original form, is aimed to the correction of a malocclusion by re-educating the muscular pattern and function.

It is interesting to note that functional orthopaedic appliances are not new. According to Di Salvo (1982), Norman W. Kingsley described an appliance to position the jaw forward as early as 1880.

The first and best well known, but by no means the only systematic approach to the design and use of functional appliances was that of Andresen (1936, cited in Graber and Neumann, 1977, page 526), although it has frequently been pointed out that Robin (1902, cited in Adams, 1979, page 102) anticipated the general shape of the appliance or "monoblock"
that is used in the Andresen appliance. The Andresen appliance was the first one to be freely movable within the oral cavity. It was intended to use muscle forces to correct malocclusions. Originally, Andresen termed his appliance the "biomechanical appliance", but later with the collaboration of Häupl, the term "activator" was introduced because of the proposed activation of the muscles. Andresen was a major force in the development of functional jaw orthopaedics, as he wrote his text of the "Norwegian System of Functional Gnatho-orthopaedics". (Grabert and Neumann, 1977, page 526)

More recently, we have appliances developed by Bimler (1956), Stockfisch (1973), Balters (1973) and Klammt (1955) with modifications to the activator. Bimler's appliance was much less bulky and incorporated wires and elastics to elicit more muscle force than previous appliances (Bimler, 1956). Stockfisch (1973), a disciple of Bimler, designed the "kinetor", or elastic bite former", which also uses the principle of attempting to improve the muscle response of the patient.

Balters (1973, cited in Owen 1981) took the activator and removed the bulk of acrylic from the palate so that the patient could tolerate the appliance better. He terms his appliance the "bionator". Klammt (1955, cited in Owen, 1981) introduced the elastic open activator, which is another attempt to reduce the bulk of the appliance, enabling speech while using the appliance, and therefore encourage better patient co-operation.

It should always be borne in mind that whatever the name of the appliance or system that is used, the central purpose
is to produce a temporary re-direction of the forces that are already at play within and about the oral cavity, until such time as premeditated changes in tooth arrangement and occlusal relationship have been brought about.

A slightly different approach to functional appliance treatment which is not lacking in precedents, is that of Fränkel (1966) in which the pressures of the lips and cheeks are prevented from impinging upon the teeth and alveolar process by means of the "Fränkel Appliance" or "Function Corrector", or "Function Regulator", producing in consequence changes in the growth patterns of these structures. Thus, the Fränkel approach differs from all others because he intends the oral vestibule to be his basis for treatment, whereas all other appliances operate inside the dental arches.

Furthermore, forward positioning of the lower jaw by the Fränkel appliance has a potentially profound effect on the condylar growth of the mandible in the correction of the antero-posterior jaw bone discrepancy. Therefore, the Fränkel appliance adds another dimension to functional jaw orthopaedics; as treatment in the transverse plane, as well as the traditional sagittal plane, becomes a realistic goal.
CHAPTER THREE

APPLIANCE DESCRIPTION/DESIGN

The Fränkel appliance developed by Rolf Fränkel of the German Democratic Republic (Fränkel 1966, 1969a, 1969b, 1971, 1974, 1975, 1980a, 1980b) consists essentially of skeleton mouth shields which lie in the vestibule of the mouth and stand clear of all portions of the dento-alveolar system where these are under developed. The wire elements unite the lateral shields with the lip pads and serve also as guiding, stabilizing and "reflex inducing" factors.

FRÄNKEL Appliance (F.R.2) illustrated from McNamara, 1982a.

**Fig 2A. LATERAL VIEW**

**Fig 2B. FRONTAL VIEW**
Fig 2C. MAXILLARY OCCLUSAL VIEW

Fig 2D. MAXILLARY OBLIQUE VIEW

Fig 2E. MANDIBULAR OCCLUSAL VIEW

Fig 2F. MANDIBULAR OBLIQUE VIEW
The base of operation of the appliance is the vestibular screens or shields. The vestibular shields and the lower labial pads act in this area to retrain the musculature and to remove restricting muscular forces from the dentition.

Six wire components are visible on the exterior surfaces of the appliance. The upper labial wire (labial bow), the canine extension (preferred description rather than canine loops), the upper lingual wire, the cross-over wire to the lower lingual shield, and the support wires for the lower labial pads from the frontal view (Fig. 2A). From the lateral view (Fig. 2B), a portion of the palatal bow-occlusal rest is also visible, embedded in the vestibular shield.

In the maxillary and mandibular views of the Fränkel appliance, the orientation of the wires relative to each other can be observed (Fig. 2C, 2D, 2E and 2F). Also shown in these diagrams is the relationship between the lower labial pads and the lower lingual pad. These pads serve as a guide for the establishment of the altered mandibular postural position in the correction of Class II malocclusion.

3.1 Acrylic Parts

Vestibular Screen: The vestibular screen provides a framework which interrupts abnormal function and establishes balanced functional patterns (Freeland, 1979). When in place, the superior and inferior borders should encroach on the patient's resting vestibular sulcus, vertically and horizontally. It should also have a lateral relief of 3.0 mm in the maxillary vestibular area and 0.5 mm in the mandibular area (Fig. 3).
The buccal shields are extended to the vestibular fold (left); if they are too short (right), the soft tissues will invaginate between the shields and the alveolar process. If they are too long, they will irritate. Fitting must be precise to exert tension on the periosteal fibers. Fig. 3, from Graber and Neumann, 1977, page 531

**Lower labial pads/lower lingual shield:**

Antero-posterior correction of Class II malocclusion is accomplished by repositioning the mandible anteriorly (Fränkel, 1975). For this purpose, the lower part of the Fränkel appliance is equipped with a template consisting of the lower labial pads which are small acrylic pads which lie in the mental sulcus below the incisors, and the lingual shield, a horseshoe of acrylic which lies lingually below the gingival margin of the lower teeth (Fränkel, 1969). Upon closure, the alveolus of the lower jaw engages in this template and stays forward.

The lower lip pads are held in place by two wires originating from the mandibular parts of the vestibular shields.
A third wire connects them (Fig. 2B). Vertically, according to Fränkel (1969), the support wire of the lower labial pad should be 7 mm below the gingival margin (depending upon the height of the central labial frenum attachment). McNamara (1982a) recommended that the lower margin of the pad to be 12 to 14 mm below the gingival margin at the level of the lateral incisor. He also emphasized that sagitally the pads should be tear-drop in shape, not rectangular. The tear-drop shape allows proper positioning of the pads in the labial sulcus, and prevents gingival stripping when the appliance moves and the jaw opens and closes.

![Diagram](image)

**Fig. 4.** from Eirew, et al. (1981) (Modified)

Correct relationship of lower arch structures in FR1 and FR2.

This shape also allows for comfortable fit for the patient, by allowing the pad to tuck into the undercut below the incisors. Enough space should be left between the lower labial pads and
vestibular shields to allow room for the attachment of the lateral frenum, (McNamara, 1982a).

The lower lingual shield (Fig.2F) is located below the lower gingival margin and anterior to the root area of the mandibular first premolars (or deciduous first deciduous molars). The lower lingual springs emerge from the shields to run along the lingual surface of the incisors at the level of the cingulum. (Graber and Neumann, 1977, p.535). (See Fig.4)

3.2 Wires
The palatal bow with its small "u" loop crosses the palate with a slight curve in a distal direction (Fig.2C and 2E). This curve provides some extra length of the wire to facilitate widening of the appliance, which is frequently necessary as the apical bases develop laterally and begin to contact the buccal or vestibular shields. The wire crosses the trimmed interdental space (see Chapter 7) between the maxillary first molar and second deciduous molar, makes a loop into the buccal shield, and emerges again to lie on the first molar between the buccal cusps (Graber and Neumann, 1977, p.534). This occlusal rest prevents superior displacement of the appliance and inhibits the eruption of the maxillary first molar. The interproximal portion of the wire helps to provide an antero-posterior lock of the appliance (McNamara, 1982a).

Fränkel (1975) recommended the interproximal portion of wire should lodge on the already made groove on the distal surface of the upper deciduous second molar, about at least 2 mm or more down from the occlusal surface to the gingiva. Owen (1981, 1983a) said that positive antero-posterior lock
will prevent the maxillary teeth from tipping lingually and mesial migration of the mandibular teeth. One disadvantageous aspect of this reliance of locking effect is that it is not possible when the deciduous molars have been exfoliated.

The shape and position of the labial bow can be seen in Fig. 2A and 2B. The labial bow lies in the middle of the labial surfaces of the incisors and runs gingivally at right angles in the natural depression between the maxillary lateral incisor and the canine. It forms a gentle curve distally at the height of the middle of the canine root. This slight bend in the wire makes it possible to adjust the wire, if necessary (Graber and Neumann, 1977, page 534).

Fränkel (1974) used cuspid clasps in his so called F.R.I. appliance. The cuspid clasp goes interproximally between the canine and first deciduous molar (or first premolar), and then recurves anteriorly on the labial surface of the upper cuspid (Fig. 5).

![Fig. 5 The cuspid clasp of the Fränkel appliance.](image)
However, McNamara (1982a) found that during the transition of the dentition, the erupting permanent cuspid often became entrapped by the cuspid clasp, which then actually inhibited the eruption of the upper cuspid rather than helping it. So he recommended the use of canine extensions which embrace the canines labially instead of lingually (Fig. 2B).

Fränkel designed his canine loops to allow positive antero-posterior locking as these wires pass between the "groove" created between the upper deciduous canine and first deciduous molar. Since the canine extensions recommended by McNamara do not provide such locking effect, he added into his Fränkel appliance an upper lingual wire, which can further be used to stabilize the upper incisors as it runs between the maxillary deciduous canine and the first deciduous molar after originating from the vestibular shields.
CHAPTER FOUR

THEORETICAL CONCEPT

4.1 A Description of Class II, Division 1 Malocclusion:

Class II, Division 1 malocclusion is the most frequently encountered severe malocclusion syndrome (Moyers, 1963, page 240). It is characterized by a mandibular dentition which is posterior to its normal relationship with the maxillary dentition. The malrelationship may be due to a basic osseous dysplasia or to forward movement of the maxillary dental arch and alveolar process.

McNamara (1981a) found in his cross-sectional study that retrusion of the mandible is the most commonly occurring factor contributing to Class II, Division 1 malocclusion.

Besides the above description of distoclusion, in Class II, Division 1 malocclusion there are certain other associated characteristics. Graber, in his textbook of "Orthodontics, Principles and Practice" (1972, page 234), described the following characteristics: The mandibular denture may or may not be normal with respect to individual tooth position and arch form. Frequently the lower anterior segment shows supraversion or overeruption of the incisor teeth. The arch form of the maxillary denture is seldom normal. Instead of the usual rounded "U" shape, it assumes a morphology approaching that of a "V". A demonstrable
narrowing in the premolar and canine regions is responsible for this, together with a protrusion or labio-version of the maxillary incisors.

A significant difference when one compares Class II, Division 1 malocclusions with those of Class I is the associated abnormal muscle function. Instead of the musculature serving as a balancing and stabilizing "splint", it can become a deforming force (Graber, 1963). With the increase in overjet (horizontal protrusion of the maxillary incisor segment) the lower lip cushions to the lingual aspect of these teeth.

The habitual posture in the more severe cases is with the maxillary incisors resting on the lower lip. The tongue no longer approximates the palate at rest. During swallowing, abnormal mentalis muscle activity and aberrant buccinator activity, together with compensatory tongue function and changed tongue position, tend to accentuate the narrowing of the maxillary arch, the protrusion, labial inclination and spacing of the maxillary incisors, the curve of Spee and the flattening of the mandibular anterior segment.

4.2 Form and Function:

The Pränkel therapy is said to be based on the theories of Roux (1895, cited in Freeland, 1979), Wolff (Enlow, 1968) and Moss (1969).

Roux evolved the theory of "functional adaptation" which put forward a fundamental principle, which determines the arrangement of the teeth and the form of the jaws in which the dentition is placed. By altering the environment
Class II, Division 1 malocclusion. The facial profile reflects the abnormally distal lower dentition relationship. Abnormal lip posture is associated with this type malocclusion.

Roux found that osseous tissue would change its form (Freeland, 1979).

Moyers (1977 cited in Frankel, 1980a) suggested that "in the new orthodontics our emphasis may change to altering the conditions which determine the pattern of occlusal development rather than altering the occlusion directly."

According to Hotz (1974 page 99), the adjustment of teeth basically involves a modification of that "natural interplay of forces" which is responsible for the shape of the dento-alveolar arches.

Frankel (1969b) suggested that tonic and motor aberrations of the orofacial muscles or an abnormal position of the
soft tissue may result in this mechanical soft tissue
guidance being affected and becoming abnormal. Scott (1961)
advocated the thesis that the lips, cheeks and tongue play a
vital role in determining the normal form of the dental
arches, and that they also act as aetiological factors in
the causation of dental malocclusion.

Skieller (1967) pointed out that sucking may cause an
undesirable change of muscular function in the orofacial
region. She said that probably the mechanical consequences
of the resultant dysfunction contribute far more to
subsequent malocclusion than the actual sucking.

Tonic and motor aberrations or deviant developments in
the orofacial complex may be manifestations of emotions as
well as nervous and mental disturbances. Tulley (1953)
drew attention to the "stress of modern life" which he
considers to be responsible for the "tight lipped" phenomenon.
The stress situation which prevails in the industrialized
countries constitutes a nervous and mental strain for children
which may lead to abnormal tone and motor functions of the
facial muscles.

Therefore, there is reason to believe that postural
disorders play a role in abnormalities of the orofacial area.

Profitt (1978) in a review of equilibrium theory has
suggested that rapid movement functions, such as swallowing,
chewing and speaking would be expected to have little if any
effect on the morphology of the dentition, while postural
alterations leading to changes in lip and tongue resting
pressure were probably significant.
Biostatistical work by Lindeman (1963) suggested that in about sixty percent of the children investigated, poor postural performance of the muscles plays a part in the development of skeletal malformation.

Further, according to Brodie and Jacob (1966) tonic and contractile perioral pressures suggest the presence of characteristic patterns of muscular tension in various classes of malocclusion.

Gould and Picton (1968) showed pressures exerted by the lips and cheeks were greater in Class II, Division 1 subjects, than in normal occlusion.

Moss (1980) has shown differences in electromyographic pattern between individuals with different facial morphology, arch symmetry and arch width.

Owen (1983a) concluded that there seems to be adequate substantiation that poor muscle function is a direct aetiological factor in the development of malocclusions. Therefore, these studies seem to lead to the belief that patients demonstrating poor dental and denture base relation or unfavourable facial morphology, also demonstrate an abnormal muscle behaviour pattern.

4.3 Basic Philosophy:

Fränkel introduced an apparatus which is capable of accomplishing skeletal and dental corrections by displacing or deflecting adverse forces from the existing perioral musculature and other soft tissue. Freeland (1979) pointed out that the interference from the appliance helps to:
a) create a more favourable oral environment, thus permitting a normalization of the teeth and denture
bases to occur. Fränkel (1976, cited in McDougall, 1982) stated that the developmental inhibition in the size of the underlying skeletal structures that support the teeth is causally related to perioral and buccal muscle function. Fränkel (1966) felt that these muscular pressures are abnormal in many patients with malocclusion, and that they restrict growth.

The advocates of the Fränkel appliance therapy claimed that the removal of these abnormal pressures enhances unrestricted growth up to the patient's inherent potential, tending to relieve dental arch crowding and discrepancies in arch relationship (Hotz, 1970).

b) "re-educate" the muscles. Fränkel (1966) pointed out that the vestibular and lip pads can be compared to an instrument over which the soft tissue is pulled back and forth, being massaged in the process. This means that the lip and cheek muscles and their neuromotor functions, such as speaking, swallowing are subjected to a major re-education scheme.

4.4 Mandibular Adaptation

Owen (1981) stated that forward mandibular positioning by the appliance would stimulate mandibular growth.

Ware and Taylor (1968) asserted that the modification in mandibular position is in the first place postural, but continued development in the new environment induces osseous changes.

The capacity of the temporomandibular joint to adapt in response to alteration in its functional environment is a
highly controversial issue in dentistry. One group of authors such as Hiniker and Ramfjord (1966); Bjork (1951) believe that the skeletal pattern cannot be influenced, another group such as McNamara (1973b); McNamara and Graber (1975); Petrovic (1975, 1977); Stockli and Willert (1971) are convinced that, in the case of bite shifting with the help of functional appliances, the lower jaw can be moved forward permanently.

4.4.A  Embryology of Condyle:

Embryologically, there is substantial evidence of the condylar adaptability to functional changes. Most of the articulations in the body are originally formed from the primary cartilagenous skeleton. Numerous clinical and experimental studies have shown that primary cartilages are extremely resistant to changes in pressure and tension, and provide the skeleton with a mechanism of growth under compressive forces (Blount and Zier, 1952) (Strobino, et.al. 1952).

In contrast to most other bones of the body, the mandibular articulation of the mandible is not derived from primary cartilage, but is secondary in nature, and perhaps is closer to the periosteum in its response to pressure and tension (Moffett, 1966) (Petrovic and Stutzmann, 1972) (Durkin,1972,1973).

McNamara (1980) claimed that immunological studies by Brigham and co-workers (1977) have shown distinct differences between the cartilage of the mandibular condyle and other cartilages of the craniofacial and appendicular skeletons. Developmentally, the condyle differs from other joints in that an embryonic zone persists throughout life (Baume
and Derichsweiller, 1961). The mechanism of jaw growth and mandibular positioning appears to be controlled by a differential rate in cellular activity within the embryonic zone of the condyle. The pattern of cellular activity changes with age, except in the posterior region which suggests constant anteriorly directed growth of the mandible (Folke, 1966). These observations are substantiated by several researchers who noted that articular surfaces of the condyle are active sites of growth and remodelling throughout life (Johnston, 1959) (Moffett, 1966) (Radin et al., 1972) (Carlsson and Oberg, 1974).

Carlson, McNamara and Jaul (1978) asserted that articular tissues are highly adaptable to mechanical demands, with changes in function and associated mechanical stresses throughout life resulting in altered articular contours and size.

Also biochemically, the condylar cartilage is distinct from the other growth cartilages of both the craniofacial region and the appendicular skeleton (Carlson et al., 1978). Morphologically, its various layers appear to be continuous with the two major layers of the periosteum along the neck of the condyle with the articular layer corresponding to the outer fibrous periosteum, and the pre chondroblastic-chondroblastic layer corresponding with the inner osteogenic layer of the periosteum (Duterloo and Jansen, 1969; Wright and Moffett, 1974; Carlson et al., 1978). These observations have led to the conclusion by Petrovic and Stutzmann (1972) that the cells of the pre chondro-blastic zone and the pre osteoblasts of the remainder of the periosteum of the mandible are homologous.
Thus since it is generally believed that mechanical forces are capable of both stimulating and inhibiting periosteal osteogenesis (Meikle; 1973), it is not illogical to expect according to McNamara and Carlson (1979) that alterations in mandibular function which result in an altered biomechanical or biophysical environment in the temporomandibular region ultimately lead to an adaptive response in the cells of the condylar cartilage.

4.4.B Studies of Condylar Growth to Altered Function

As early as 1933, Breitner showed that condylar growth site responds to physical forces and that distraction of the condyle within fossa may serve as a stimulus to adaptive condyle growth.

Unilateral surgery involving unilateral detachment with and without anterior positioning of the masseter muscle is used to alter the functional forces of the lateral pterygoid muscle of the rat. This alteration in muscle function led to a change in morphology of the mandibular condyle, and demonstrated the adaptive nature of the condylar cartilage to functional demands (Ghafari and Heeley, 1982).

McNamara and Carlson (1979) claimed that the prechondroblastic-chondroblastic cartilage is the principal site of adaptive condylar growth. Recent experimental research demonstrates that the role of the growth cartilage within the condyle is to maintain the functional integrity of the temporomandibular joint during translation of the mandible downward and forward during craniofacial growth (Stöckli and Willert, 1971) (McNamara 1972, 1973b) (Petrovic et al., 1975).

Furthermore, the apparently haphazard arrangement of cells within the pre chondroblastic and chondroblastic zones according to McNamara (1973b) suggests that the condyle has the capacity for multidirectional growth. Thus, it possesses the potential for relatively rapid adaptation to altered mandibular position or function.

Petrovic and co-workers (1975) have shown that repeated application of a postural hyperpropulsor during the growth period in rats resulted in a significant increase in overall length of the mandible in treated animals relative to controls after both have reached maturity.

McNamara and Carlson (1979) have shown cephalometrically and in a preliminary histologic study that growth of the temporomandibular joint particularly of the condylar cartilage, can be increased in comparison to control level values through the insertion of an appliance which prompts the jaw to function in an anterior position.

In contrast, a group of authors such as Hiniker and Ramfjord (1966); Ramfjord and Enlow (1971); Ramfjord, Walden and Enlow (1971); Ramfjord and Blankenship (1981), observed only insignificant adaptive changes in the temporomandibular joints of Rhesus monkeys exposed to anterior displacement of the mandible. These studies have emphasized
the primacy of accommodative changes in the dento-alveolar region in the adaptive response prompting the observation by Ramfjord and Ash (1971, page 178) that there is a "need for adapting the occlusion to the joints rather than hoping for the joints to adapt to the occlusion."

These contrasting views can be explained by the fact that

(1) the latter authors utilized non-growing animals,
(2) forward activation amounted to 1.5 mm only in the latter studies. The effect was traumatization of the dental support rather than adaptation in the joints.

4.4.C. The Role of Muscle Function in Condylar Growth

Charlier (1967) and Petrovic and Stutzmann (1972b) suggested that condylar growth may be dependent upon functional stimulation, especially from the lateral pterygoid.

Later studies by Petrovic and Stutzmann (1972) cited in McNamara, 1973a) furnished new data concerning the relationship between the function of the lateral pterygoid muscle and the growth of the the temporomandibular joint. The resection of the lateral pterygoid muscle from the mandibular condyle in growing rats caused a decrease in condylar growth. Without this muscle, chondroblasts in condylar cartilage tended to become osteoblasts. The unilateral resection of the lateral pterygoid muscle was followed by a reduction in cell multiplication in the adjacent condyle. Therefore, it seems that this muscle is a part of the chain of biomechanical processes which control the growth of condylar cartilage of the mandible.
4.4.D  Neuromuscular Response to Protrusive Function

Ever since the introduction of the Norwegian system of orthodontic treatment by Andresen and Häupl (1936), the stimulated muscle activity produced by the functional appliance has been widely discussed.

Andresen (1936, cited in Ahlgren, 1978) claimed that in the treatment of Class II, Division 1 malocclusion, the protractor muscles of the mandible were stimulated and the retractor muscles were inhibited by the use of an activator. The stimulation of the protractor muscles was an important part of the treatment, because in distocclusion (Class II) cases, these muscles were weak and underdeveloped. In other words, Andresen claimed that the treatment was directed not only at the malocclusion but also at the dysfunction.

Andresen's hypothesis was later seriously questioned by Eschler (1952, cited in Ahlgren 1978), who claimed that, in the treatment of distocclusion cases, it was the retractor muscles that were stimulated because of the stretching of these muscles by the activator. Eschler based his theory on the stretch reflex of the muscles.

In his investigation of the electromyographic response during activator treatment Ahlgren (1966, 1978) produced evidence lending support to Andresen's opinion that the use of an activator stimulated the protractor muscles and inhibited the retractors. (Fig 7)

This finding is also supported by McNamara (1980). He found characteristic decrease in the activity of the posterior temporalis muscle, an increase in the activity of the masseter
Fig. 7  Diagram of early electromyographic response from the temporal (elevator-retractor) and masseter (elevator-protractor) muscles during activator treatment of a Class II, Division 1 malocclusion. (From Ahlgren, 1978)

...muscle and, most significantly, an increase in the function of the superior head of the lateral pterygoid muscle, following appliance placement. (Fig 8)
Fig. 8, from McNamara, 1980
An increase in postural activity could be observed in the superior head of the lateral pterygoid muscle one day to one week following appliance placement.

Ahlgren's late (end of treatment) electromyographic response can be summarized diagrammatically in Fig. 9. The gradual return toward original levels and patterns of muscle activity can therefore be observed by the end of treatment; unless a dual bite has developed.

These electromyographic changes of the lateral pterygoid muscle, however, are questioned by Auf der Maur (1980). Contrary to Ahlgren's findings (1978) and McNamara investigations (1973b) (1980), Auf der Maur found in his twin patient that no activity of the lateral pterygoid muscle is needed to maintain the protruded position of the mandible while the activator is being worn. (Fig. 9a)
Hence electromyographic changes of the lateral pterygoid muscle remain a controversial issue.
Diagram of late electromyographic response to the temporal (elevator-retractor) and masseter (elevator-protractor) muscles during activator treatment of a Class II, Division 1 malocclusion. A, Intercuspal position before treatment. B, Closure with an activator in the mouth. C, Intercuspal position at the end of treatment. D, Closure in dual bite. Fig. 9, from Ahlgren (1978)
The activator is in place, the mandible is in a protruded position caused by the construction bite. A short activity of the muscular system of the floor of the mouth is noticeable. No activity of the lateral pterygoid muscle. Fig. 9a, from Auf der Maur (1980)
4.4.E. Timing of Skeletal/Muscular Adaptation

It has been widely accepted that constant mandibular forward positioning would initially induce alteration in muscle function, especially lateral pterygoid muscle activity (McNamara, 1973b). This increased activity lasted for a period of time (4 to 8 weeks in monkeys, McNamara and Carlson, 1979), followed by gradual reappearance of normal muscle pattern activity (12 to 24 weeks after appliance cementation in monkeys, McNamara and Carlson, 1979).

Any single muscle or muscle group which has been elongated, has several adaptive mechanisms available to re-establish functional homeostasis (McNamara, Hinton and Hoffman, 1982):

1. Elongation of muscle themselves. Crawford (1954) has shown that the functional length of a growing muscle can be increased by increasing the amount it must be shortened during contraction. He states that experimentally lengthened muscles increase in length either through the addition of sarcomeres or through re-orientation of the muscle fibres themselves.

2. Altered neuromuscular feedback mechanisms. Reflex control of tonus of the involved musculature can be modified through the activity of the fusimotor or gamma efferent system without direct obvious anatomical changes of the muscles themselves. Nichols and Holm (1973) have shown that autogenetic reflexes play an important role in muscular control since they compensate for variations in muscle properties.
3. Migration of muscle attachments. Enlow (1962) and, Hoyte and Enlow (1966) have described the nature of the moving muscle attachments to growing bone.

4. Change in muscle dimensions due to linear displacement and/or rotations of the bony elements. There is lengthening of some muscles and shortening of others as the bony elements are separated and the mandibulo-maxillary relationship altered antero-posteriorly. Thus creating differential stress within attached connective tissue which is presumably transmitted to bone.

The adaptations at the condylar cartilage are also time dependent. According to McNamara and Carlson (1979), there was a dramatic increase in the thickness of the prechondroblastic-chondroblastic layer in the posterior region of the condyle during the initial weeks following placement of the protrusive appliance. After this initial time, there was a gradual diminution of the response of the cartilage until the thickness of the prechondroblastic-chondroblastic layer returned to original. Thus, the gradual disappearance of modified neuromuscular patterns may be directly correlated to the gradual skeletal adaptation.

Specifically, it appears that as skeletal adaptations occur (that is, the mandibular condyle becomes re-established structurally within the glenoid fossa), the need for adaptive muscle function is reduced. Therefore, there seems to be a correlation in time between the appearance and disappearance of altered neuromuscular function and the activity of condylar growth.
4.4.F. **Proposed Model of a General Sequence of Adaptation**

McNamara (1980) developed an excellent animal description to give us an overview of neuromuscular and skeletal adaptations occurring during the functional protrusion (Fig 10).

Overview of neuromuscular and skeletal adaptations occurring during the functional protrusion experiments. The insertion of the appliance (A) results in a change in the sensory stimuli to various oral facial receptors. This information is relayed (B) to the central nervous system (CNS) which mediates changes in the level of activity (C) of various craniofacial muscles. This change in activity leads to the forward displacement of the mandible (D) in both phasic and tonic activities. The above neuromuscular responses are rapid in nature. Skeletal adaptations are more gradual. Structural harmony can be re-established by a combination of mechanisms including dentoalveolar movement (E₁) or increased condylar growth (E₂). The exact nature of the skeletal adaptations depend upon the age of the animal. Such adaptations again alter the sensor stimuli which is transmitted (F) to the central nervous system. The need for neuromuscular adaptations is reduced (G) so that normal structural and functional balance is once again attained.

*Fig.10, from McNamara, 1980*
The placement of the appliance results in an immediate change in the stimuli to the receptors in the orofacial region, particularly those in the tongue, gingiva, palate, dentition and the temporomandibular joint. McNamara (1980) said that this alteration of stimuli is transmitted to the central nervous system which mediates changes in muscle activity, most significantly an increase in the function of the lateral pterygoid muscle. These muscular changes are very rapid (Ahlgren, 1978).

Structural adaptations are more gradual in nature. Depending upon age, structural balance is achieved by a forward movement of the dentition and/or increased growth at the temporomandibular joint. As structural balance is restored during the weeks and months following appliance placement, the need for altered muscle activity is lessened, and there is a gradual return to more typical muscle patterns; that is, the final electromyograms are similar to those seen before the experiments, though there have now been extensive bony adaptation (McNamara, 1973b).

4.4.G. **Condylar Growth Response To Altered Function**

*In Perspective*

One question that must be answered is that whether we can influence the condylar growth with anterior positioning of the mandible.

Experimental investigations such as Haüpl and Psansky (1939), Derichsweiller (1958), Hoffer and Colico (1958), Baume and Derichsweiller (1961), Joho (1968), Leib and Schlagbaucer (1970), Stöckli and Willert (1971), Stöckli
(1972), Adams et al. (1972), Elgoyhen et al. (1972), McNamara (1972, 1973b, 1975), McNamara and Graber (1975), McNamara and Carlson (1979), McNamara, Hinton and Hoffman (1982), Petrovic et al. (1975) demonstrated that functional anterior displacement of the mandible produced increased growth rate at the head of the condyle.

McNamara (1973b) stressed the important difference between the response in young animals and in adult animals. Marked skeletal adaptation occurred only in young animals whereas movements in the dentition prevail in adult animals.

Sergl (1976) commented that the clinical findings of Korkhaus (1957), Weise (1957), Hausser (1961), Herren (1963), Müller (1963, 1965), Meach (1966), Marscher and Harris (1966), Freunthaller (1967) support the clinical impression of many orthodontists that mandibular growth rate can be increased and that the mandible can be relocated permanently in a more forward position. Hirzel and Grewe (1974) stated that May (1972) using cephalometric laminagraphs observed that the horizontal growth of the condyle was more than three times as great in the functional activator group as in the control group in a study at the University of Minnesota. Fränkel (1974) has also shown cephalometrically that the position of the mandible can be permanently advanced by treatment. However Björk (1951), Ewald and Harvold (1966), Jakobson (1967), Harvold (1968), Harvold and Vargervik (1971) could not substantiate these views.

Such disagreement of the use of functional appliance as to the effects on the mandibular growth, according to McNamara (1975) is due to:

a) Use of different diagnostic criteria and measuring techniques.
b) Erroneous assumption that all functional appliances have the same mechanism of action.

It should be remembered that the Fränkel appliance is distinct and different compared with other functional activator appliances. Activators are loose fitting devices and, as claimed by Björk (1951) changes in the relationship of teeth are mainly produced by rearrangements of the dento-alveolar structures and not by changes in the basal relationship of the jaws. This may be because pressure applied by the inclined planes frequently incorporated in the activator causes the dental system to react so rapidly that no prolonged effect on the joint can be accomplished.

The Fränkel appliance, on the other hand, accomplishes an anterior displacement without bringing the appliance into contact with the mandibular teeth. Thus, according to Fränkel (1975a), changes in the antero-posterior occlusion of the teeth in the buccal segments cannot be explained by mesial movement of the mandibular teeth, just as the correction of the overjet cannot be the result of proclination of the lower incisors. However, this assertion is questioned by clinical findings observed by Adams (1969), Schulhof and Engel (1982), and Robertson (1983). The effect of the lingual shield which comes in contact with the mandibular supporting tissue requires further investigation, especially in relation to its effect on the lower incisor antero-posterior position.

With respect to the Fränkel appliance, the position of the mandible is changed through gradual training of the
protractor and retractor muscles, followed by condylar rebuilding. Fränkel (1975) pointed out that the lingual shield guide the mandible to a mesial position and causes pressure sensation on the lingual side of the alveolar process. This reactivates the protractor muscles, especially the lateral pterygoid muscles which are gradually conditioned to hold the mandible in the position determined by the construction bite. The basal correction is due to histodifferentiation on the condylar growth site which has been stimulated by a real repositioning of the mandible.

In short, therefore, by changing the position of the condyle within the glenoid fossa, the biomechanical conditions in the joint are altered, which in turn redirect the growth process. In Moss' terms, Fränkel (1975) said that his apparatus does influence the spatial position of the mandible. In this way, translative growth processes might be induced and directionally influenced at the condyle.
CHAPTER FIVE

APPLIANCE CONSTRUCTION

5.1 Impressions:

One begins with upper and lower impressions of the mouth. Successful Fränkel therapy depends upon the fit and comfort of the appliance, thus proper impression technique is of the utmost importance. A properly fabricated appliance will have superior and inferior borders of the vestibular shields that will slightly encroach on the patient's resting vestibular sulcus, vertically and horizontally (Fränkel, 1971, 1974). Therefore, an impression tray which does not cause over extension or lateral distortion of the associated soft tissue should be used. Lateral distortion of the soft tissue prevents the proper extension of the flange of the impression deep into the vestibular sulcus and in the anterior labial region.

McNamara (1982b) recommended two types of tray, custom trays and thermal sensitive trays. He currently uses thermal sensitive trays, which are made out of non-heat-conducting plastic. The trays are dropped in a water bath at about 175 degrees, placed on the study model for a rough trim, placed back in the water bath, and then placed in the patient's mouth and moulded to fit the patient's arch. Compound can be used to extend the trays in the lower labial region and in the areas of the tuberosity. Only use one-half of the
usual amount of alginate in these trays because they fit so closely.

Logan (1971) recommended that the impressions are taken on an anatomical basis with no muscle trimming in any sense of the word. The whole height of the alveolar process must be carefully recorded and it is very important that the child is asked to relax the muscles of the lips while this is being done. Often the lower lip is automatically contracted and this will prevent the correct recording of the mucosa overlying the alveolar process in the apical region of the lower incisors.

The ideal Fränkel impression has maximum extension vertically, but minimum extension laterally and antero-posteriorly. There should not be thick rolls of alginate in the vestibule, because this will distort the extension of the vestibular shields when the appliance is made (McNamara, 1982a). In any case, these impressions should have a very full depth of sulcus since when in place, the edges of the vestibular shields and lip pads gently contact the soft tissue. A properly fabricated appliance will have superior and inferior borders of the vestibular shields that will slightly encroach on the patient's resting vestibular sulcus, vertically and horizontally (Eirew, 1976).

The impressions should then be cast with a wide periphery in order to obtain full details of this sulcus which would be modified during the early stages of construction. McNamara and Huge (1981) recommends that one should make sure that the distance from the lateral extension of the base of the model to the alveolar surface should be at least 5 mm. This
will allow for the proper application of wax relief and acrylic at a later time. Also, one should not trim the postero-lateral corner of the model bases too severely, since doing so will make the placement of the wax relief in the region of the last molar difficult. Adequate base is also necessary to allow trimming in a manner similar to that used for orthodontic study models.

5.2 Mounting The Work Models:

The models are then mounted on an articulator using the wax working bite. For most Class II problems, the bite will normally have been taken in an edge-to-edge incisor relationship with the upper and lower centre lines coincident.

The bite should never be protruded beyond the edge-to-edge position, otherwise Class III malocclusion and/or deepening of the overbite may be accidently created. Great care must be taken in mounting the casts on the articulator not to open the bite at any stage during processing. There should be a minimum of 2.5 mm of posterior interocclusal space to allow the wires to pass between the maxillary and mandibular teeth.

5.3 Model Modification:

The next step in the fabrication of the Fränkel appliance is the trimming of plaster casts for the vestibular shields and the lip pads. This is one of the most difficult technical aspects in the construction of the apparatus and has to be done with meticulous care. To produce the tissue tension necessary for the appositional development of the
apical bases (which will be discussed in Chapter 7), the vestibular shields must extend high into the sulci in the areas where this development is desired. (Fränkel 1971, 1974).

If the vestibular areas are not trimmed enough and the vestibular shields are too short, the soft tissue attachments will fold inside the shield, counteracting the therapeutic effect of the appliance (Fig. 3). If the shields are too long, they will irritate the mucosa, and the patient cannot wear the appliance. According to McDowell and Phillips (1976), the sulcus should be deepened 3 to 5 mm above the upper first premolars and about 3 mm above permanent molars.

Even the best-fitting impression tray does not give adequate extension in the lower labial region, since when the impression is taken the depth of the sulcus usually is distorted and somewhat diminished. Thus, it is necessary to modify the contours of this area manually so that the proper inferior and posterior extensions of the lower labial pads can be achieved. McNamara and Huge (1981) recommends the lower labial region to be carved with a pear-shaped carbide bur and a laboratory knife. According to McNamara (1982a), the extension of the lower labial relief is usually 12 mm below the lower border of the gingival margin, so that the lower labial wire will be approximately 7 mm below the gingival margin of the incisors.

Graber and Neumann (1977, page 531) recommended that this sulcus is carefully trimmed about 5 mm from the greatest curvature of the alveolar base.
Figure 11. Position of the mandibular lip pads: (a) solid line, actual depth of the sulcus; interrupted line, distortion by impression taking; (b) correct trimming; (c) wrong position of the pad, caused by inadequate trimming; and (d) correct position of pad.

Fig. 11 (from Graber and Neumann, 1977, page 531)

In Fig.11 the solid line marks the real depth of the sulcus, and the interrupted line points out the distortion by the impression. Fig.11 (b) shows the correct trimming of the sulcus. Seen from the side, the external surface of the alveolar should be nearly vertical after the trimming.

In addition to the trimming of the sulci, the contacts between the maxillary first molars and second deciduous molars and between the maxillary deciduous canine and deciduous first molar are carved away. On the cast this is done by sawing a 1 mm wide groove between the teeth (Graber and Neumann, 1977, page 531). The grooves accommodate the palatal bow and the upper lingual wire. It is better to carve the grooves too deep than too
shallow to insure a firm seating of the appliance on the maxilla, a precondition for the forward placement of the mandible in the construction bite position (see Chapter 6).

5.4 Wax Relief

To achieve the desired expansion of the dental arches and the alveolar processes up to the apical base, the vestibular shields have to be an appropriate distance from the lateral aspects of the teeth and the alveolus. Therefore, the next step after the trimming is to cover the buccal aspects of the models with a layer of wax.

First, pencil outlines are drawn on the model to approximate the position of the ultimate vestibular shields and labial and lingual pads. They are used as a guide in placing the wax. Layers of wax of specific dimensions are then applied to the construction models to provide for the desired relief between the acrylic portions of the appliance and the dento-alveolar region. McNamara and Huge (1981) recommends 3.0mm of wax relief in the maxillary alveolar region and 0.5mm in the mandibular region is requested. The wax layer, according to Graber and Neumann (1977, page 532) is especially important in the apical region of the maxillary first premolars, because in this area is the majority of Class II Division 1 malocclusions the maxilla is narrowed transversely to the greatest degree.

Graber and Neumann (1977, page 532) said that in some instances the amount of wax relief in the most superior areas may be slightly more than 3mm, depending upon the severity of undercut above the canine region and upon the path of insertion of the appliance.
It should also be noted that the wax relief on the mandibular cast tapers to a narrow edge inferiorly. Although the thickness of wax relief at the inferior border is only 0.5 mm, there may be 4 to 6 mm of wax relief in the region of the dentition (McNamara and Hugé, 1981).

This wax relief is carried out into the deepened exteriors and should then be smoothed and trimmed to the outline of the future side shields. In the same way, wax is added to the labial alveolus so as to keep the lip shields clear of the tissues on insertion. The relief here should be 2 mm deep in the sulcus, thickening to 3 mm at the lower edge (McDowell and Phillips, 1976).

5.5 Construction and Position Of Wires

After the wax layer has been applied, the wires are bent and placed on the models. The stabilizing and connecting wires are of heavier wire (1.5 mm to 0.8 mm), whereas the tooth-moving wires are thinner (0.8 mm to 0.9 mm). These wires should not be in contact with the soft tissues in order to avoid abrasions.

The wires situated in the vestibule which are not covered by the acrylic should not be more than 1.5 mm from the alveolar mucosa. On the lingual side of the alveolar bone and on the palate, the distance between the wires and mucosa should not be more than 0.75 mm. On the vestibular side the wires should be bent to follow the natural curve of the labial alveolar bone in order to avoid irritation of the soft tissues. The wire must run parallel to the lining, a clearance of 0.75 mm between wax and wire. The ends of the
wires are bent at right angles to the wax layer. This will help to stabilize the position of the wires at their distal ends.

5.5.A Maxillary Wires

The palatal wires which also form occlusal rests on the upper first permanent molars, is made from 1.2 mm -1.5 mm stainless steel wire. It crosses the palate with a slight curve in a distal direction. Graber and Neumann (1977, p.534), explain that this curve would provide some extra length of wire to facilitate widening of the appliance which is sometimes necessary as the apical bases develop laterally and begin to contact the buccal shields. The wire crosses the trimmed interdental space between the upper first molar and upper second deciduous molar (or second molar), makes a loop into the buccal shield, and emerges again to lie on the first molar between the buccal cusps. The maxillary rests should lie parallel to the occlusal plane, so that the molars are free to expand laterally. As the wire crosses the palate, it should be kept slightly away from the palatal mucosa tissue to prevent irritation.

Upper lingual wire should be made of 0.9 mm stainless steel. The wire originates in the area of the future vestibular shield, curves slightly upward into the disked area between the upper canine and the upper first deciduous molar (unless the first premolar is present), and then recurves along the lingual surface of the upper incisors at the level of the cingulum. The presence of the upper lingual wire, because it lies at the level of the cingulum, was
designed to prevent lingual tipping of the incisors during treatment (McNamara and Hugè, 1981).

Canine extensions are preferred by McNamara (1982a) instead of canine clasps because the latter tends to interfere with the eruption of the permanent canine, particularly during the transition period, from the mixed to the permanent dentition. The canine extensions made of 0.8 mm wire act as an extension of the vestibular shields in the canine region. The canine extensions are placed 2 mm to 3 mm away from the deciduous canines. If permanent canines are present, the canine arms can be located in a slightly closer position.

The shape and position of the upper labial wire (0.9 mm in diameter) can be seen in Fig.1B. This labial bow lies in the middle of the labial surfaces of the incisors and runs gingivally at right angles in the natural depression between the maxillary lateral incisors and the canine. Here it forms a small half loop which should lie approximately 2 mm away from the tissues above the canines before entering the vestibular shields. This is particularly important when the permanent canines are erupting, as they may hit the wire if it is not bent correctly. However, if the loops are located more than 2 mm away from the alveolar mucosa, irritation of the inside of the lip may result. This slight loop bend in the wire makes it possible to adjust the wire if necessary. The arch of the labial bow is bent in an ideal contour and rests gently on the teeth.
5.5.B. Mandibular Wires

The lip pads are held in place by lower labial wire(s). This assembly can be constructed either of three individual wires as shown in Fig. 12 or of one continuous wire.

![Fig. 12 (From McNamara and Hug, 1981)](image)

The tags of all the wires are bent at right angles so that the pads will be prevented from rotating around the wires. The 0.9 mm wire should pass from what would be the vestibular shield in a slight antero-posterior direction, as well as in the same horizontal plane so that the lip pads can be advanced or retracted as necessary. Like all the wires in this appliance the lower labial wires are positioned at least 0.5 mm to 0.75 mm away from the wax relief in order to ensure that the wires will be embedded completely in the acrylic. The gable bend of the centre wire must be high enough to avoid irritation of the labial frenum.

The design and location of the lingual parts of the mandibular portion of the appliance is shown in Fig. 13.
Again like the lower labial support wire, it can be formed either from a single piece of 1.0 mm stainless steel or three separate pieces of wire.

The wires (1.00 mm) are fabricated in the general configuration of the future lower lingual pad. They are then curved back on themselves and directed upward and laterally to cross the inter-occlusal area between the upper and the lower arches, in the region of inter-proximal area between the mandibular first and second deciduous molars. If the crossover wires lodge inter-proximally between the teeth, tooth eruption will be inhibited and possible mesial movement of the lower dentition may occur during treatment.

The lateral ends of the wire are parallel to the occlusal plane and parallel to each other because they can be used as guides when the lower anterior section of the appliance is advanced in future treatment adjustments. The portion of the crossover wire embedded in the vestibular shield must be perfectly straight so that it can slide through the vestibular
shield as the lower labial and lingual shields are advanced as a single unit. However, with this advancing technique, one may question the future accurate fit of the lingual and labial pads. In the final analysis, it would seem necessary to destroy or modify the acrylic parts of the labial and lingual shields.

The wire assembly should be positioned approximately 1 mm to 2 mm away from the underlying tissue to allow trimming of the acrylic. The wire(s) should be positioned approximately 3 mm to 4 mm below the gingival margin on the lingual surface of the mandible. Otherwise gingival irritation and stripping of the lingual gingiva may occur by the acrylic lingual shield being finished too high.

The lower lingual springs made of 0.8 mm stainless steel wire are contoured to the lingual curvature of the lower incisors at the level of the cingulum (Fig.10). Such placement would ensure three-fold effect (Eirew, et.al., 1981):

1. Screen tongue pressure from the lower incisors. As the working bite of the appliance is in near edge-to-edge contact, the risk of unopposed tongue pressure against the lower incisors is considerable.

2. To procline the lower incisors actively in the very small number of cases where this is really indicated, i.e., where retroclination exists at the start of treatment. This applies mostly in Class II, Division 2 or where a sucking habit, biting or lip trap has tilted the lower incisors lingually.

3. To align imbricated lower incisors. This may only be done in the final stages of treatment when there
is positive contact between the upper and lower incisors and after deliberate tightening of the upper labial bow to resist protrusive forces. Fränkel (1971) suggested that pressure on the cinguli of the lower front teeth will also produce an intrusive and bite opening effect.

5.6. Fabrication of Vestibular Shields and Pads

After the wires have been bent, they are secured on the model with modelling wax. The shields and pads are fabricated in cold curing acryliscs. The total thickness of the shields and the pads should not exceed 2.5 mm.

The lower labial pads should have a tear drop in shape, not rectangular in the sagittal dimension (Fig.4). McNamara (1982a) reasoned that the tear drop shape allows proper positioning of the pads in the labial sulcus, and prevents gingival stripping when the appliance moves and the jaw opens and closes. This shape also allows for a more comfortable fit for the patient by allowing the pad to tuck into the alveolar undercut below the incisors. He also recommends that the bottom of the pad should be 12 mm to 14 mm below the gingival margin at the level of the lateral incisor.

The anterior edge of the superior portion of the vestibular shield should extend forward to approximately the middle of the canine. Inferiorly, the anterior edge of the vestibular shields should extend anteriorly to the distal aspects of the maxillary canine. In the posterior region, the appliance should extend to and cover the last erupted tooth, usually the upper first molar. The total thickness of the vestibular shields and
pads should not exceed 2.5 mm (McDowell and Phillips, 1976).

5.7. Final Check:

All the wires should be checked as distortion can easily occur during the finishing process. Crossover wire must be checked. For example, the position of the lower crossover wires should not touch the lower dentition, otherwise future eruption of the teeth involved will be prevented and mesial migration of the lower dentition will be induced.

The acrylic borders should be accurately positioned on the models. All margins have to be well rounded and polished.
CHAPTER SIX

CLINICAL MANAGEMENT

The Fränkel form of treatment differs radically from orthodontics as it is generally practised in that, we are mainly concerned with moving teeth into positions using mechanical devices designed to put pressure on the teeth. In the Fränkel's method, there is no pressure put on the teeth by the apparatus which merely releases the dental arch from the constraint of an unfavourable environment (Fränkel, 1971, 1974). Therefore, Logan (1971) recommended that we should transfer our skill from the moving teeth to helping the patient to tolerate treatment. We are not treating a malocclusion but a child.

Preconditioned factors for success of treatment using the Fränkel appliance (Graber and Neumann, 1977, page 564):

2. Right psychological introduction of the appliance.
3. The cooperation of the patient and the parents.

For practical purposes clinical management may be divided into the following stages:
6.1 Preparation

(A) Initial Patient Evaluation

(i) Physiology:

History: The usual family history, general medical, dental and orthodontic information should be acquired. Specific questions regarding the patient's respiratory history should be asked, including whether they snore when they are sleeping, what they are allergic to, whether they breathe through their mouth, if they have frequent colds, if they have frequent sore throats or tonsillitis, or if patient has any chewing or swallowing difficulty. Thus, specific information related to naso-respiratory obstruction can be assessed. In the case of positive findings the Fränkel therapy may have to be delayed until adequate or satisfactory naso-respiratory airway is established.

Radiography: McNamara (1982b) recommended that lateral and postero-anterior head film should be taken

a) to aid in diagnosis of the malocclusion;

b) to look for any possible underlying airway problems, which might not be obvious during a clinical examination;

c) to be used as an excellent visual aid when discussing the patient's problem.

Clinical: If it is decided that the case is an Angle Class II, Division 1 malocclusion facial
muscle balance must be carefully evaluated. The lips should be carefully observed to see if there is any sign of environmental imbalance. Of particular interest is a hyperactive mentalis muscle which is usually an indicator of a hypoactive orbicularis oris muscle (Fränkel, 1980b), since one of the goals of Fränkel treatment is to eliminate the hypoactivity of the orbicularis oris and the hyperactivity of the mentalis through lip seal exercises in conjunction with the appliance wear.

One useful diagnostic aid in determining a suitable Class II Fränkel candidate is through profile evaluation. That is, a significant improvement in facial form should be apparent through the anterior positioning of the lower jaw (Owen, 1981, 1983a). Any particular habits such as mouth breathing and thumbsucking which are likely to hinder the therapy should be explored. The question of sucking habits is best done by observing the child's hands and fingers. The presence of such habits does not contraindicate the Fränkel therapy, as long as the child is prepared to give up this detrimental habit.

As it has been emphasized that the Fränkel appliance is not a tooth moving appliance. Thus intra-orally, the clinician should check whether or not all the teeth are present, whether there are any supernumeraries and whether there is any element of crowding present.
(ii) **Psychology:**

The co-operation of the parents and child is a major factor in determining the success of the Fränkel therapy. The first thing is to assess the motive of the child. It is possible by careful questioning and discussion to find out whether or not the child sees anything wrong with his or her appearance and teeth, and whether he or she wishes to do anything about it. When it has been established that the child does see the disability and wishes to do something about it, the clinician should let the child hear himself or herself expressing their concern. The parent's grasp of the orthodontic problem is evaluated. This may vary from the one who says that she knows nothing about it and that she thinks her child's teeth look all right and that the dentist simply told her, or in some cases sent a message to her saying that the child had better see an orthodontist, to the mother who says that her child's front teeth stick out and that the girl looks terrible.

(B) **Preparation For The Appliance**

(i) **Explanation of the therapy:**

Time spent on full and frank discussion of the treatment with parents and child is not a waste of time but is essential if treatment is to be successful. The patient and parents should understand the basic philosophy of Fränkel therapy,
which is treating not only the teeth but also the skeletal structures and the muscular system (McNamara, 1982b).

Unaesthetic facial appearance is the most common motive of children and parents in seeking treatment. Stricher, et.al. (1979) dealing with psycho-social aspects of craniofacial disfigurement claimed that concern for physical attractiveness begins early in the childhood. In this context a number of orofacial characteristics such as lips, chin, jaw and mouth were mentioned. Deviations of tooth alignment, except in severe malocclusions were near the bottom of the rankings. Weakness of the orofacial musculature, flaccid lips, mentalis bulk and a deep mento-labial crease were regarded as being of particular importance as unattractive attributes. Extreme caution must be exercised if the child is being made aware of unattractive facial attributes and of how they can be improved with this treatment.

McNamara (1982b) pointed out that if the parents are only concerned with alignment of anterior teeth, the orthodontist must advise parents of the importance of disorders in the neuromuscular behaviour and their impact on the unfavourable facial appearance. Only when parents are aware of the psycho-social implication of such features and the need for treatment will they be sufficiently
interested to co-operate with the full course of treatment and to follow the necessary instructions. It may be explained to the patient and parent that, through gradual retraining of perioral musculature achieved through the positioning of lower labial pads and a series of lip exercises, improvement in lip seal competency can be obtained. Such an improvement will not only result in better facial profile but also enhance naso-respiratory function. Thus overall health of the child is improved as well.

During this time, a series of lip exercises may be given. These include (McNamara, 1982b):

. to remember to keep the lips sealed or together;
. a tongue blade or toothpick is held between the lips with the teeth together for at least 30 minutes daily. At the same time, the patient is instructed to consciously try to relax the mentalis muscle;
. the parents must become involved in supporting the child's effort and reminding him or her of the need to maintain the lip seal.

According to Fränkel's (1980b) long clinical experience, a calendar block may be useful to record progress. Every morning a "reminder" with a large letter "L" must be given to the child when leaving for school by one of the parents. When lip
seal training with tongue blade during homework or watching television has been carried out, parents should make a mark on the calendar each day.

(ii) **Impressions:**

Proper impression technique is essential as successful Fränkel therapy depends upon the fit and comfort of the appliance. The reader should refer back to Chapter 5 for proper impression technique.

(iii) **Bite registration:**

The next step after impressions are taken, is to take the bite registration. The construction bite, usually taken with a horseshoe wafer of medium hard wax, must orient the upper and lower dental arches in all three planes of space (horizontally, vertically and transversely).

The bite position is highly critical. In the treatment of Class II cases, Fränkel (1975) stated that the mandible should not be brought forward more than 2.5 mm to 3.0 mm, with only enough vertical opening for the crossover wires to pass through the interocclusal area. However, McNamara (1982b) claimed that a mandibular advancement of 4 mm to 6 mm can be easily tolerated by most patients. For most Class II problems, this amount of advancement will place the incisors in an edge-to-edge relationship. For more severe cases, the mandible will have to be advanced again after 4 to
6 months of full-time wear either by splitting the buccal shields and advancing the lower labial and lingual pads as a unit or by constructing a new appliance (Grabner and Neumann, 1977 page 538). Each step would be followed by a renewed growth stimulation in the condylar process.

When the mandible is advanced during fabrication of the bite, most cases will provide a vertical clearance of several millimetres at the deciduous first molar area because of incisor supra-occlusion. If advancement of the mandible does not provide at least 2.5 mm to 3.5 mm of clearance to allow the crossover wires to transverse inter-occlusally at the deciduous first molar area, the bite must be opened additionally to provide this clearance, (even in the presence of anterior open bite) - McNamara, (1982a).

It is also important to relate the mandible to the maxilla in the transverse dimension with bite registration. The upper and lower centre lines should be carefully related to each other, conforming to the true relationship of the dental arches. Most cases are symmetrical and require equal bilateral advancement, therefore, in the absence of a dental asymmetry, the dental midlines will coincide. If, however, lateral shift has taken place which usually manifested with dental midlines asymmetry (e.g., early loss of a deciduous
canine), care must be taken to maintain the midline discrepancy as correction would result in mandibular displacement and possible temporomandibular joint trauma. In this case, McNamara (1982b) recommended that the bite registration should reflect symmetrical mandibular advancement and a dental midline asymmetry.

(iv) Speech exercise:

To maximize co-operation, the patient must learn to speak properly while wearing the appliance. Logan (1971) recommended that at this stage, the child is given a poem which has been chosen so as to contain as many sibilants as possible. The child carries this about in his pocket and is told he is going to use it as a gymnastic exercise to get his teeth straight once he begins wearing his brace. He is reminded about the use of auditory feedback. He is reminded that the sound will come out of his mouth, go to his ears, proceed from there to his brain, and there he has to appraise it. If the sound is not good then he is to recognise it as such and try again to get the sound better. According to Logan (1971), this is a very important control element in treatment which the child must operate personally. The child is also given a written explanation to take to his teacher so that when he comes to wearing the appliance in school the
6.2 Treatment Implementation

(A) Introduction of the child to the appliance

The purpose of this stage is to enable the child to discover from his or her observation that the appliance is tolerable, that speech is possible, and that the overjet is reduced when the appliance is in place with a consequent improvement in his or her appearance.

Before the appliance is inserted in the mouth, the margins of the acrylic parts are inspected for smoothness. Eirew (1969) commented that one of the most remarkable experiences in orthodontic practice is to witness a child's first ever insertion of a Fränkel appliance.

The appliance is large in circumference and is usually made in edge-to-edge bite. Severe cases of Class II only reach this position with the greatest difficulty and stretching. Therefore first insertion can be quite a struggle. Then, during the next minute or so, as one speaks quietly and reassuringly, a remarkable transformation takes place. The spasm relaxes, the whole face seems to soften and melt in a new shape, disguising the malocclusion and the unsightly lip posture. To a watching parent this can be a most impressive and moving experience. The child wearing the appliance should be
invited to use a face mirror to look at the incisors and notice the changes that have taken place, including the fact that his or her front teeth do not stick out any more.

The correct seating of the appliance on the maxilla and the mandible is examined separately. If the appliance is satisfactory, notching of the teeth may be done with a diamond cylinder bur (McNamara 1982b). The notches are located at the distal aspect of the upper deciduous cuspid, the mesial aspect of the upper first deciduous molar, and the distal aspect of the upper second deciduous molar. The upper first permanent molar is not notched. The presence of upper bicuspids indicates the need of separation either using brass wires or elastic separators prior this appointment. The permanent teeth are not notched. However, the work models of a patient with partial or complete permanent dentition are notched (McNamara, 1982b).

After notching (or separation), it is best to place two index fingers under the inferior aspect of the vestibular shields and push the appliance vertically upward to check whether the wires are seated into the notches on the maxillary teeth. The extension of the shields is, then, checked so as to have the required distance from the alveolar parts to facilitate widening of the dental arches. The margins of the shields and pads should fit exactly in the sulci, but there should be no blanching of the mucosa. Blanching is most likely to
occur in the region of the buccal frenulae and the lower margin of the lip pads. There should be no overextension of vestibular shields in the posterior and canine regions. Owing to the use of clear plastic, it is possible to see blanching taking place where undue pressure is being exerted on the mucous membrane.

In general, any pressure and tightness complained of by the child should be carefully checked to differentiate between the intending stretching which the patient will get used to, and trauma likely to lead to mucosal ulceration.

Eirew (1976) recommended that peripheral easing should be undertaken most reluctantly and sparingly, a shortened margin may allow soft tissue to "creep" under the shield. A slow "breaking in" regime which will be described shortly, is therefore prescribed to avoid unnecessary easing. Finally, the clinician should palpate on the outside of the child's face to ensure that there is no sharpness and everything blends in contour.

In order to maximize co-operation, the patient must learn to speak properly while wearing the appliance (Logan, 1971) (Fränkel, 1980b) (McNamara, 1982b). With the appliance in place, the child is to repeat the speech exercise which was mentioned previously. This is recorded on a tape recorder. Speech on this first occasion can either be surprisingly good or may be not so intelligible. The child is then told to repeat the poem again and to listen carefully to himself or herself speaking. Now the
child is told that it is not necessary to speak in that particular fashion, that one can speak quite normally but it is necessary to keep the lower jaw forward and incisors practically edge-to-edge. The patient is then requested to repeat the exercise once again with the teeth in the indicated position and to listen carefully as it is carried out. It is pointed out that this effort is very much better than the previous ones. The child is told once again about the auditory feedback; that the sound of voice has to come into the ears and be appraised in the sensorium and that as a result of the appraisal he must make the appropriate changes to the position of his mandible. Once again the child is invited to repeat the exercise this time with auditory feedback working and this attempt is recorded. The speech by now is usually practically normal and the first recording and the second recording are now played over so that the patient can hear the difference. All this must be done carefully and slowly with careful checks to ensure that the child is assimilating what is said. It is no use hurrying over this process and not taking the child with step by step (Logan, 1971). Furthermore, McNamara (1982b) instructed his patients to read out aloud at home to parents or another member of the family with the appliance in place, until satisfactory speech patterns are re-established.

General instructions:
The appliance is to be worn on a full-time basis, with the exception of eating, toothbrushing, playing contact

While it is important to stress ultimate full-time wear, there is a break-in period. The establishment of a new neuromuscular reflex response to bring the jaw forward takes several weeks. Thus, the patient is instructed to wear the appliance for a few hours (e.g., 2 hours) a day at first, increasing wear an hour or two each day over a two-week period (McNamara, 1982b). During this period, the tissues will gradually adjust to the appliance. Actual pressure sores are gradually eliminated by cautious easing and padding with small strips of lint or cotton wool. "Bonjela" or an astringent mouthwash may also help.

At the end of two weeks, most patients are wearing the appliance full-time, except at night. The patient should be completely adapted to wearing the appliance during the day before the appliance is worn at night. If the patient has not adapted to holding the constructed mesial position of the mandible, the jaw will drop back in sleep, and abrasions of the mucosa are likely to result (Eirew, 1976).

The patient is also told that when the appliance is taken out of the mouth it must be washed carefully with soap and warm water and placed in a container. To avoid distortion or damage to the appliance, on no account must
the patient carry it loose in the pocket. The patient is also warned that if the appliance begins to press, like a new pair of shoes as Logan (1971) puts it, it may produce a little mark on the mouth, in which case the patient is to continue wearing the appliance and to arrange to see the operator as soon as possible with the mark still present so that the adjustment can be exactly made.

(B) **Supervision of Treatment**

The appliance and treatment progress should be checked at four to six week intervals. During these visits, the clinician looks for:

(a) **Any problems**

*Breakage*: the wires break occasionally and these can be repaired with electric or flame soldering or a tube repair soldering. Breakage of the acrylic part of the appliance may be readily repaired using an adhesive such as cyanoacrylate, and backing it up with cold cure acrylic. If the appliance has been deformed beyond repair, the appliance should be completely remade. Occasionally, the child finds difficulty with the appliance coming out at night. Logan (1971) recommended a cure by making use of a simple headgear including a tape tied under the chin. Usually it is not necessary to use this headgear for more than one or two nights; thereafter the appliance stays in place.
Co-operation and evaluation of treatment progress

Logan (1971) explained that "we must transfer our skill from the moving of teeth to helping the patient to tolerate the treatment." Motivation is the key word to maximize the child's co-operation. The clinician should talk with the child for any problems, ask him or her about hours of wear, and get some idea of the level of co-operation. McNamara (1982b) used a chart as a means to keep an appliance wear record. The appliance use should total 20 hours per day. A build up of plaque or calculus on the appliance may also be used as an indication that the child is wearing it, although cleaning (the appliance) is essential. Another indicator that the patient is wearing the appliance adequately is the presence of wear marks in the depth of the vestibule when shields and pads have been properly extended into the vestibule. These "wear marks" are apparently areas of local hyperaemia and a supposedly increased area of mucosal mitotic activity produced by the tension of the shields and pads on the tissues (Owen, 1983a). Logan (1971) checked the degree of co-operation by the speech. The child is invited to say his poem given previously and the quality of the sibilants is very carefully noted. The clinician must ensure that the child is consciously using the auditory feedback.
Treatment progress can be evaluated by measuring the change in the inter-molar, inter-premolar width, and the overjet and careful noting of the occlusion. After the child has been wearing the appliance for several months they should have some difficulty positioning their lower teeth and jaw posteriorly. They can do it, but it is uncomfortable. McNamara (1982b) called it "pterygoid response" because presumably the lateral pterygoid muscles are helping keep the mandible forward (see Chapter Four). If the child does not experience difficulty in positioning the jaw backward, the operator should be suspicious that the patient is not wearing the appliance. Occasionally, a patient will say he can't bite on his posterior teeth. The only place he can occlude is on the anterior teeth. According to Logan (1971), a reduction of the disto-occlusion takes place in 3 months, and within a month there is a definite increase in the inter-premolar width and this continues for 3 to 4 months. If the child is not able to manage the apparatus, it will be found that in 2 months nothing has happened at all.

(c) Required adjustments:

During the treatment, only a few changes are made with the appliance.

The palatal bow should lodge well into the proximal spaces. As the teeth erupt, the wire will begin
to impinge on the inter-dental papillae. When that happens, the molar supports on the maxillary first molar should be bent cervically to relieve pressure.

The labial bow should be carefully kept away from the teeth until after mandibular growth has established a balanced Class I relationship. Owen (1983a) said that retraction of the maxillary incisors too early in treatment may produce an incisor interference which may prevent or limit the potential for condylar/mandibular growth. The incisors can always be retracted toward the end of treatment, otherwise this tipping will be magnified to the detriment of the overall treatment.

The lower labial pads must be placed well into the sulcus to produce the necessary mucosal stretching. If the patient has a severe Class II, the mandible should be brought forward in steps. In fact, Fränkel (1975) believed that several advances of the appliance in small increments is the best possible way of achieving the physiologic response. He recommended that the bite only be brought forward 2 mm or 3 mm every four to five months. McNamara (1982b) advanced his appliance 4 mm to 6 mm at any one time.

At the moment, no definitive studies have been published on the subject of how much the bite should be advanced at one time.
To advance the bite in severe cases, the labial and lingual pads can be brought forward as a unit by cutting the vestibular shield between the extension of the crossover wire and the upper lingual wire with a crosscut fissure bur.

Fig 14 Advancing the Fränkel. A. Initial cut through the vestibular shield. Note that the extension of the crossover wire remains intact. B. The lower labial pads and lingual shield are moved anteriorly as a unit as the anterior section is brought forward. from McNamara (1982a).

The cut is extended downward so that the acrylic is freed, but the extension of the crossover wire is still embedded in the buccal shield. The lower anterior part of the appliance can then be slide forward, with the 1.25 mm crossover extension as the guide wire. The anterior assembly is advanced the desired amount, the space between the acrylic parts is refilled with cold cure acrylic, and the
shields are recontoured. McNamara (1982a) called this procedure "advancing the Fränkel." As it has been mentioned before, one may question the future accuracy of the lingual and labial pads after the advancement. It seems that the above procedure would require further modification of lingual and labial pads.

(c) **Stabilization/Retention**

Once the occlusion is as near as normal as it is likely to reach, which may take about two years, a stabilization program commences. During this time the appliance is worn at night time only. As to how long this is to be worn no one really knows. Logan (1971) thinks that the child should wear it until growth stops at about the age of 16 or so. The occlusion should also be checked twice a year to make sure that it is stable and to ensure that no untoward development is occurring. Graber and Neumann (1977, page 563) recommend a retention period of 2 to 3 years.
CHAPTER SEVEN

THERAPEUTIC EFFECTS

The effects of the Fränkel appliance occur in three areas:

1. Basal bones
   i. mandibular growth
   ii. maxillary retraction/re retardation

2. Dento-alveolar

3. Muscle

7.1 Basal Bone Changes

Growth is an important factor that can help or hinder the orthodontic treatment of young people. Relating growth to orthodontic treatment implies an attempt to correlate therapeutic effect with growth increment. The ability to predict and control the magnitude and direction of natural growth potential would be beneficial in orthodontic treatment.

(i) Mandibular growth

By influencing the spatial position of the mandible, it affects the underlying condition to regulate the growth processes. In this way, transative processes might be induced and directionally influenced at the
condyle (Fränkel, 1975). As Ware and Taylor (1968) put it: "The modification in mandibular position is in the first place postural but continued development in the new environment induces permanent osseous changes."

However, uncertainties still present about whether this forward mandibular growth adaptation occurs or not, as many authors are differing in their views. The proponents of the activator type functional appliances such as Gresham, (1952), Häupl (1952), Herren (1959), Korkhaus (1960), Marschner and Harris (1966), Hausser (1969), Ahlgren (1972)(1978), Demisch (1972), May (1972), Enlow (1975) claimed that these appliances stimulate mandibular growth.

Other investigations such as Björk (1951) (1953), Softley (1953), Meach (1966), Jacobsson (1967), Trayfoot (1968), Hasund (1969), Harvold and Vargervik (1971), Woodside (1973), Harvold (1974), Weislander and Lagerstrom (1979) and others, could not find any evidence of condylar growth increases. They showed that sagittal improvement caused by these appliances is due to dento-alveolar changes and that these appliances tend to tip the mandibular incisors labially.

Given these views, it is important to realise that the mode of action of the Fränkel appliance is different from that of the activator-type appliances. The acrylic parts of the activator are inside the dento-alveolar arch (the Fränkel appliance has only a lingual shield). The
activator becomes effective by being in contact with the dento-alveolar process, the Fränkel appliance by standing away from it (except with the lower lingual pads and maxillary crossover wires). The lower lingual shield functions to guide or hold the mandible in a more forward position. The maxillary crossover wires which usually lodge between the deciduous teeth, provide antero-posterior locking of the appliance. According to Owen (1981, 1983a), the presence of such antero-posterior lock will prevent not only the maxillary teeth from tipping lingually but also reduce the likelihood of mesial migration of the mandibular dentition, thus condylar growth can be induced. Activators are operative by exerting pressures, the Fränkel appliance by withholding pressure and, in addition by exerting traction on the outer alveolar wall. Unlike the activator the projecting vestibular shields of the Fränkel appliance screen the dentition from the muscular forces, i.e., the lips and cheeks.

Sagittal correction by the Fränkel apparatus, therefore, can only be explained by skeletal mandibular growth adaptation, not through mesial movement of the mandibular buccal teeth, since none of the parts of the appliance touch the mandibular buccal dentition. This is confirmed by a study conducted by Petrovic, et al. (1982). Using organ cultures designed to detect the sites and rates of formation and resorption of the alveolar bone, they concluded that no mesially directed
movement of the mandibular premolar could be detected. These authors also noticed that there is more marked effect of the Fränkel appliances in patients with anterior growth rotating mandibles. They attributed the higher responsiveness of the condylar cartilage and of the sub-periosteal layer of the posterior border of the mandible to orthopaedically-elicited stimulation of growth.

Fränkel (1974) and Owen (1981) have shown cephalometrically that the position of the mandible can be advanced permanently by treatment. Creekmore and Radney (1983) found that in their Class II and Class I Fränkel sample, there is an increase in mandibular length of 1.1 mm as a result of an increased backward direction of condylar growth. Cephalometrically, Owen (1981) concluded that there seems to be increased mandibular growth in the sagittal plane, correcting Class II malocclusions by virtue of forward mandibular growth greater than anticipated from average increments.

However, clinical findings by Adams (1969); Schulhof and Engel (1982) and Robertson (1983) found it otherwise. According to these authors, the reduction in the incisor overjet (and to a lesser extent in the overbite) seemed to be largely the result of simple palatal tilting of the crowns of the upper incisors, together with some labial proclination of the crowns of the lower incisors. It is important, however, that when we are talking about functional appliances to know what appliance design was
involved. Because appliance design might make a difference. Improper pad placement, improper vestibular shield design, improper clasp, lack of notching of the teeth, and the faulty position of the lingual wire may produce undesirable results. For example, the primary changes in the dento-alveolar area observed by Robertson (1983) may be due to the fact that notching of the deciduous maxillary teeth was not employed. In other words, the antero-posterior locking effect of the appliance inside the mouth is not present, thus only encouraging mesial migration of the mandibular teeth and lingual tipping of the maxillary anterior teeth. Another factor causing forward tipping of the lower incisors is faulty lingual springs. (Eirew, McDowell and Phillips, 1981). These authors stated that the lingual springs may produce unwanted proclination in several ways:

i) Through being incorrectly constructed, in contact with the lower teeth. They should be slightly offset, as shown in Fig.15.

ii) Through being distorted or maladjusted during the course of treatment. As these springs are formed from 0.8 mm wire, accidental distortion is rare.

iii) Through accidental downward rotation of the acrylic lingual shield. This may be caused by tongue pressure over a long period or by rough handling of the appliance.
Correct offset of lingual springs.
Construction of double hanger.

Downward rotation of the lingual shield was observed more frequently when only single supporting wires (hangers) were used to connect the lingual shield with the buccal shields (Fig.15) or when these hangers were placed too close to the cheek teeth. Eirew, et.al. (1981) recommended the following to prevent possibility of the proclination of lower incisors:

(a) the use of double hangers (Fig.15) to reduce risk of the downward rotation of the lingual shield.
(b) inclusion of a lower labial bow, routinely or in selected cases.

Furthermore, Owen (1983a) observed significant mandibular intermolar width increase as well as gonial angle opening
in some of his treated cases. The mechanics of this
gonial angle change is unknown. This author postulated
that it may be because the incisors are often held in
contact while the molars are out of contact, producing
a "bending" of the mandible under the altered functional
loading. As far as the reported mandibular width
increase, one plausible reason for this is the relaxation
of the buccinator and circumoral muscles (as reported
by Freeland, 1979).

(ii) Maxillary Retraction/Retardation

According to Owen (1981, one of the potential
changes made by the Fränkel appliance is maxillary
retraction. Similarly, Creekmore and Radney (1983)
found that forward growth of the maxilla in Class II
Fränkel cases is significantly reduced compared to the
untreated cases. Owen (1981) reasoned that it may be
as the patient sleeps, muscles attempt to return their
resting length. The protractors allow the retractors
through reciprocal reflex activities to retract the
mandible to its normal position. This retracting
pressure is transmitted to the maxilla through the appliance
and the result is similar to headgear traction and
activator appliances. Even in cases where maxillary
retraction is not desired, Owen (1981) said that it
still seems to occur. This phenomenon should be borne
in mind when one is considering Class II treatment.
Study by Owen (1983b) claimed potential increase in the nasal cavity and maxillary width. Owen (1983b) attempted to offer an explanation for the increase in the nasal cavity, that it may be the result of a constant attempt to gain a consistent oral seal and possibly to breathe more through the nose than prior to treatment. The maxillary width increase may be the result of the tension produced by the vestibular shields, as suggested by Fränkel (1974) and supported by Donnelly, Swoope and Moffett (1973).

7.2 Dento-alveolar

Dento-alveolar changes contribute to the overall correction of Fränkel therapy. Arch widening and decrowding process occur as the projecting shields of the Fränkel appliance screen the dento-alveolar development from adverse muscular forces (Fränkel, 1971, 1974).

Fränkel (1971,1974) asserted that:

a) Tongue, cheek and lips are in a state of balance with each other. As reported by Horowitz and Hixon (1966, page 166), the teeth erupt clinically into a "channel" located between the tongue, lips and cheeks.

b) The form of the dental arch in a given case reflects the present state of this biomechanical balance. Fränkel (1976) believed that the developmental inhibition in the size of the underlying skeletal structures that support the teeth is causally related
to perioral and buccal muscle function. Fränkel further postulated that the elimination of aberrant perioral and buccal muscle activity during development will result in full development of dental arches with less functional and morphologic deviation.

Expansion of the maxillary and mandibular dental arches occurs to a much greater extent in patients undergoing Fränkel treatment than in the control subjects. Degree of arch widening is 3 to 4 times higher than active plates (Fränkel, 1969a). Lateral expansion is therefore a unique potential of the Fränkel appliance, setting it apart from all other functional jaw orthopaedic appliances. It is the only appliance that operates in the oral vestibule and expands the basal bone by means of tension on the periosteum. All other appliances expand by active pressure on the palatal side, warping the alveolar process without altering the buccal basal bone.

Statistical investigations of results of appliance therapy have been limited. Mosch (1971, cited by Fränkel, 1971) who studied 400 cases treated with only the Fränkel appliance, observed that as a result of merely withholding cheek pressure through the use of the vestibular shields and lower labial pads, a spontaneous widening of the dental arch occurred with great regularity. Fränkel (1971) noted a mean increase in transpalatal width of over 4 mm in both the premolar and molar regions during a two-year treatment time.
Table 1. The increase between antimeres in the maxillary dental arch achieved by Function Correctors. Total number of cases: 400.

<table>
<thead>
<tr>
<th>Teeth</th>
<th>Number of cases (mm)</th>
<th>Mean (mm)</th>
<th>S (mm)</th>
<th>SEM (mm)</th>
<th>Range (mm)</th>
<th>Interval between measurements mean in months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxillary first deciduous molar</td>
<td>158</td>
<td>4.38</td>
<td>1.31</td>
<td>0.1</td>
<td>2.5 to 9</td>
<td>17</td>
</tr>
<tr>
<td>Maxillary first premolar</td>
<td>125</td>
<td>4.71</td>
<td>1.53</td>
<td>0.14</td>
<td>2.5 to 9.5</td>
<td>21</td>
</tr>
<tr>
<td>Maxillary first permanent molar</td>
<td>306</td>
<td>4.49</td>
<td>1.51</td>
<td>0.09</td>
<td>2.5 to 11.5</td>
<td>23</td>
</tr>
</tbody>
</table>

S = Standard deviation.  
SEM = Standard error of the mean.

Table 1, from Fränkel, 1971

Average expansion values described by McNamara (1982a) which are further substantiated by McDougall, et al. (1982) are:

<table>
<thead>
<tr>
<th></th>
<th>Expansion across maxillary arch (mm)</th>
<th>Expansion mandibular arch (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>at canine region</td>
<td>3.0</td>
<td>2.1</td>
</tr>
<tr>
<td>first premolar</td>
<td>5.7</td>
<td>4.4</td>
</tr>
<tr>
<td>first molar</td>
<td>4.5</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Table 2

Thus, it appears that the largest expansion values are recorded in the premolar and molar regions. Lesser values are recorded in the canine region. Fränkel post-treatment
arch forms bear some resemblance to the Brader arch form, as they tend to be very broad in the bicuspid region (McNamara, 1982a).

McDougall, et.al. (1982) noticed that there is a trend toward larger increments of arch expansion in the narrow palate subgroup than in the already wide palate sub-group. Furthermore, McDougall, et.al. (1982) observed that the maxillary expansion did not result from just simple tooth tipping laterally, but appeared to demonstrate primarily a bodily movement of the buccal segment laterally.

Lesser alveolar expansion in the lower arch than the upper arch can also be seen. McDougall, et.al. (1982) noted that more uprighting of teeth occurred in the lower arch than in the upper arch. This observation can be explained by the fact that the lower dentition erupts in a more lingual direction than does the upper dentition (as shown by a study conducted by Van der Linden and Duterloo, 1976).

Because of the uprighting mechanism in the lower arch resulting from diminished resistance of the associated soft tissues, there is less alveolar expansion in the lower arch than in the upper arch. Also, it should be noted that the vestibular shields are held 3.0 mm away from the maxillary alveolus but only 0.5 mm from the mandibular alveolus at the depth of the sulcus. All these expansion findings seem to contradict those of Kerr (1981) who used the Fränkel appliance on nine cleft palate patients. He did not find a significant expansion in either maxillary or mandibular canine measurements. The findings of this discrepancy could be explained
because wear-time appears inadequate for his sample (an average of 12.7 hours per day, when 20 hours per day is the goal). Furthermore, cleft palate patients may present greatly different conditions to non-cleft patients when use of the Fränkel appliance is being considered. It is beyond the scope of this treatise to point out such differences.

Fränkel (1969a) claimed that this widening effect has been brought about by artificially changing the "interplay of forces." This is not done by bringing additional mechanical forces, such as screws or springs into operation against the teeth. Eirew (1976) explained that the arch widening may be attributed to:

a) a change in tongue posture, i.e., the force acting on the lingual alveolar surfaces becomes more effective since the counter-acting force of the cheeks is eliminated.

Fränkel (1966) attached great importance to the role of the tongue and opposed the placings of any bulky parts in the tongue space. He claimed many malocclusions are due to failure of tongue to fully occupy the anterior oral space. According to Fränkel (1966), the natural rest position of the tongue against the roof of the palate is not due to muscular action but is maintained solely by the action of the atmospheric pressure. Fränkel gave reference to the studies by Korbiz (1914), Noltemeier (1949a, 1949b), Donders (1953),
Eckert-Mobius, (1962, 1963) which revealed that the deglutition reflex, which is accompanied by lip seal results in the air being "pumped out" of the cavium proprium by the tongue's peristalsis, thus creating a partial vacuum which is completely filled by the soft tissue of the tongue, under the action of the atmospheric pressure. In this way, one gets a completely enclosed space between the tongue on the one hand and the lip and cheeks on the other. Fränkel (1966) said that this space must be regarded as the most appropriate site for directing the morphogenesis of the tooth-bearing alveolar process. The projection of the mandible strains the floor of the mouth and a subsequent re-orientation of the tongue in a rostral/cranial direction. Thus the fact that the oral cavity proper remains free from any space-taking elements is of vital importance for the "normalization" of functional movement and also for ensuring the proper rest position of the tongue against the roof of the palate.

Both tongue and palate are, therefore, free to make contact during swallowing under the action of the atmospheric pressure. This in turn means the tongue can exert a physiological morphogenetic influence on the maxilla.

As a tooth erupts, according to Atkinson (1966), it tends to follow the path of least resistance. Thus by changing the biomechanical forces during
therapeutic intervention, the eruption pathway of the tooth can be altered.
In the maxillary arch, the eruption usually occurs laterally and vertically at the same time. Hence, a downward and outward movement of the tooth is noted. The posterior teeth in the mandible normally tend to erupt in a lingual direction (Van der Linden and Duterloo 1976). Fränkel (1974) believed that the removal of the buccal muscular forces allows for an uprighting of the lower posterior teeth during eruption. Visual clinical findings by McDougall, et.al. (1981) confirmed this observation.

(b) Stretching effects:
Traction of the outer alveolar surface facing the apical third of the root is also caused by the vestibular screens. The magnitude of this force is considerable, provided the vestibular shields are correctly made and provoke a tension of the soft tissues in the vestibular fold. Thus, further to the lateral physiologic spread of teeth, this strong stretching effect will counteract the tendency of tipping movement of the root apex lingually and facilitates further the drift of teeth in an outward direction (Fränkel, 1971) (Graber and Neumann, 1977, page 559). See Fig.16, from Fränkel (1971). Therefore, the lateral movement of the teeth is not a tipping one, but appears to be a bodily tooth movement. However,
Fig. 16 Schematic representation of the influence of vestibular screens upon the eruptive path and the dentoalveolar development. The traction on the apical base (see arrow) facilitates the drift of erupting teeth in an outward direction and induces remodelling in the outer alveolar process A. from Fränkel (1971)

this assertion has not yet been substantiated radiographically or by examination of tooth orientation in successive study models or otherwise by any study except visual clinical findings by McDougall, et.al. (1982)

In addition to widening the dento-alveolar arches by deformation and transformation of the alveolar wall, the vestibular shields and lip pads may promote widening the arches by a new bone formation in the apical base. Fränkel (1974) gave reference to the experiments of Pauwells (1960), Altman (1964) and Pritchard (1971) in which it is suggested that the
periosteum comes under directionally altered strain leading to an altered inclination of the regional subperiosteal fibres and, as a consequence, to an alteration in the orientation of the new subperiosteal trabeculae. In other words, the subperiosteal fibrous tissue is developed into an osteogenetic scaffolding which induces bone deposition in the apical area of the outer alveolar wall. Further, Fränkel (1974) pointed out that such alveolar development can be better accomplished by harnessing the growth-inducing potential of the erupting tooth, that is, when the forces responsible for the alveolar growth are still at the peak of their activity. Therefore, in this sense, the inner surface of the vestibular screens can be thought of as a corrected configuration of the dento-alveolar process which is built up by acrylic to normal shape and size. In this way, the perioral muscular environment is faced with a normalized dento-alveolar configuration and so allowed to adapt in structure and function.

The Fränkel appliance, once inserted, operates for the re-education and training of the orofacial musculature at the subconscious level. Thus, form and function will be corrected together from the outset. This appears to be of the utmost importance for the stability of the treatment result (Reidel, 1960).
Apart from the expansion laterally, vertical and anteroposterior dento-alveolar changes can also be observed. For example, the lower labial pads and the vestibular shields also prevent an interincisal or interocclusal positioning of the cheeks and lips which can have a restricting effect on the vertical eruption of the teeth. Creekmore and Radney (1983) noted that vertical development of mandibular molars is significantly greater than in the untreated sample. This is possible, because the construction bite is taken so that, as the mandible is held forward the bite is opened in the posterior segments.

The elongation of the posterior teeth takes place according to the same principle that operates with anterior bite planes and activators, except that the lower labial pads and the vestibular shields also prevent an interincisal or interocclusal positioning of the cheeks and lips. Fränkel (1974) believed that disturbance in vertical development is more often caused by the cheeks than by the effect of the tongue.

The dental change most prone to relapse is forward tipping of the lower incisors (Nance, 1947) but this seldom occurs with a properly designed and fitted Fränkel appliance. None of the parts of the apparatus exerted any force to the mandibular posterior and anterior teeth. The presence of the
lower lingual springs are primarily to stabilize the lower incisors. Although (as already discussed, page 76), findings by Adams (1969); Schulhof and Engel (1982) and Robertson (1983) could not substantiate this finding.

Owen (1983a) said that lingual tipping of the maxillary incisors is common, whether desired or not. As it has been pointed out that if the maxillary incisors are retracted (tipped lingually) too early in treatment (through overactivation of labial bow), this can produce incisor interference and limit the potential for condylar/mandibular growth (Owen, 1981).

7.3 Muscle

Another effect of the Fränkel appliance is its influence on the soft tissue themselves. While the vestibular shields prevent the abnormal muscle forces from exerting their influence on the bony structures, it is claimed that they rehabilitate the muscles that have caused the deformity. The projecting vestibular shields and lip pads stretch, massage and improving blood circulation the perioral soft tissue band. They loosen up tight muscles and improve tonicity where it is lacking (Fränkel, 1969b).

A patient with a hypoactive orbicularis oris muscle tends to keep his or her lips apart. In this situation, Delaire (1978, cited in McNamara, 1982a) said that the
mental is muscle is used as a compensatory muscle to keep his or her lips in contact. The lower labial pads of the appliance acts as an inhibitor of the compensatory mentalis muscle activity and force the retraining of the orbicularis oris musculature to produce lip seal (McNamara, 1982a). In other words, the alteration of the volume and shape of the vestibule brought about by the appliance exposes the perioral musculature to a new tactile and proprioceptive stimuli. By supporting the lower labial lip in the region of the mentolabial sulcus, the lip pads also prevent the lip from curling outward; thus facilitating a normal contact with the upper lip. Lip seal training (Fränkel, 1980b) with the Fränkel appliance would also reinforce in activating and improving the tone of the muscles, creating the anterior oral seal and suspending the mandible in a better postural position.

Normalization of the oral seal also creates the main prerequisite for a normalization of respiration. Fränkel (1966) claimed teleroentgenography showed that this kind of treatment resulted frequently in a significant dilatation of the epipharynx and recession of the swelling of the nasopharyngeal tonsil.

Patients with hyperactive cheek muscles may also be corrected with the Fränkel appliance. The buccal musculature is retrained by the vestibular shields. McNamara (1982a) pointed out that clinical evidence of the effect of the appliance on the buccal musculature is seen in the use of cheek retractors. Often at the beginning, it is difficult to use large retractors for intra-oral photography. After four
or five months of Fränkel treatment, retraction of the cheek can be obtained quite easily.

As Owen (1983a) stated, patients with good co-operation will almost invariably develop a much more relaxed perioral musculature during the course of treatment.
CHAPTER EIGHT

TREATMENT TIMING, ADVANTAGES AND DISADVANTAGES

Treatment Timing

Graber and Neumann (1977, page 563) pointed out that the best therapeutic effect from the Fränkel appliance is during when the occlusion is forming and the soft tissue and bony tissues are undergoing their most accelerated growth changes.

Eirew (1976) stated that Fränkel appliance usage is to preempt abnormal development and to induce normal growth rather than to correct fully established malformation.

Studies by McNamara and Carlson (1979) revealed that the induction of proliferation and histo-differentiation in the prechondroblastic zone occurred primarily in infant and juvenile animals. Hence, since the Fränkel appliances literally "train the jaw", it is important to commence at an early date and the period of incipient permanent dentition would appear to be a particularly favourable time to start.

The functional matrix hypothesis presented by Moss (1968, 1969) and by Moss and Salentijn (1969a, 1969b) states that non-skeletal tissues, organs, or functioning spaces determine growth, development, and ultimate morphology of the skeletal tissues of the body. In this concept the teeth are considered a functional matrix and their presence or absence determines the presence or absence of alveolar bone. The Fränkel appliance
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in this sense acts as an artificial matrix during treatment. The Fränkel appliance is therefore especially valuable when treatment is undertaken during the mixed dentition because this appliance can utilize the ability of an erupting tooth to act as a matrix for alveolar growth.

Lewis and Lehman (1932) and Baume (1959) have shown that the intercanine width increases during eruption of the permanent incisors and again during eruption of the permanent canines. Duterloo and Bierman (1977) show that the alveolar crest is relatively inactive after the deciduous teeth erupt, but it is most active during eruption of the permanent teeth and then becomes relatively inactive again after the permanent teeth have erupted.

It appears from these studies that the optimal time is prior to and during eruption of the permanent teeth. It is during this period of the mixed dentition that the Fränkel appliance offers its greatest possible treatment benefits. Treatment in the deciduous dentition is not advocated because children at that age level are not mature enough. After the lower lateral incisors have erupted, the treatment plan is easier to make, and the lateral growth potential is still present. Graber and Neumann (1977, page 559) stated after the mandibular canines and premolars have erupted, stimulation of transverse development in the mandibular arch is limited. In the maxilla, however, possibility for arch expansion is still good even at a later age.
Advantages

1. Treatment may be started early to take advantage of rapid growth period.

2. The appliance needs almost no adjustment (depending on the severity of the malocclusion) and therefore fewer occasions of service. This resulted in reduced chairside time.

3. Less potential harm to bone, teeth and soft tissue resulted from the gentle action of the appliance as compared with fixed appliance.

4. The resultant orthopaedic effect has been claimed to be similar to mandibular surgery (Creekmore and Radney, 1983).

5. Arch widening and decrowding may be achieved in the process. This could be important in borderline cases where extraction is a question mark. It should also be noted that mandibular lateral expansion with most conventional appliances has been shown to be futile, particularly across the permanent canines (Nance, 1947).

6. It induces changes in abnormal masticatory and perioral muscle function, e.g., hyperactive mentalis activity is eliminated and abnormal swallowing. Thus facial balance may be obtained at the end of the treatment which is conducive to stabilizing the dental correction.

7. Oral seal with the aid of lip exercises may also be obtained.
8. According to Owen's study (1983b), respiratory function improves together with the evidence of the maxillary and nasal cavity increase.

9. Since there is no direct tooth moving effect, the lower incisors are not proclined forward (unlike the effect of activators), especially those already proclined before.

10. Long-term stability after an improved structural balance is gained as form and function are corrected simultaneously.

11. Little or no impairment of aesthetics; in fact aesthetics often is enhanced considerably through forward displacement of the mandible and lower lip support.

Disadvantages

1. The appliance is difficult to make as there are numerous subtle features to be observed. One requires sophisticated knowledge and experience as well as advanced technical and three dimension perception.

2. The action of the Fränkel appliance is dependent on growth direction and magnitude. Therefore, timing of treatment is critical.

3. Guidelines for patient selection must be strictly observed. Some of the requirements mentioned by Hirzel and Grewe (1974) are:
a) favourable growth pattern.
b) normal or diminished lower facial height.
c) acceptable dental arch-apical base relationship.
d) no severe crowding, spacing or rotation should be present.
e) maxillary incisors protruded.

4. Average length of treatment is 3 to 4 years, together with a period of retention.
CHAPTER NINE

CONCLUSIONS

1. The Fränkel appliance represents one of the more recent approaches to early treatment of Class II malocclusions.

2. The Fränkel appliance may have a growth-directing effect during the growth period.
   As Fränkel (1966) concluded that:
   
   Configuration and structure of the tooth bearing gnathic skeleton are subject to mechanical influences of the environment which result in a modification of growth zones and lead to the formation of a supporting structure.

3. The Fränkel apparatus has been claimed to be capable of simultaneous correction of skeletal, dental and muscular deficiencies. Therefore, it may be said that it is different and unique when compared with conventional or traditional appliances.

4. This appliance may be used during the mixed and early permanent dentition stages to effect changes in antero-posterior, transverse, and vertical jaw relationship.

5. Fränkel treatment is not a panacea as construction, selection and handling management require considerable knowledge to obtain the necessary goals.
6. Careful patient selection is required as this therapy is not an answer to all types of Class II malocclusion. Graber and Neumann (1977, page 564) stated that preconditions for success of the treatment are:

2. Right psychological introduction of the appliance.
3. Co-operation of patients and parents.
ADAMS, C.P:

ADAMS, C.P:
The design and construction of removable orthodontic appliances, Wright & Sons, Bristol, p 102, 1979.

ADAMS, C.P., MEIKLE, M.C., NORWICK, K.W., AND TURPIN, D.I:

AHLGREN, J:

AHLGREN, J:

AHLGREN, J:

ALTMANN, K:

ALTMANN, K:

ALTMANN, K:
ANDRESEN, V:

ANDRESEN, V. AND HÄUPL, K:

ANGLE, E.H:
Philadelphia, p 140, 1907.

ATKINSON, S.R:

AUF DER MAUR, H.J:

BALTERS, W:

BAUME, L.J:

BAUME, L.J:

BAUME, L.J., AND DERICHSWEILLER, H:

BIMLER, H.P:
BISHARA, S.E., CHADHA, J.M. AND POTTER, R.B:

BJÖRK, A:

BLOUNT, W.P. AND ZEIER, F:

BREITNER, C:
Experimental changes in the mesio-distal relations of the upper and lower dental arches, Angle Orthod., 3:67-75, 1933.

BRIGHAM, G., SCALLETTA, L., JOHNSTON, Jr. L. AND OCCHINO, J:

BRODIE, A.G., AND JACOBS, R.M:

CARLSON, D.S., McNAMARA, J.A. AND JAUL, D:

CARLSSON, G.E. AND OBERG, T:
CHARLIER, J.P:
Cited in McNamara, 1973 b.

CHARLIER, J., PETROVIC, A. AND STUTZMANN, J:

CREEKMORE, T.D. AND RADNEY, L.J:

COLICO, G.L:

CRAWFORD, G.N.C:

DAHAN, J:

DELAIRE, J:

DEMUSCHE, A:
DERICHWEILLER, H:

DI SALVO, N.A:

DONDERS:

DONNELLY, M.W., SWOOP, C.C. AND MOFFETT, B.C:

DURKIN, J.F:

DURKIN, J.F., HEELEY, J.D. AND IRVING, J.F:

DUTERLOO, H.S. AND BIERMANN, M.W:

DUTERLOO, H.S AND JANSEN, H.W.B:

ECKERT - MöBIUS:
EKERT - MÖBIUS:
Grundsätzliches Atmung aesh: rhoio-logisch-
kieferorthopadisches Grenz-problem, Acta oto-
Laryngologica supplementum 183:36, 1963. Cited in
Fränkel, 1966.

EIREW, H.L:
Dynamic - Functional appliances, Dent. Pract. and

EIREW, H.L:
The function regulator of Fränkel, Brit. J. of

EIREW, H.L, McDOWELL, F. AND PHILLIPS, J.F:
The Fränkel appliance - Avoidance of lower incisor

ELGOYHEN, J.C., MOYERS, R.E., McNAMARA, J.A. AND RIOLO, M.L:
Craniofacial adaptation to protrusive function in

ENLOW, D.H:
Functions of the Haversian system, Am.J.Anatomy,

ENLOW, D.H:
Wolff's law and the factor of architectonic

ENLOW, D.H:
Handbook of Facial Growth, W.B. Saunders Co.,

ESCHLER, J:
Die funktionelle Orthopadie des Kausystems,

EVALD, H. AND HARVOLD, E.P:
The effect of activators on maxillary-mandibular

FOLKE, L.E. AND STALLARD, R.E:
Condylar adaptation to a change in intermaxillary
FRÄNKEL, R:


FRÄNKEL, R:


FRÄNKEL, R:


FRÄNKEL, R:


FRÄNKEL, R:


FRÄNKEL, R:


FRÄNKEL, R:


FRÄNKEL, R:


FRÄNKEL, R:

FREELAND, T.D:

FREUNTHALLER, P:

FREUNTHALLER, P:

GHAFARI, J. AND HEELEY, J:

GOULD, M. AND PICTON, D:

GRABER, T.M:

GRABER, T.M:

GRABER, T.M. AND NEUMANN, B:
GRESHAM, H:

HAHN, G.W:
Retention, the stepchild of orthodontia, Angle Orthod. 14:1:12, 1944.

HARVOLD, E.P:

HARVOLD, E.P. AND VARGERVIK, K:

HASUND, A:

HÄUPL, K. AND PASANSKY, R:

HAUSSER, E:

HAUSSER, E:

HERREN, P:

HINIKER, J.J. AND RANFJORD, S.P:

HIRZEL, H. AND CREWE, J:

KORKHAUS, G:

KOSKI, K:

LEWIS, S.J. AND LEHMAN, I.A:

LIEB, G. AND SCHLAGBAUER, P:

LINDEMAN, K. et.al:

LOGAN, W.R:

LUEDTKE, G.L:

LUFFINGHAM, J.K:

McDOUGALL, P.D., McCAMARA, J.A. Jr. AND DIERKES, J.M:
HOFFER, O. AND COLICO, G.L:  
Le modificazioni dell A.T.M. consequenti a 
spostamento mesiale della mandibula. Rass.Int. 

HOROWITZ, S.L. AND HIXON, E.H:  
The Nature of Orthodontic Diagnosis, the C.V. Mosby 

HOTZ, R.P:  
Orthodontics in Daily Practice, Hans Huber Publishers, 

HOTZ. R.P:  
Application and appliance manipulation of functional 

HOYTE, D.A.N. AND ENLOW, D.H:  
Wolff's law and the problem of muscle attachment 

JAKOBSSON, S.O:  
Cephalometric evaluation of treatment effect on 
Class II Division I malocclusions, Am.J.Orthod. 

JOHNSON, L.C:  
Kinetics of osteoarthritis, Lab.Invest., 8:1223-1241, 

JOHO, J.P:  
Changes in form and size of the mandible in the 
orthopaedically treated Macaca Irus (an experimental 

KERR, M.P., WELCH, C.D., MORRE, R.N., TEKIELI, M.L. AND 
RUSCELLO, D.M:  
Functional regulator therapy for cleft palate 

KLAASSEN, C.B:  
Treatment of Class II malocclusion with functional 

KLAMMT, G:  
Der offene aktivator, Dtsch. Stomatol. 5:322-327, 

KORBICZ, A:  
Kursus der systematischen orthodontik Verlag H.
McNAMARA, J.A. Jr:

McNAMARA, J.A. Jr:

McNAMARA, J.A. Jr:

McNAMARA, J.A. Jr:

McNAMARA, J.A. Jr:

McNAMARA, J.A. Jr:
Components of Class II malocclusion in children 8-10 years of age, Angle Orthod. 51:177-202, 1981.

McNAMARA, J.A. Jr:

McNAMARA, J.A. Jr:

McNAMARA, J.A. Jr. AND CARLSON, D.S:

McNAMARA, J.A. Jr., CONNELLY, T.G. AND McBRIIDE, M.C:
Histological studies of temporomandibular joint adaptations. In McNamara, J.A. Jr. (editor): Determinants of mandibular form and growth, Monograph no. 4, Craniofacial Growth Series, Centre

McNAMARA, J.A. Jr. AND GRABER, L.W:

McNAMARA, J.A. Jr., HINTON, R.J. AND HOFFMAN, D.L:

McNAMARA, J.A. Jr. AND HUGE, S:

MARSCHNER, J.F. AND HARRIS, J.E:

MAY, J.F:

MEACH, C.L:

MERRIFIELD, L.L. AND CORSS, J.J:

MOFFETT, B.C. Jr:

MOORREES, C.F., FANNINGS, E.A. AND GRON, A.M:

MOSS, J.P:
MOSS, M.L:

MOSS, M.L:

MOSS, M.L. AND SALENTIJN, L:

MOSS, M.L. AND SALENTIJN, L:

MOYERS, R.E:

MOYERS, R.E:

MOYERS, R.E. AND McNAMARA, J.A:

MOYERS, R.E., ELGOYHEN, J.C., RIOLO, M.L., McNAMARA, J.A.Jr., AND KURODA, T:

MULLER, G:

MULLER, G:
Die kraniometrische Beurteilung des Behandlungs

NANCE, H.N:

NICHOLS, T.R. AND HOUK, J.C:

NOLTEMEIER, H:

NOLTEMEIER, H:

OWEN, A.H:

OWEN, A.H:

OWEN, A.H:

PARKHOUSE, R.C:

PAUWELL, F:

PAUWELL, F:
Gesamm abhendbingen zur funktronellen anatomie
Cited in McDougall, 1982.

PETROVIC, A.G:
Mechanisms and regulation of mandibular condylar
growth, Acta.Morphol.Neere-Scand. 10:25-34,
1972.

PETROVIC, A.G:
Control of postnatal growth of secondary cartilages
of the mandible by mechanisms regulating occlusion,

PETROVIC, A. AND STUTZMANN, J:
Le muscle pterygoidien externe et al croissance
due condyle mandibulaire recherches experimentales
chez le jeune rat, Orthod.Franc.43:271-285,

PETROVIC, A.G. AND STUTZMANN J:
Control of the condylar cartilage growth rate,
in McNamara, J.A. (ed): the Biology of Occlusal
Development, Monograph 7, Craniofacial Growth
Series, Center for Human Growth and Development,
University of Michigan, Ann Arbor, 1977. Cited in
Owen, 1983a.

PETROVIC, A., STUTZMANN, J. AND GASSON, N:
The final length of the mandible: is it genetically
determined? In Carlson, D.S. (ed): Craniofacial
biology, Monograph 10, Craniofacial Growth Series,
Center for Human Growth and Development, the
University of Michigan, Ann Arbor, 1981. Cited
in McNamara, 1982b.

PETROVIC. A., STUTZMANN, J. AND OUDET, C:
Control processes in the post natal growth of the
condylar cartilage. In McNamara, J.A. (ed):
Determinants of mandibular form and growth,
Monograph 4, Craniofacial Growth Series, Centre for
Human Growth and Development, The University of
PETROVIC, A., STUTZMANN, J., OZEROVIC AND VIDOVIC, Z:
Does the Fränkel appliance produce forward

POSEN, A.L:
The influence of maximum perioral and tongue
force on the incisor teeth, Angle Orthod.

PRITCHARD, J.J:
The control of trigger mechanism induced by
mechanical forces, which causes responses of
mesenchymal cells in general and bone mesenchymal
cells in general and bone apposition and resorp-
tion in particular, Craniofacial Conference,

PROFITT, W.R:
Equilibrium theory revisited: Factors influencing
position of the teeth, Angle Orthod. 48:175-186,
1978.

Radin, E.L., Paul, I.L. AND ROSE, R.M:
The role of mechanical factors in pathogenesis
of primary osteoarthritis, Lancet 4:519-521,
1972.

RAMFJORD, S.P. AND ASH, M.M:
Oclusion, W.B. Saunders, Philadelphia, p 178,
1971.

RAMFJORD, S.P. AND BLANKENSHIP, J.R:
Increased occlusal vertical dimension in adult

RAMFJORD, S.P. AND ENLOW, S.P:
Anterior displacement of the mandible in adult
Rhesus monkeys: long term observations, J.

RAMFJORD, S.P., WALDEN, J.M. AND ENLOW, S.P:
Unilateral function and the temporomandibular
joint in Rhesus monkeys, Oral Surg. 32:236-247,
1971.

REIDEL, P:
RINGENBURG, Q.M:
Influence of serial extraction on growth and
development of the maxilla and mandible, Am. J.

ROBERTSON, N.R.E:
An examination of treatment changes in children
treated with the function regulator of Fränkel.

ROGERS, A.P:
Muscle training and its relation of orthodontia,
Int. J. Orthod. 4:555-567, 1918.

SCHULHOF, R.J. AND ENGLE, G.A:
Results of Class II functional appliance treatment,

SCOTT, J:
The role of the soft tissues in determining
normal and abnormal dental occlusion, Dept. Pract.

SERGL, H.G:
The treatment of Class II Division I with

SKEILLER, V:
Cephalometric growth analysis in treatment of
1967.

SOFTLEY, J:
Cephalometric changes in seven 'postnormal'
cases treated by the Andresen method, Dent. Rec.

STÖCKLI, P.W:
Die Reaktivtransfarhigkeit des mandibularen
gelenkknorpels auf orthopadische stimulation
wahrend der wachstumsphase. Schweig. Mschr.
Zahnheilk 82:335-376, 1972. Cited in Sergl,
1976.
STÖCKLI, P.W. AND WILLERT, H.G:

STOCKFISH, H:

STRANG, R:

STRICKER, G., CLIFFORD, E., COHEN, L.K., GIDDON, D.B., MESKIN, L.H. AND EVANS, C.A:

STROBRO, L.J., FRENCH, G.O. AND COLORNE, P.C:

REIDEL, R.A:
Current Orthodontic concepts and techniques. vol.II, ed. Graber, T.M. chapter 9, W.B.

TRAYFOOT, J. AND RICHARDSON, A:

TULLEY, W.J:
Methods of recording patterns of behaviour of the oro-facial muscle using the electromyograph, Dent.Rec. 73:741-748, 1953.

TWEED, C.H:
Clinical Orthodontics, C.V. Mosby Co., St.

VAN DER LINDEN, F.P.G.M. AND DUTERLOO, H.S:
WARE, W.H. AND TAYLOR, R.C:
Condylar re-positioning following osteotomies
for correction of mandibular prognathism, Am.

WEISE, W:
Klinische befunde, die fur einen mandibularen
bzw artikularen gewebeumbau sprechen. Fortschr.
Kieferorthop. 18:303, 1957. Cited in Sergl,
1976.

WEISLANDER, L. AND LAGERSTROM, L:
The effect of activator treatment on Class II

WOODSIDE, D.G:
Some effects of activator treatment on the mandible

WRIGHT, D.M. AND MOFFETT, B.C. Jr:
The postnatal development of the human temporo-