# Maxillary Skeletal and Dental Change With Fränkel Appliance Therapy

## — an implant study

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**An implant study using postero- anterior cephalometric radiographs to evaluate expansion effects of the Fränkel appliance. Significant alveolar and apical base expansion was found in the treatment group, with much smaller increases at the midpalatal suture. Molar tipping was insignificant.**

KEY WORDS: EXPANSION, FUNCTIONAL REGULATOR (FR), IMPLANT, MAXILLA, PALATAL SUTURE

Functional appliances, specifically the Fränkel Functional Regulator (FR) as used to correct Class II malocclusions, have provided unique new therapeutic tools for the orthodontist. The concepts of expansion of the dental arches and "decrowding" of teeth are once again challenging other methods of treatment for many cases.

Although Fränkel has speculated on the mode of action of this appliance, little documented research has been reported in the literature.

According to Fränkel, the buccal shields of the FR achieve expansion and remodeling of the dentoalveolar arch through "pressure elimination" and "traction application." The buccal shields remove the pressures of the perioral musculature and soft tissue from around the dentition, transferring them to the musculature of the opposite side. This allows the developing permanent tooth buds to erupt in a more buccal direction. The apical extension of the shield into the mucobuccal fold places tension on the muscle fibers and periosteum, stimulat-

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ing bone apposition (FRÄNKEL 1966, 1969A, 1969B, 1970, 1973, 1974, AND FRÄNKEL AND REIB 1971).

The above pressure-elimination hypothesis appears to be supported by the work of PROFFIT (1973, 1978), VIG ET AL. (1977), AND FAULK (1969). The periosteal tension hypothesis is supported by HARVOLD (1975). While this research presents some basis for a scientific explanation of the overall mechanism of action of the buccal shield, there is still no data which documents the exact bony and dental changes taking place in the maxilla.

## Objectives

The purpose of this study is to investigate the following questions:

- Although maxillary expansion has been reported, is it in fact occurring, and if so, where?
- Does it take place at the apical base, or at the alveolar level?
- Does expansion take place in the midpalatal suture, or are the alveolar arches being remodeled in a more buccal direction with no effect at the suture?
- Do the teeth remain upright over alveolar bone, or does one see tipping with expansion?
- If expansion does occur, how much can be attributed to the appliance and how much to normal growth?

## Methods and Materials

Sixteen subjects (12 male and 4 female) were selected for the experimental group at the University of Detroit Orthodontic Department to be treated with the Fränkel Appliance (FR2) under the direction and supervision of Dr. James McNamara. All subjects were Caucasian, between 8.0 and 12.7 years (mean age 9.9 years).

Dental relationships of all patients were diagnosed as Class II, Division I malocclusion, with skeletal mandibular retrusion. This was determined from clinical evaluation of the facial profile, dental cast analysis, and the following four cephalometric measurements: S-N-A 79°-84°, S-N-B 73°- 78°, S-N/Go-Gn 26°-43°, and point A to perpendicular plane −2.0mm to +2.0mm.

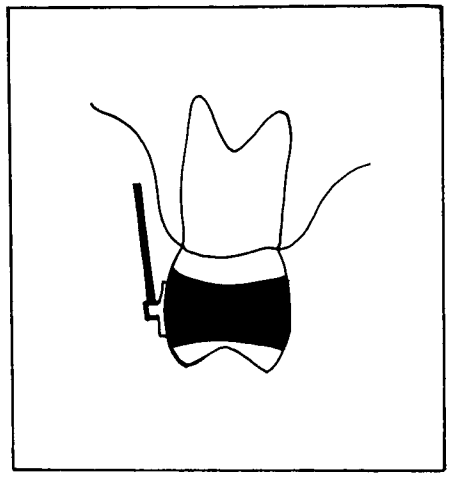

**Fig. 1** A rectangular wire fitted into the molar tube and bent 90° gingivally serves as an indicator of change in molar inclination.

The experimental group was matched with a control group selected from the Center for Human Growth Development in Ann Arbor, Michigan. The control group consisted of 16 males and 7 females of the same racial background, similar ages (mean 10.3 years), and similar skeletal configuration as defined by the above four cephalometric measurements.

The upper right and left first molars were banded, with horizontal tubes welded to the buccal of each band. A 019×.025″ wire, bent at a right angle to extend approximately 10mm gingivally, was adjusted to insert into each tube with no rotational freedom (Fig. 1). This wire was used to evaluate changes in molar angulation.

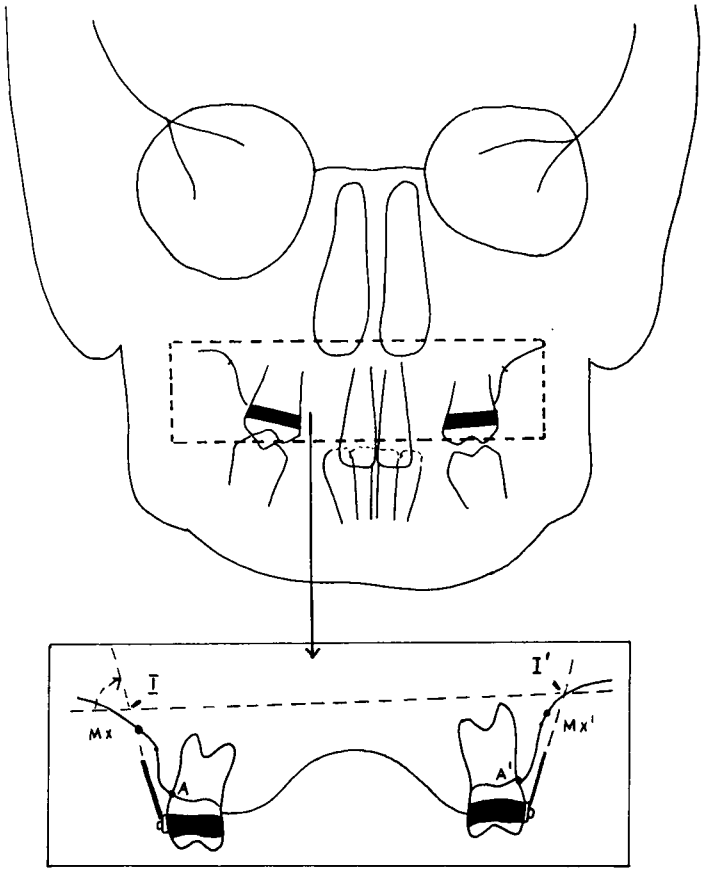


**Fig. 2** Markers in the P-A radiograph. In addition to the wires shown in Fig. 1, tantalum implants were placed at points I and I'. Points A and A' are at the junction of the alveolar bone contour with the tooth; points Mx and Mx' are at the deepest buccal curvature of the bone outline.

Tantalum implants were placed in the area of greatest lateral concavity of the alveolar process of the maxilla, at the approximate level of the maxillary first molar apices, following the method described by BJÖRK (1955, 1963, 1964). These implants were used as bone markers for width measurement, and to identify any expansion at the midpalatal suture (Fig. 2).

P-A radiographs were taken at 6-month intervals to evaluate the maxillary skeletal and dental changes. In order to reproduce the head position in the cephalostat as accurately as possible, earrods and a calibrated nasion pad were used to orient and stabilize the patient's head in all three planes of space, and all magnification factors were kept constant.

In all cases, the FR2 appliance had the "standard" buccal relief of 3mm in the maxilla and 0.5mm in the mandible. At the beginning of treatment, the occlusion in all cases exhibited a normal buccolin-

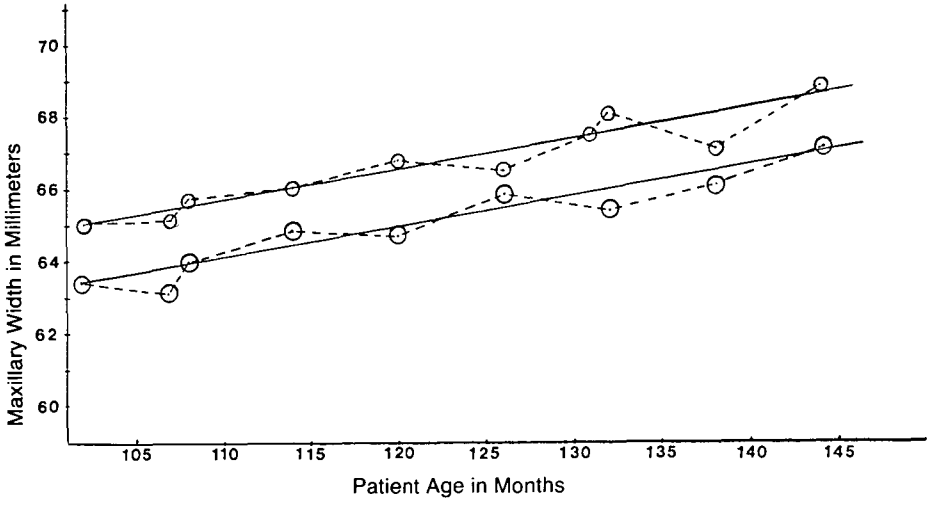


**Fig. 3** Control group from 8 to 12 years, showing mean width between A and A′ (lower line), and between Mx and Mx′ (upper line).

gual molar relationship in centric relation. Each patient was seen at 4-week intervals for observation and adjustment.

## *Method of Analysis*

Width changes in the maxilla were compared between the experimental group (treated with the Fränkel appliance) and the control group (no treatment). Evaluation of hand-wrist radiographs indicated that no patient in the experimental group had entered the circumpubertal growth spurt during treatment.

P-A radiographs were made after 6 months and 12 months of treatment. Measurements were made by three individuals, using calipers calibrated to 0.05mm. The inter-judge error was determined to be 0.6mm, which approximates the accepted cephalometric tracing error.

The following dimensions were measured:

1. Most medial aspect of the implant in the maxilla on the right to the medial aspect of the implant on the left, (represented in Fig. 2 by I- I′).

2. Deepest point in the concavity of the alveolar buccal surface of the maxilla on the right to the same point on the opposite side (represented in Fig. 2 by Mx-Mx′).

3. Point where the maxillary alveolar bone meets the buccal contour of the first molar on the right to the same point on the left (represented in Fig. 2 by A-A′).

4. Angle formed by the line I-I′ with the wires on the buccal of the first molars (Fig. 2).

Width changes in the control group at Mx-Mx′ and at A-A′ were evaluated graphically from P-A radiographs taken at 12-month intervals over a 3-year period. Each width measurement was plotted on a graph against the age of the patient in months. Mean width for each age was calculated in months, and a line of best fit constructed (Fig. 3).

The constructed lines showed a consistent linear relationship of the mean widths plotted against age. The slopes shown in Fig. 3 represent the mean width changes at any given age for the control group.

A Student's **t** test was used to determine the significance of the difference between the mean width changes of the experimental and control group.

## Results

In the experimental group, the mean 12-month change in width from I- I′, as assessed by superimposing serial radiographs on the implants, was 0.57mm. The mean 12-month change in width from Mx-Mx′ was 2.8mm , and from A-A′ it was 2.7mm (Table 1).

In the control group, the mean 12-month change in width from Mx-Mx′ was 0.9mm, and from A-A′ it was 1.1mm (Figs. 3 and 4).

The angulation changes of the maxillary first molars were negligible, with buccal tipping ranging from 0° to +2° on the right side and from −1° to +2° on the left.

## Discussion

Although many clinicians have observed maxillary arch expansion with the use of the Fränkel appliance, the exact areas of change are not known. Dentoalveolar, sutural and apical base remodeling have all been considered. In the present study there was a significant increase in the width of the maxilla in patients undergoing Fränkel therapy, with the most significant increase seen at the level of the apical base (Mx-Mx′), and alveolar process (A-A′).

The initial changes observed during the first 6 months of treatment were most dramatic at the alveolar level (A-A′ = 1.3mm, compared to Mx-Mx′ = 0.7mm). During the last 6 months, more growth appeared to take place at the apical base (A-A′ = 1.4mm and Mx-Mx′ = 2.1mm).

This observed differential growth may possibly be due to the mechanisms of action of the appliance as speculated by Dr. Fränkel (pressure elimination at A-A′ and periosteal traction at Mx-Mx′). In all cases, the difference in expansion between the control and experimental

**Table 1**

Mean change in Width of the Maxilla (mm)
in the Experimental Group at
Mx-Mx′ and A-A′
Over the 12-month Treatment Time

| | Control Group | | Experimental Group | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Mx − Mx′ | 0.9 | 0.46 | 2.8 | 0.92 |
| A − A′ | 1.1 | 0.31 | 2.7 | 1.00 |

$p < .0001$

group at both levels was statistically very significant ($p < .0001$). This expansion appeared to be related to the appliance therapy and not to normal growth of the maxilla.

A much smaller but measurable increase was noted at the midpalatal suture. This midpalatal increase appeared to be within the range expected for normal growth. It was felt that the increase in width of the midpalatal suture was not due to implant movement, since a consistent lateral displacement with no angulation changes was observed when the implants were superimposed.

All patients in both the experimental and control groups had not entered the circumpubertal growth spurt, based on the absence of the adductor sesamoid and the hook of the hamate in the hand-wrist film.

Evaluation of molar angulation indicated no change in most cases. Small changes noted in a few cases appeared to be attributable to inaccuracies in measurement and lack of radiographic clarity.

From the findings of this research it appears that the type of expansion obtained with the FR appliance is significantly different from that obtained with rapid palatal expansion. With the FR appliance, the mechanism of action is mainly at the dentoalveolar and apical base, with little midpalatal suture effect, while large sutural changes are commonly found with rapid palatal expansion.

Because most Fränkel therapy takes place in the middle to late mixed dentition stage, many permanent teeth will erupt into position with increased arch dimensions, which may contribute to more stable results.

Although an attempt was made to carefully select the experimental and control subjects, some limitations were encountered in attempting to compile a completely homogeneous group. All of the patients had a normal maxilla and a retruded mandible, but they exhibited a wide range of the S-N/Go-Gn angle. The effect that this might have had on the growth of the maxillary complex is not known.

To date, little reported data is available to explain maxillary arch expansion changes with the functional regulator, so comparison of our results with other reports in the literature is not possible. Although Fränkel's clinical observations and general hypothesis explaining the operation of the appliance anticipated our findings, no in-depth analysis of dental changes and bony remodeling has yet been made. Further research is certainly needed.

## Summary and Conclusions

- There was a significant increase in the width of the maxilla at the apical base and alveolar process with the use of an FR2 functional regulator.
- The increase in width at the alveolar process appeared to be very steady throughout treatment.
- The rate of increase in width at the level of the apical base appeared to be relatively slow during the first 6 months of treatment, with the rate doubling during the last 6 months of treatment.
- The overall increase in width at both levels was approximately the same over the 12-month period.
- There was a relatively small but consistent increase in the width of the maxilla attributable to change at the midpalatal suture.
- There was very little change in the angulation of the maxillary first molar.

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