Frontal Facial Changes with the Fränkel Appliance

Albert H. Owen III

A study of 50 cases treated with the Fränkel appliance shows significantly greater increase in bigonial width and related decrease in frontofacial taper as seen in the P-A cephalometric view than in comparable cases treated with Edgewise therapy or in untreated norms from the Bolton and FOR studies.

KEY WORDS: · CEPHALOMETRICS · FRÄNKEL · FRONTAL VIEW · · FUNCTIONAL APPLIANCE · WIDTH ·

Dentofacial orthopaedics is a significant component of orthodontic/orthopaedic treatment that has gained increasing attention in recent years. The goals of both components of this therapy are a physiologic balance among the skeleton, muscles and teeth of the entire stomatognathic system, with alterations in musculoskeletal relations generally regarded as orthopaedic changes. While anatomic relationships and treatment changes in the sagittal dimension have been studied extensively, the face is a three-dimensional structure, and width can often be the most critical factor in sagittal development and therapy.

This study investigates facial changes that occur in the transverse dimension with treatment using the Fränkel appliance. Comparison with patients treated with Edgewise therapy helps to visualize the possibilities for facial change with the two treatment modalities.

— Literature Review —

According to LAVELLE (1968), there has been an apparent secular narrowing of the dental arches over the past several generations. The etiology of this change is unclear, although oral respiration has been suggested by several investigators (LINDER-ARONSON AND BACKSTRÖM 1960, RICKETTS 1968 AND 1979, PAUL AND NANDA 1973, AND SUBTELNY 1980). Others have suggested that dietary changes from tough,

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unprocessed foods to refined and easily masticated foods have caused an underdevelopment of the function-sensitive masticatory components (PRICE 1936, AND LOMBARDI 1982).

Fränkel has proposed that the buccinator muscles may be hypertonic, constricting the dental arches and related facial features (FRÄNKEL 1974 AND 1976).

It has been reported that growth in the lateral dimension is 90% complete by the age of nine (SALZMANN 1966, AND ENLOW 1975). For the majority of orthodontic patients who reach the orthodontic office after this growth is complete, the clinical possibilities for increasing the transverse dimension are very limited. Studies of mandibular cuspids have shown expansion to be unstable (PEAK 1956, GRABER 1966, BISHARA ET AL. 1973, AND HERBERGER 1981).

It appears that the clinical means for producing permanent changes in the transverse dimension have been limited to palatal expansion and surgery. Palatal expansion studies report a significant increase in the transverse dimension of the maxillae (HAAS 1965, 1970, TIMMS 1980). JACOBS (1980) has shown possibilities for changing the transverse dimension by orthognathic surgery, which has become commonplace in some areas.

Fränkel has also shown lateral expansion using the functional regulator (FRÄNKEL 1969, 1971, 1974, AND 1976), as have MCDOUGALL, MCNAMARA AND DIERKES (1982) and OWEN (1983) in more recent studies.

None of the above studies considered the effects, if any, of the lateral expansion which occurred in the soft tissue. It appears that there have been no studies on treatment-induced changes in the frontal facial aspect.

Objective

This study investigates the possibility of change in the frontal facial features as the result of treatment using the Fränkel appliance. If the Fränkel appliance can widen the arches and regulate hypertonic buccinator muscles as Fränkel claims (FRÄNKEL 1971, 1974, AND 1976), then measurable changes might be expected in the face as it is viewed straight on.

TWO SPECIFIC PARAMETERS ARE EVALUATED IN THIS STUDY:

1) Increase in the mandibular width as measured across the antegonial notches, and

2) Increase in the lower face width compared to the middle and upper face widths.

— Methods and Materials —

Fifty patients in the private practice of the Author were treated using a modified Fränkel functional regulator. Ages at the start of treatment ranged from 5.9 to 13.8 years, with an average age of 9.6 ± 1.5 years. Twenty-nine of these patients were girls, and 21 were boys. All were Caucasians who were selected for this type of treatment on the basis of the presence of crowding as determined from dental casts and panoramic radiographs.

The Angle molar relationships were evenly distributed between Class I and Class II, with 23 Class I and 27 Class II. All of the patients in this study were considered to be cooperative in the use of their appliances, wearing them approximately 20 hours per day. Since this study is an evaluation of the effects of this type of therapy rather than patient cooperation, that factor was controlled by using only patients who had successfully completed the Fränkel portion of their treatment. Uncooperative patients, and those still in active FJO treatment, were not included. All except two of these patients have since begun the second phase of their overall treatment, using Edgewise appliances to detail and finalize the occlusal correction.

The reference ("control") sample consisted of 50 patients who had been successfully treated with Edgewise appliances in the Author's practice. Their ages ranged from 8.3 to 15.1 years, with an average age of 11.6±1.5 years. Thirty of these control patients were girls, and 20 were boys. Each had a crowded dentition before treatment as determined by the same dental cast and panoramic radiograph criteria as the experimental group. Angle molar relationships were 23 Class I and 27 Class II, which which is the same distribution as the Fränkel sample. Their orthodontic treatment was undertaken to correct various problems in addition to the crowding, including excessive overjet, overbite, and crossbite.

Active appliance therapy averaged 21.5 months for the Fränkel phase of the study sample and 31 months for the Edgewise sample. The longer treatment time for the Edgewise sample was due to the fact that this represented total treatment time, including several two-phase patients whose overall treatment lasted much longer than a single-phase Edgewise treatment.

Frontal cephalographs were taken at the beginning of active treatment and at either the completion of full-time appliance wear or at the end of active treatment. The x-ray target to transmeatal plane distance was five feet, and the distance from transmeatal plane to film was 15cm. The tilt of the head was standardized by aligning the outer canthus of the eye with a line scribed 15mm above the top of the ear rod, according to RICKETTS (1981). The cephalographs were traced by Rocky Mountain Data Systems, Inc., and also by the Author using 0.5mm lead on .003″ matte acetate tracing film. Where discrepancies were found between the two tracings, they were rechecked against the original film and a final determination made by the Author.

This study introduces the *frontofacial taper* as a new evaluation of facial proportion in the frontal view (Fig. 1). This is based on the relative widths between zygomatic arches and mandibular rami. The *mandibular width* is measured between the antegonial notches, AG to GA in this illustration. These landmarks are relatively conspicuous and easy to locate on most P–A cephalographs, but where there is no definite notch in the antegonial area they require some interpretation by the operator. Zygomatic arches (ZA and AZ) are also conspicuous landmarks on these films.

The lines ZA–AG and AZ–GA roughly outline the face in the frontal view, and correspond approximately to the soft tissue drape in the full frontal view. The *frontal facial taper* is the angle between these two lines, representing the angular taper of the face. This can be a useful indicator for quantifying changes in facial width with growth and treatment.

This study does not evaluate possible correlations with cranial shape such as brachycephaly, mesocephaly and dolichocephaly, although such a study could prove useful.

No statistical comparison among these samples was performed because the parameters for sample selection for the Bolton or FOR groups are not known. While it may be assumed that no attempt was made to select a particular type of face in any of these samplings, the Bolton sample was selected for acceptable dentofacial relationships. The comparisons in Tables

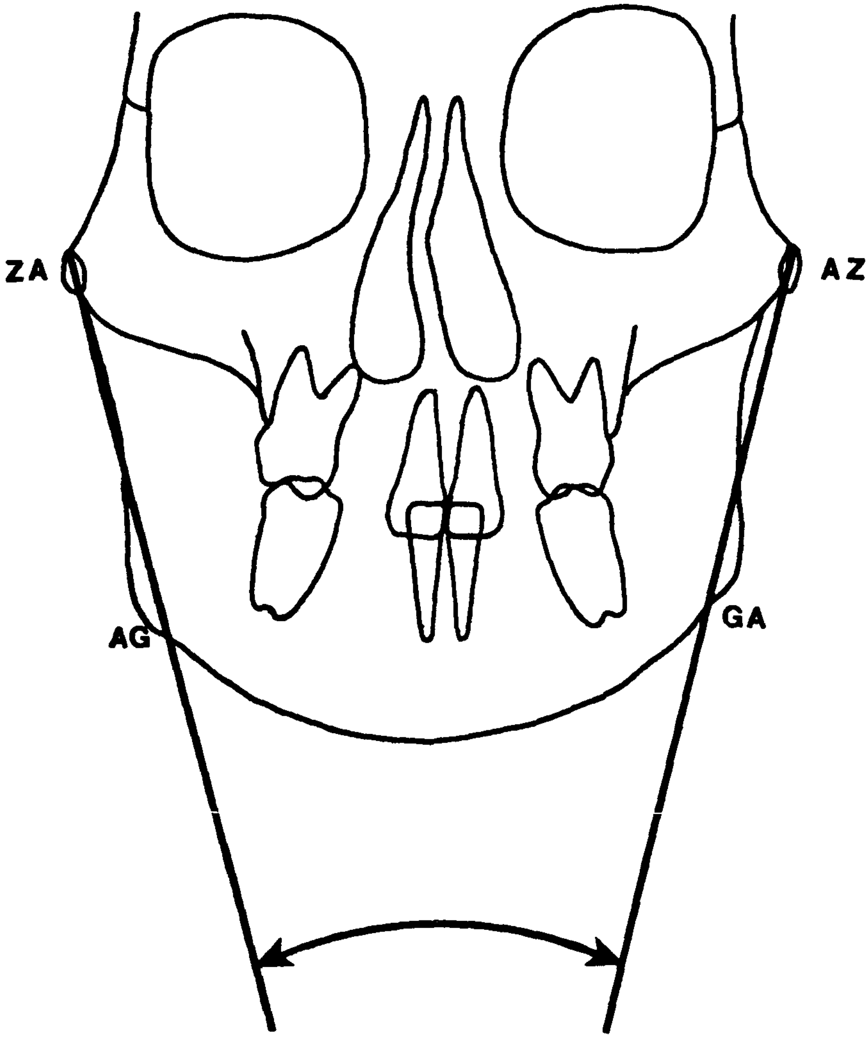

Figure 1
The frontal facial taper angle is formed by the lines passing through the zygomatic arch (ZA and AZ) and antegonial notch (AG and GA) on left and right sides.
This angle usually decreases at 0.2° per year.
Mandibular width, measured between antegonial notches AG and GA, increases between about 0.66mm and 1.50mm per year.

Table 1

Mandibular Width (Ag-GA)
Mean values and annual increases (millimeters)

Age	Bolton Study		FOR Study		Owen Control		Owen Fränkel	
6	74	—	74	—	—	—	—	—
7	75	1	74	0	—	—	—	—
8	76	1	76	2	—	—	—	—
9	79	3	77	1	—	—	76	—
10	81	2	77	1	—	—	79	3
11	83	2	79	2	80	—	81	2
12	85	2	82	3	81	1	—	—
13	85	0	83	1	83	2	—	—
14	87	2	85	2	—	—	—	—
15	88	1	87	2	—	—	—	—
16	90	2	89	2	—	—	—	—
17	91	1	91	2	—	—	—	—
18	92	1	93	2	—	—	—	—
Total Change	18	1.5	19	1.5	3	1.1	5	2.9

Table 2

Frontal Facial Taper
Mean values and mean annual changes (degrees)

Age	Bolton Study		FOR Study		Owen Control		Owen Fränkel	
6	38	—	36	—	—	—	—	—
7	38	0	36	0	—	—	—	—
8	38	0	36	0	—	—	—	—
9	38	0	36	0	—	—	34	—
10	39	+1	35	−1	—	—	32	−2
11	39	0	35	0	31.5	0	31	−1
12	38	−1	35	0	31.5	0	—	—
13	38	0	35	0	31.0	−0.5	—	—
14	37	−1	35	0	—	—	—	—
15	36	−1	34	−1	—	—	—	—
16	36	0	34	0	—	—	—	—
17	36	0	33	−1	—	—	—	—
18	36	0	33	0	—	—	—	—
Total Change	−2	−0.2	−3	−0.3	−0.5	−0.1	−3	−1.8

1 and 2 are shown for reader reference, and to demonstrate the variations as well as the reasonable similarity among the Author's Edgewise/control sample and these untreated reference groups.

These comparisons indicate that Edgewise treatment in the Author's practice did not produce any consistent changes that are dissimilar to average growth without treatment.

— Results —

A multivariate analysis of variance with the two response variables, annual change in mandibular width and in frontal facial taper, was run against the Fränkel and control group with age as a covariate.

Age was not found to be significant in this young age group (Hotelling's T^2, $p = .97$), so it was eliminated as a covariate.

The control sample, treated only with full Edgewise therapy, was compared to both the Bolton norms (Broadbent and Golden 1975) and Foundation for Orthodontic Research (FOR) norms (Ricketts, et al. 1982) to ascertain whether it represented average growth increments in the transverse dimension. By direct measurement using the Author's landmark identification on the Bolton series of average tracings, the Bolton Study shows the mandibular width increasing 1.50mm per year. The mean increase reported in the FOR study is essentially the same (1.508mm per year).

The mandibular width and yearly increase values are shown in Table 1. The mean Bolton and FOR figures compare closely, with the 1.1mm per year found in the Author's Edgewise sample. The 0–3mm range in the Bolton and FOR samples demonstrates the variation in these measurements.

Frontal facial taper angles were constructed and tabulated from the tracings in the same two studies, and the results are shown in Table 2. The overall decrease in the frontal facial taper for the Bolton Study sample was 0.16°/yr, and for the FOR group 0.25°/yr. The comparable value for the control sample was 0.13 ± 0.7°/yr.

The response variables were significantly different between the two groups, with an overall significance of $p < .001$. The increase in mandibular width was significantly greater in the Fränkel treatment group than in the control group (Tables 3–5), while the frontal facial taper of the Fränkel group decreased significantly more than in the control group (Tables 6–8).

These differences are shown graphically in Figures 2 and 3. Figure 2 plots the increase in the mandibular width of the Fränkel sample versus the Edgewise, Bolton and FOR values. Figure 3 plots the decrease in the frontal facial taper of the treatment group compared to those three reference samples. In both comparisons, it appears that the morphologic response to Fränkel treatment is significantly different from Edgewise therapy or average growth.

The treatment and Edgewise samples were examined further on the basis of their Angle classification. A multivariate analysis with annual changes in the frontal facial taper and mandibular width as dependent variables was run against both Class I and Class II, division 1 malocclusions. Tables 4, 5, 7 and 8 present the descriptive statistics for these groups, and Figures 4 and 5 show them graphically.

The statistical differences between the Fränkel sample and edgewise sample for Class I and Class II patients are all significant at the $p < .001$ level.

Figures 6 and 7 show the mean frontal cephalographs from the Bolton and FOR study superimposed at ages 9 and 11. These superimpositions are on the sagittal plane registered at the intersection with the zygomatic arch plane (Owen 1983). This superimposition shows the average amount of growth change found in the frontal facial taper angle during the approximate treatment years.

Figure 8 shows the mandibular outlines from the Bolton and FOR norms superimposed on the sagittal plane and the frontal mandibular plane (gonial plane) to show the average increase in mandibular width during those same two years.

Figures 9 and 10 show a patient from the non-Fränkel sample. In spite of correction of a unilateral crossbite by rapid maxillary expansion during treatment, the cephalographs show a transverse change in the mandible similar to that in the Bolton and FOR norms. The Edgewise patient shown in Figures 11 and 12 had a bilateral maxillary crossbite corrected using a Haas rapid palatal expansion appliance. According to Haas (1980), rapid maxillary expansion may lead to expansion of the mandibular dental arch, apparently in response to the occlusal forces from the wider maxillary teeth being transmitted to the mandibular teeth, and the wider maxillary dentition and basal bone holding the constrictive forces of the buccinator mechanism away from the mandibular dentition (the latter is this Author's interpretation).

In spite of the orthopaedic approach to increasing the lateral dimension in these two Edgewise/control cases, the increase in mandibular width was not unlike that in the the Bolton and FOR growth reference samples. The frontal facial taper also remained similar to the reference averages. No known reported study shows the bizygomatic width being increased as a result of rapid maxillary expansion; if this were to occur, then the frontal facial taper could conceivably remain unchanged in spite of some mandibular expansion.

Figures 13 to 20 show four patients from the treatment sample. Facial changes in these patients present an apparent broadening of the lower part of the face reflecting the changes seen in these cephalometric records.

In the treatment patients, the Fränkel appears to have changed the normal or expected transverse growth changes in the mandible toward a more brachyfacial development. Although these changes are slight, they do appear to be significant.

— Discussion —

Although rapid maxillary expansion has been shown to produce an orthopaedic widening of the maxillae and subsequent mandibular dental expansion by Haas (1970 and 1980) and others (Wertz 1970 and Timms 1980), this expansion has not been shown to expand the zygomatic arches or the mandible itself. It would appear to have no effect on the frontal facial taper angle or the mandibular width. This is borne out by the two cases presented in Figures 9–12.

The Fränkel appliance has been shown to expand dental arches by Fränkel (Fränkel 1974 and 1976, McDougall, McNamara, and Dierkes 1982, and Owen 1983). The study by McDougall et al. was limited to dentoalveolar changes and showed highly significant lateral expansion in Class II patients. Owen studied more basilar structures as well as the dentoalveolar changes and found highly significant lateral expansion even in these deeper structures.

Kerr (1981) reported no expansion ia a study of cleft palate patients. The lack of expansion in his study may be attributable

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Table 3

Mandibular Width
(millimeters) (N=50)

	Fränkel Group			Control Group		
	Mean	S.D.	S.E.	Mean	S.D.	S.E.
MdW T1	76.1	3.7	0.52	80.7	4.2	0.60
MdW T2	81.0	3.5	0.49	82.3	4.6	0.65
Difference	4.9	1.9	0.27	2.6	1.7	0.25
Annual Change	2.9	1.3	0.19	1.1	0.7	0.10
	t=10.58 d.f.=98 p=.001					

Table 4

Mandibular Width, Class I
(millimeters) (N=23)

	Fränkel Group			Control Group		
	Mean	S.D.	S.E.	Mean	S.D.	S.E.
MdW T1	75.9	3.5	0.73	80.0	4.5	0.94
MdW T2	80.7	3.1	0.65	82.4	5.4	1.12
Annual change	2.8	1.3	0.26	.9	.7	0.16

Table 5

Mandibular Width, Class II, division 1
(millimeters) (N=27)

	Fränkel Group			Control Group		
	Mean	S.D.	S.E.	Mean	S.D.	S.E.
MdW T1	76.2	3.9	0.75	81.3	4.0	0.76
MdW T2	81.2	3.8	0.72	82.3	4.0	0.75
Annual Change	3.0	1.4	0.27	0.4	0.6	0.11

Table 6

Frontal Facial Taper
(degrees) (N=50)

	Fränkel Group			Control Group		
	Mean	S.D.	S.E.	Mean	S.D.	S.E.
Taper T1	33.9	3.9	0.56	31.5	4.1	0.59
Taper T2	30.9	3.9	0.55	31.1	3.7	0.52
Difference	−3.0	1.8	0.26	−0.5	1.8	0.25
Annual Change	−1.8	1.3	0.18	−0.1	0.7	0.10
	t=7.95 d.f.=98 p=.001					

Table 7

Frontal Facial Taper, Class I
(degrees) (N=23)

	Fränkel Group			Control Group		
	Mean	S.D.	S.E.	Mean	S.D.	S.E.
Taper T1	33.4	4.0	.82	33.9	3.2	.67
Taper T2	30.9	3.9	.82	32.2	3.3	.69
Annual change	−1.4	0.8	.17	−0.6	0.5	.11

Table 8

Frontal Facial Taper, Class II, division 1
(degrees) (N=27)

	Fränkel Group			Control Group		
	Mean	S.D.	S.E.	Mean	S.D.	S.E.
Taper T1	34.3	3.9	.75	29.6	3.8	.74
Taper T2	30.9	4.0	.77	30.1	3.7	.72
Annual change	−2.1	1.5	.29	0.3	0.6	.12

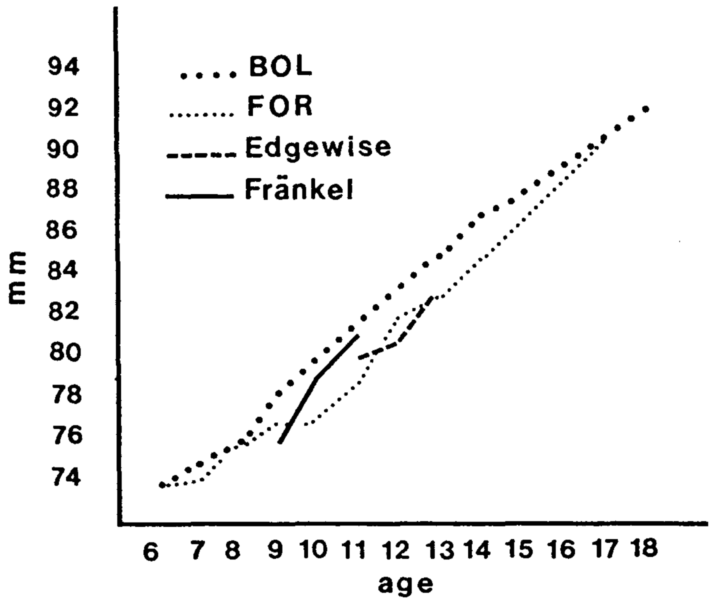

Figure 2
Mean Mandibular Width (mm)
plotted against age

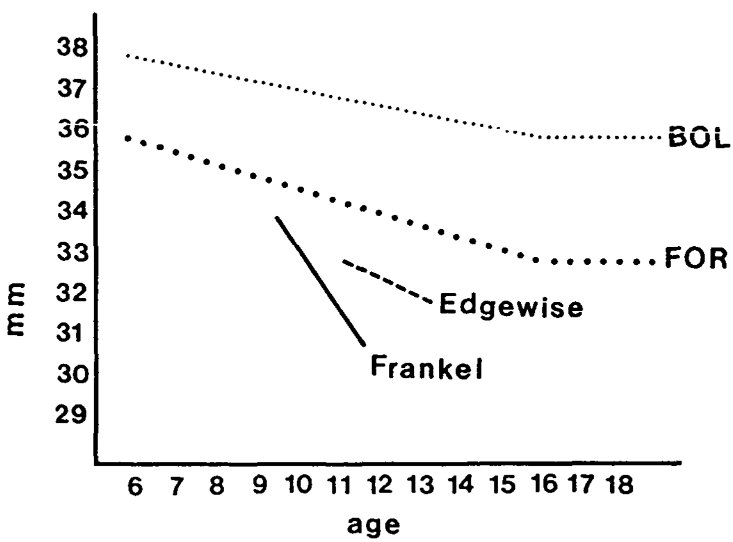

Figure 3
Mean Frontal Facial Taper (degrees)
plotted against age

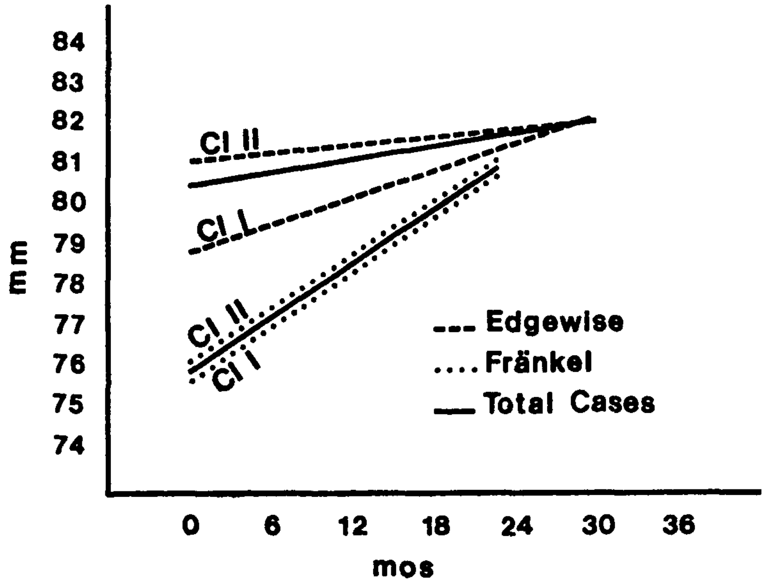

Figure 4
Mean Mandibular width changes during treatment

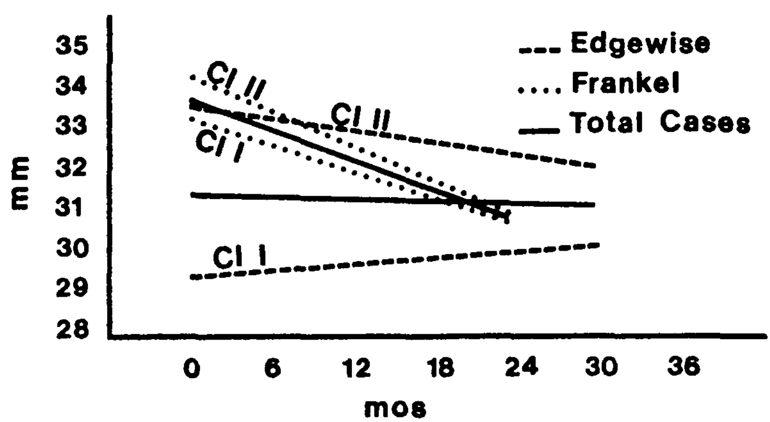

Figure 5
Mean Frontal Facial Taper changes during treatment

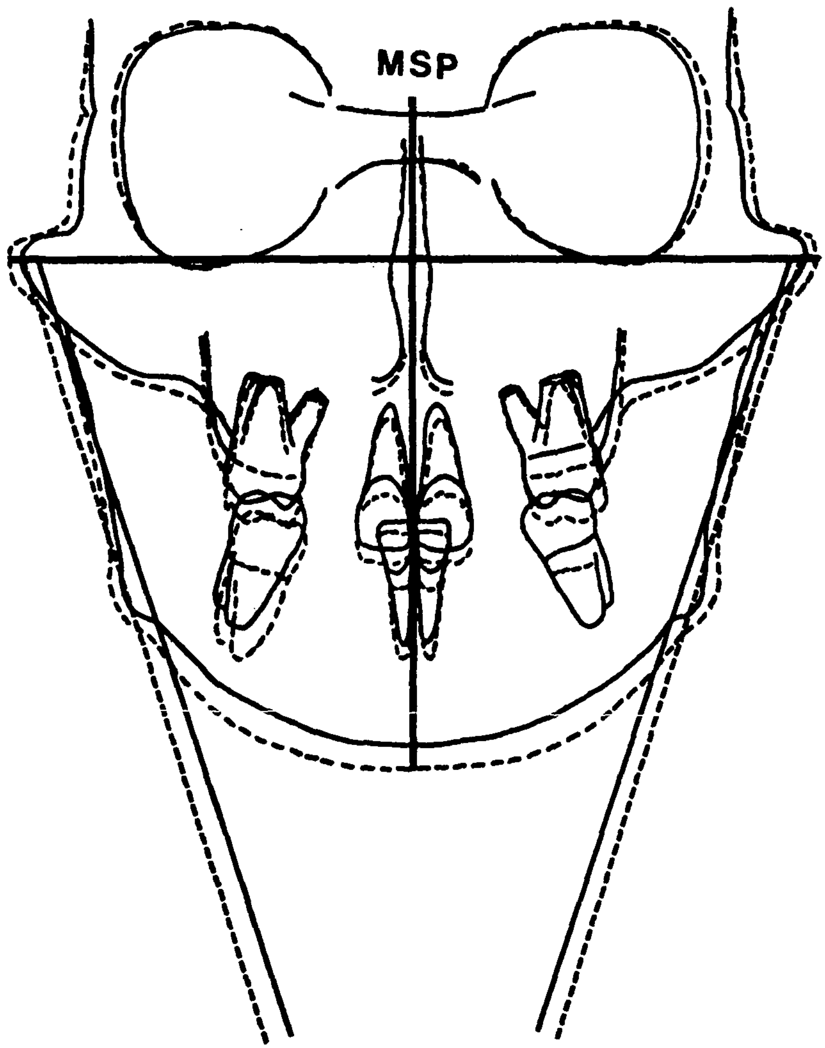

Figure 6
Mean Frontal Facial Taper in Bolton series at ages 9 and 11

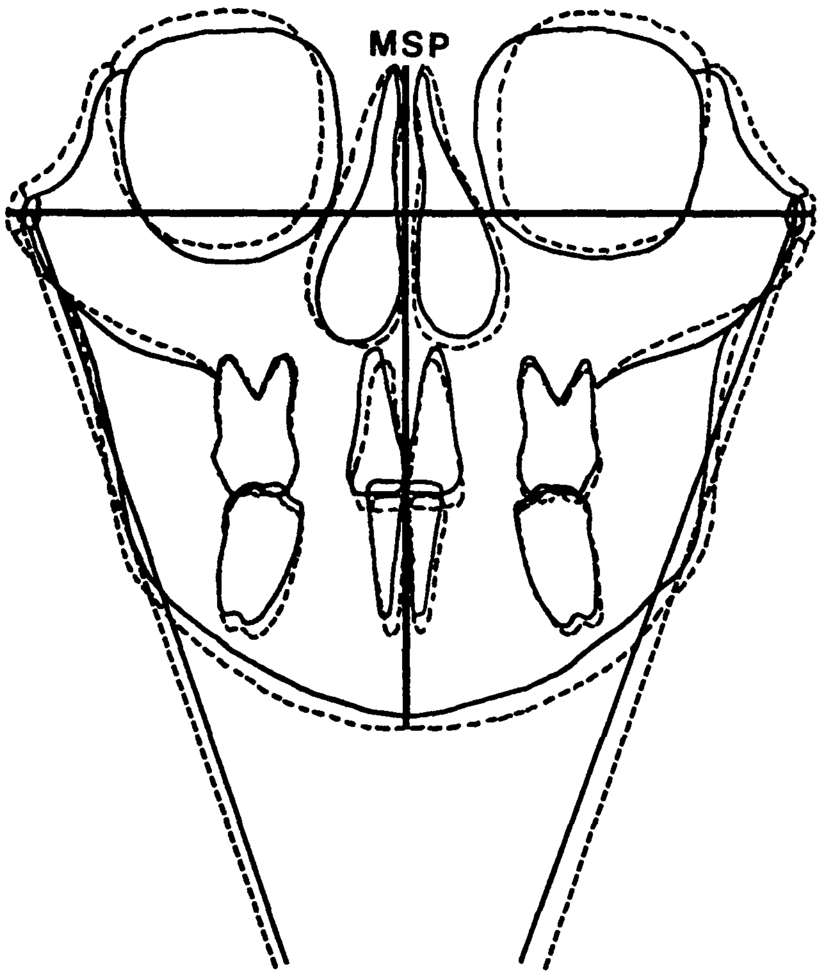

Figure 7
Mean Frontal Facial Taper in FOR series at ages 9 and 11

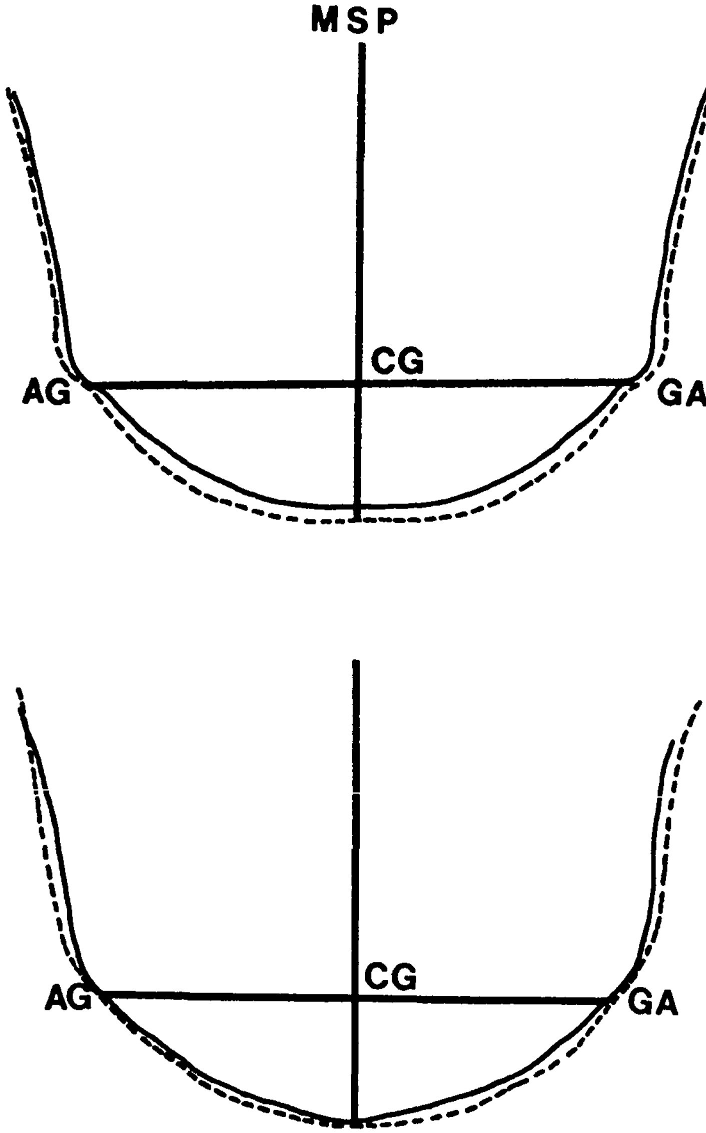

Figure 8
Superimposed mandibular outlines at 9 and 11 years from the Bolton sample (top) and FOR sample (bottom)

to using a wearing time averaging only 12.7 hours per day instead of 20 suggested by Fränkel, treating older patients who are not as responsive to the periosteal tension as younger patients, and possible appliance design deficiencies which were very common during the early years of Fränkel treatment in this country.

The phenomenon of lateral expansion in the area of the depth of the vestibule was postulated by FRÄNKEL (1974 AND 1976) to be a result of tension on the periosteum created by the vestibular shield. The piezoelectric theory of bone transformation, which postulates that tension/compression effects generate electrical charges that stimulate bone changes, is supported by DONNELY, SNOOPE, AND MOFFETT (1973), BASSETT (1968) and STEINBERG, WERT AND KOROSTOFF (1973). The lateral tension is presumed to cause bony apposition and would appear to be substantiated by OWEN'S 1983 study. It must be noted that this tension only occurs when properly shaped buccal shields extend into the depth of the vestibule; under-extended shields do not appear to produce the same morphological response, and claims of lateral expansion with small buccal pads or overlay wires should be carefully scrutinized. The latter may have some influence on the tooth crowns, but they cannot influence the muscle attachments.

The lower border of the vestibular shield is several millimeters above the antegonial notches and yet, the frontal cephalographs suggest expansion of the inferior border of the mandible across the antegonial notches. Some of the expansion would appear to be the result of properly extended vestibular shields and subsequent bony apposition in this area. A second postulate to explain the expansion of the mandible beyond the dentoalveolar structures is the effect of the vestibular shields on the musculature. FRÄNKEL (1974 AND 1976) postulated that one cause of the initial narrowing of the dental arches is the hypertonic buccinator mechanism.

One of the objectives of the vestibular shield is to force any hypertonic muscles, particularly the buccinator, to become more isotonic. FREELAND (1979) reports that this myofunctional change appears to be the case. Perhaps as the buccinator muscle is trained to relax (or is "regulated" as the term "functional regulator" implies), this allows for expansion of the underlying bony structures which include the maxilla and mandible.

Lip seal exercises, which FRÄNKEL (1969, 1969, AND 1973) states are imperative to successful treatment, may also have an additive effect on the entire buccinator mechanism. It would appear that, as the entire circumoral and perioral musculature are all "regulated" simultaneously, there would be a far greater cumulative effect than with local or isolated regulators such as lip bumpers, overlay arch wires, buccal pads, etc.

The results from this study suggest that the mandible itself is being expanded, or allowed to expand, from the influence of the functional regulator. This expansion apparently occurs in response to the vestibular shields, which remove a hostile or hyperactive muscle drape in the lateral borders of the oral region. The mandibular width, as measured between the antegonial notches, expands significantly more than usual or average growth. This mandibular expansion leads to a broadening of the lower face, and a decrease in the facial taper as viewed from the frontal aspect. Although a similar expansion occurs in the maxilla, it is masked by the zygomatic arches which are beyond the influence of the appliance.

Class I Edgewise treatment showed a decrease in the frontal facial taper similar

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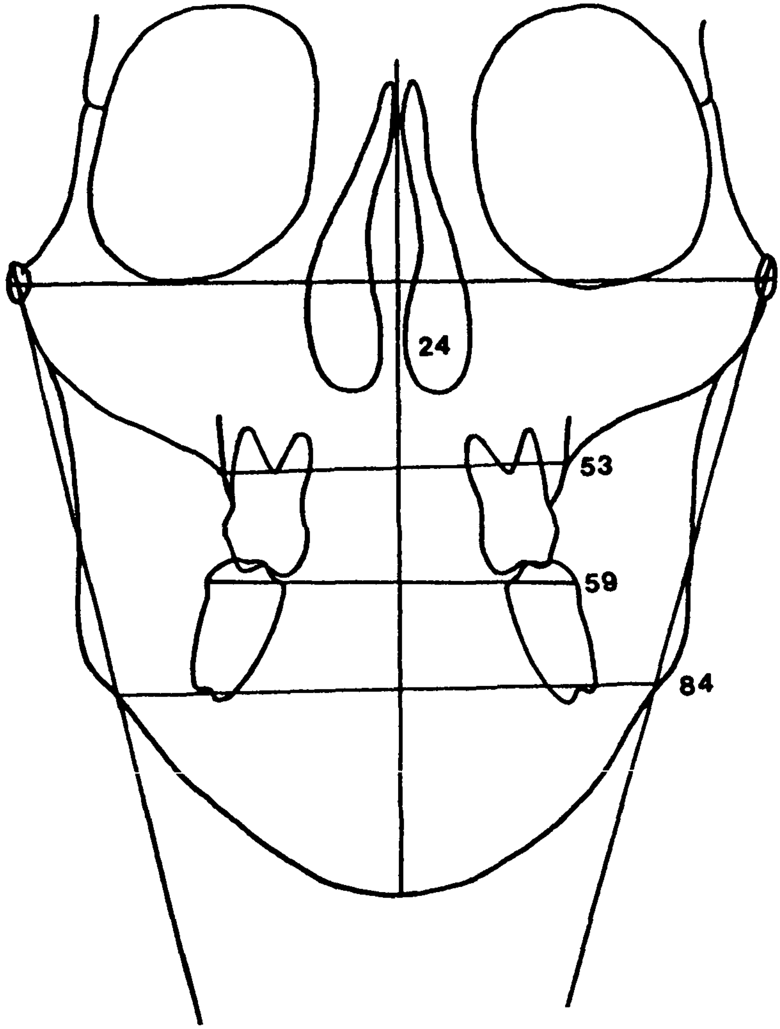

Figure 9
Pretreatment tracing of a patient with a unilateral crossbite at 11.3 years. Treatment was accomplished with rapid palatal expansion and Edgewise therapy.
The posttreatment tracing is shown in Figure 10 (opposite).

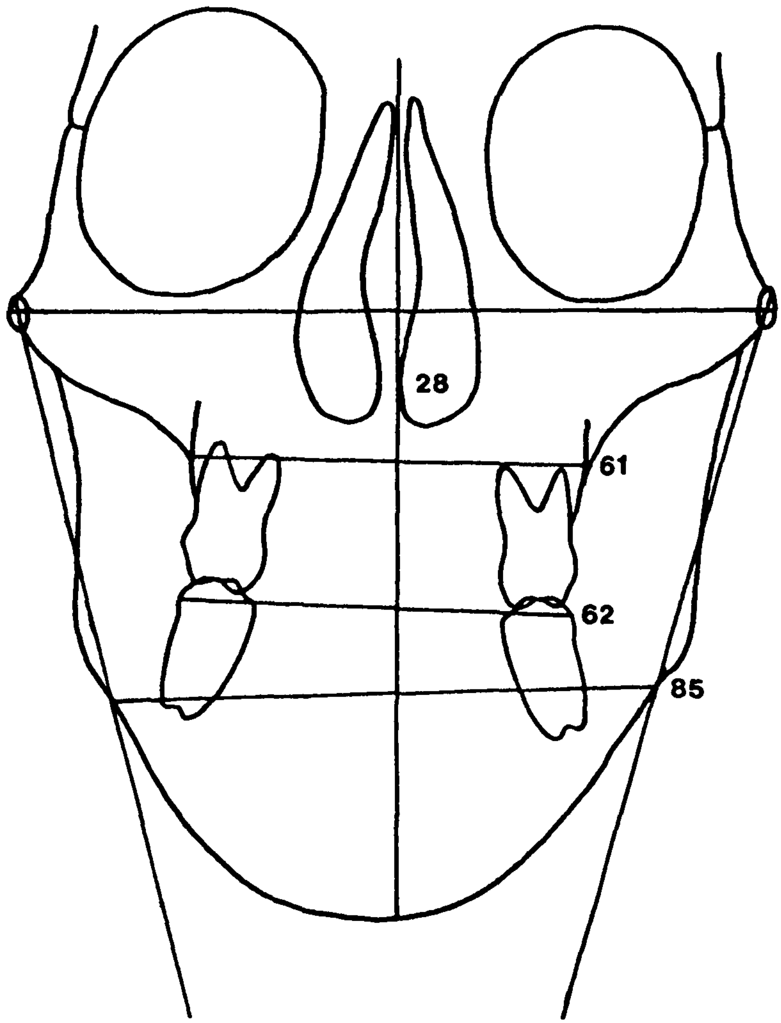

Figure 10
The patient shown in Figure 9 (opposite) at age 13.1, after treatment with rapid palatal expansion and 24 months of full-banded Edgewise therapy. Mandibular changes are similar to Bolton and FOR norms.

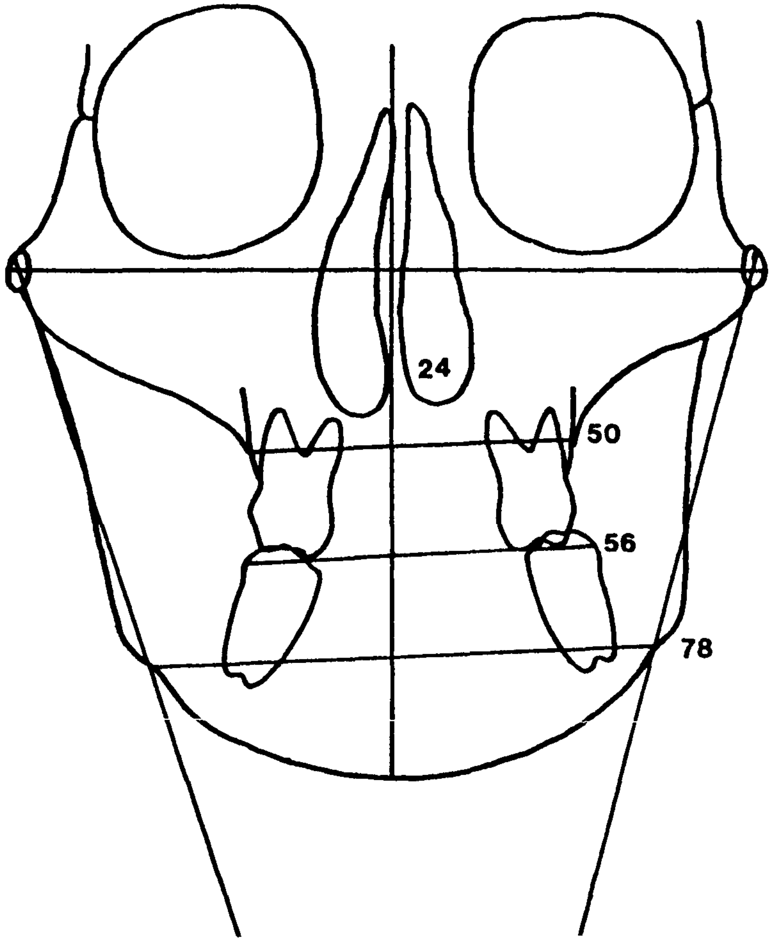

Figure 11
Pretreatment tracing of a patient with a bilateral crossbite at 10.5 years. Treatment was accomplished with rapid palatal expansion and Edgewise therapy.
The posttreatment tracing is shown in Figure 12 (opposite).

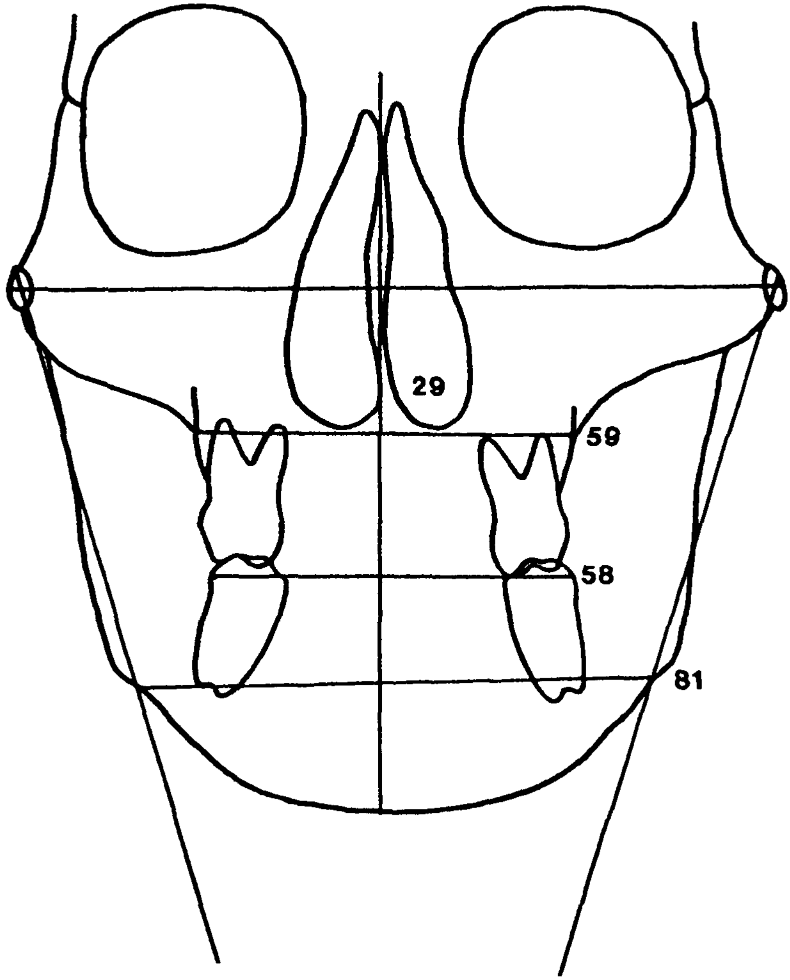

Figure 12
Posttreatment tracing of the patient shown in Figure 11 (opposite) at age 12.8, after treatment with Haas rapid maxillary expansion appliance and 28 months of Edgewise therapy.
Mandibular changes are similar to Bolton and FOR norms.

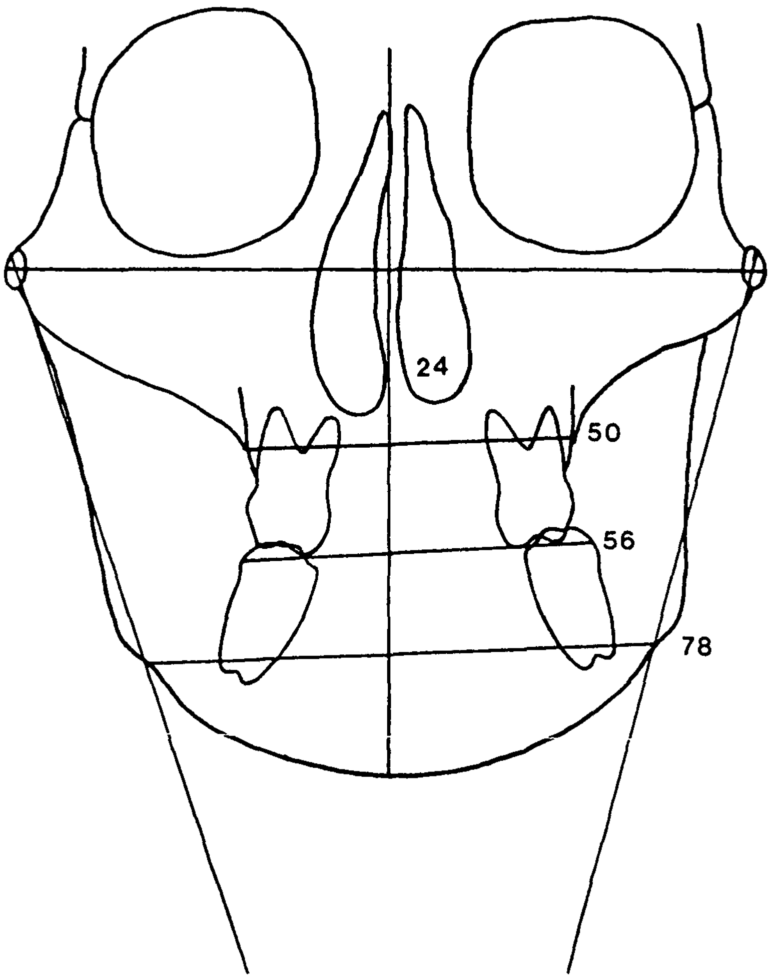

Figure 13
Pretreatment tracing of Fränkel patient number one, at 10.5 years of age.
The posttreatment tracing is shown in Figure 14 (opposite).

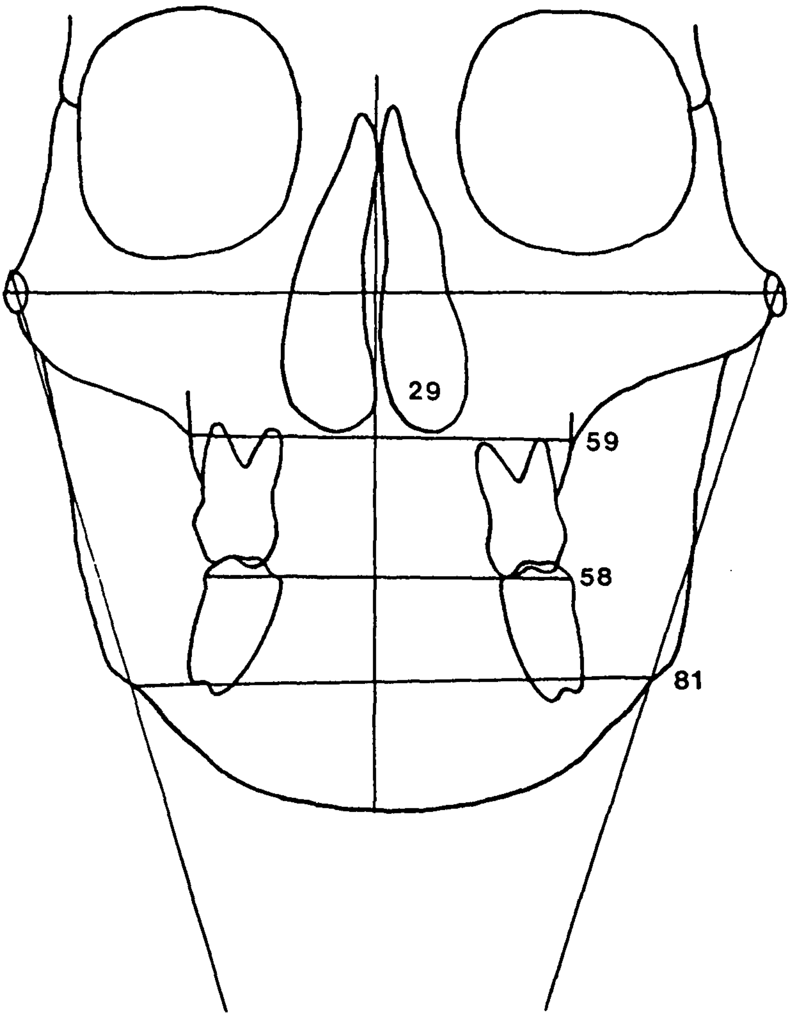

Figure 14
Posttreatment tracing of the Fränkel patient shown in Figure 13 (opposite) at 12.8 years of age.

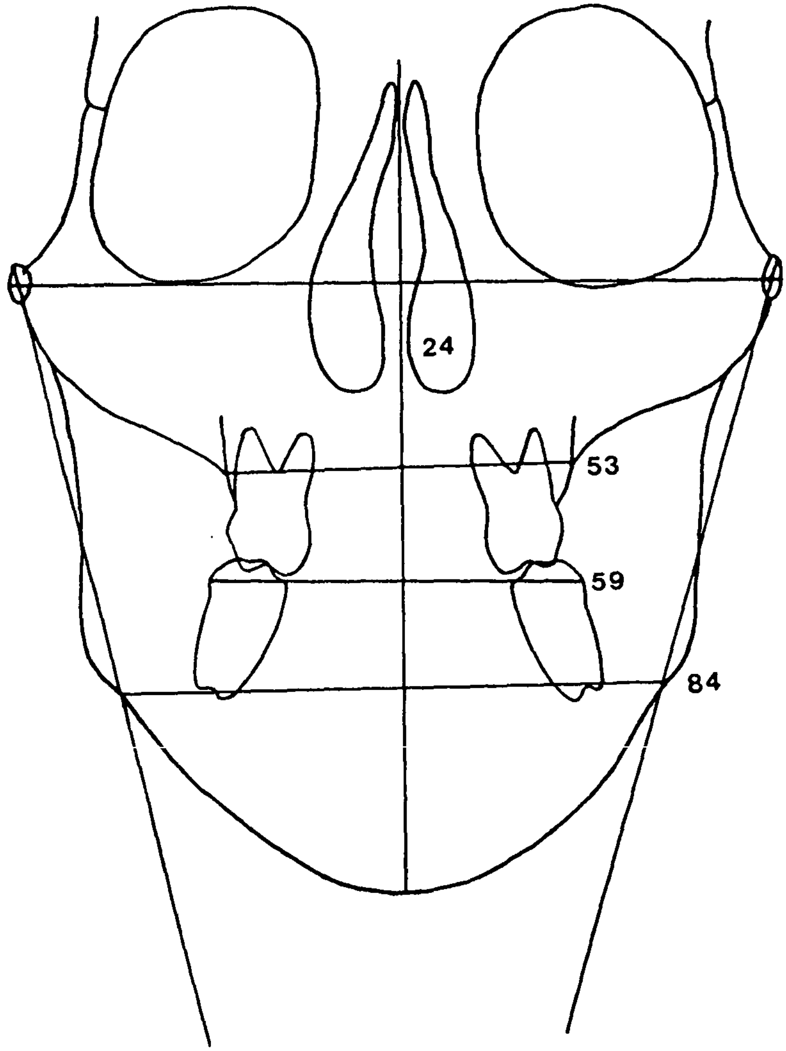

Figure 15
Pretreatment tracing of Fränkel patient number two, at 11.3 years of age. The posttreatment tracing is shown in Figure 16 (opposite).

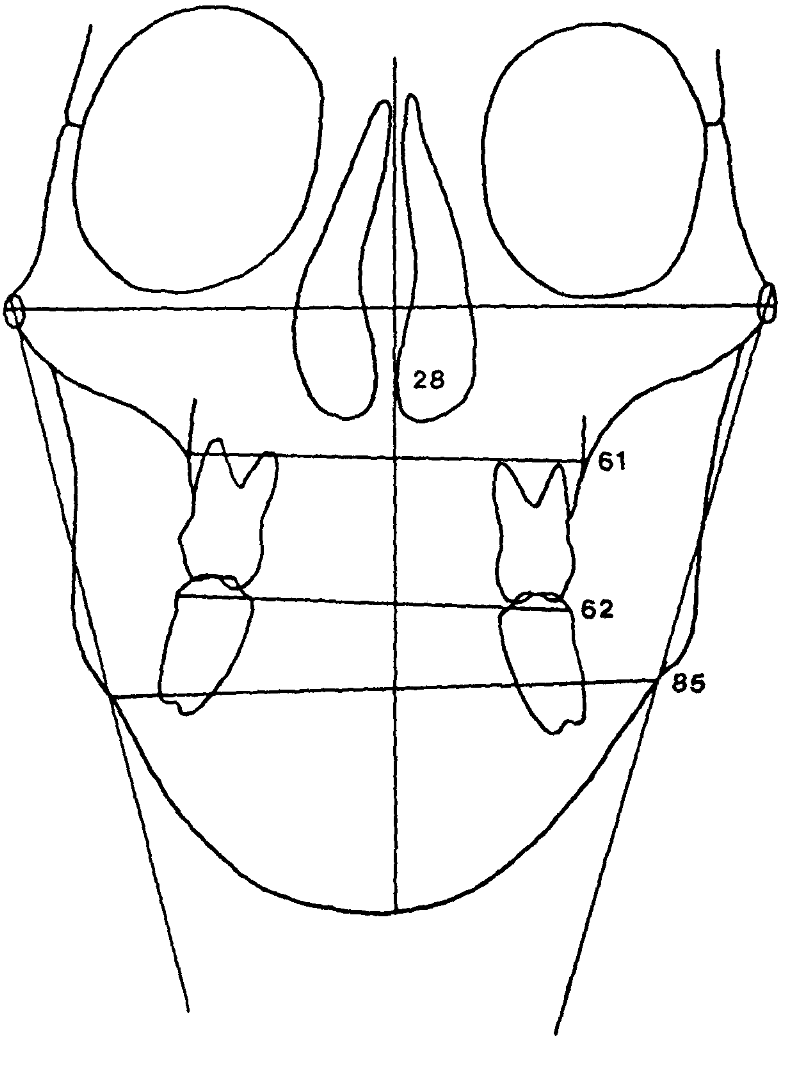

Figure 16
Posttreatment tracing of the Fränkel patient *shown in Figure 15* (opposite) at 13.1 years of age.

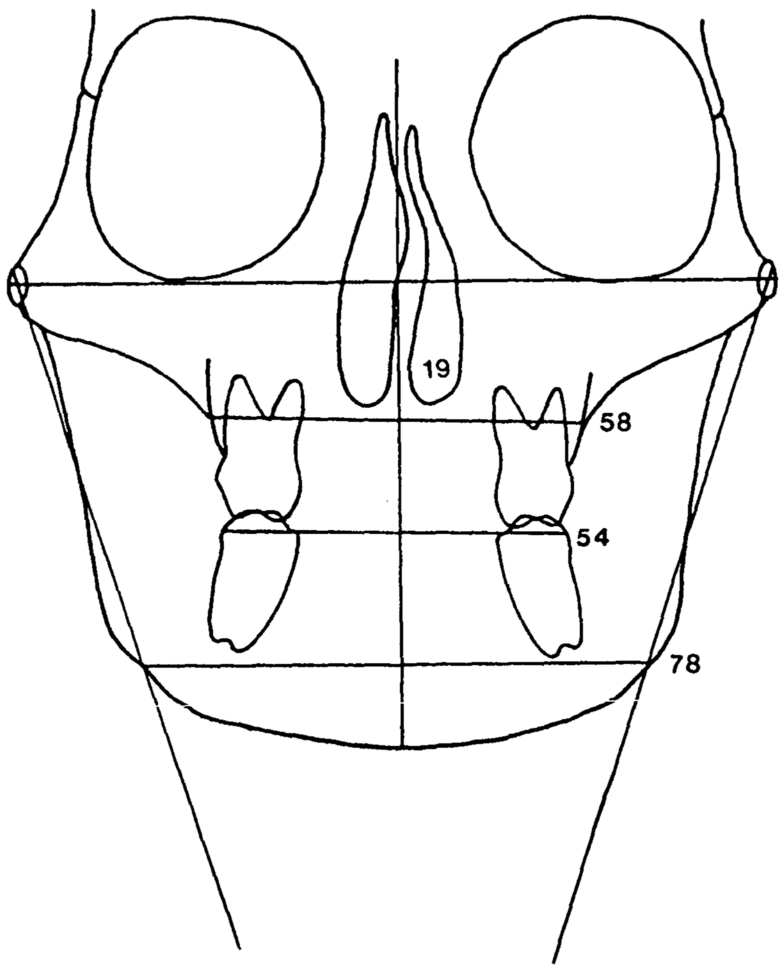

Figure 17
Pretreatment tracing of Fränkel patient number three, at 9.1 years of age. The posttreatment tracing is shown in Figure 18 (opposite).

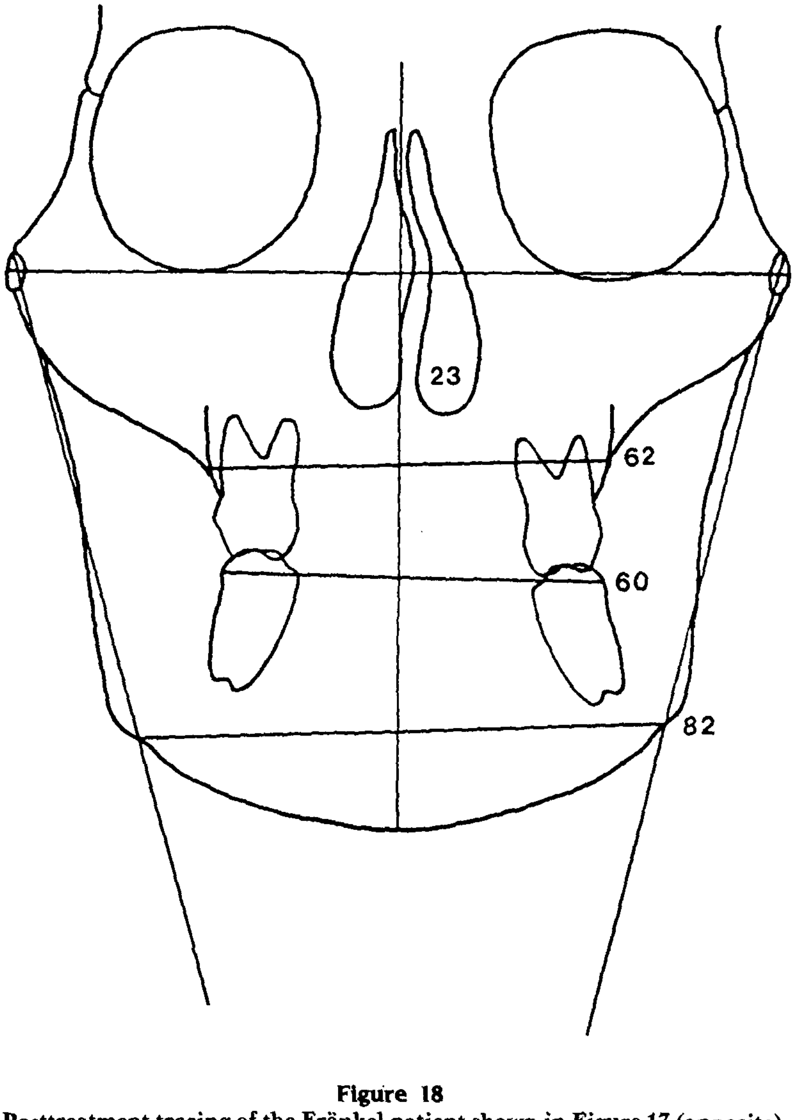

Figure 18
Posttreatment tracing of the Fränkel patient shown in Figure 17 (opposite) at 10.11 years of age.

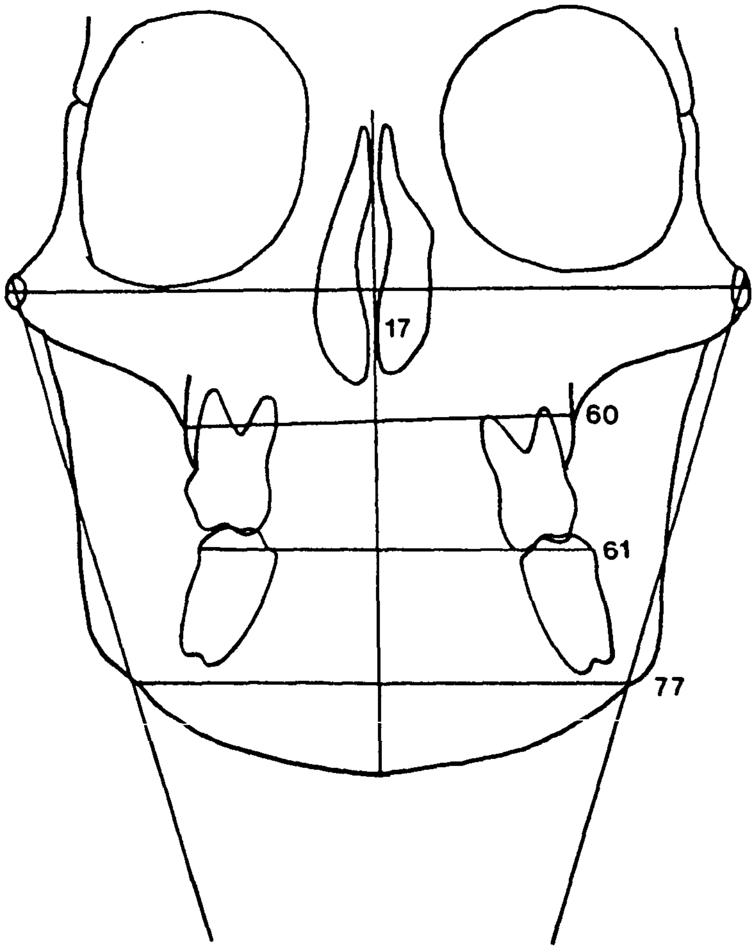

Figure 19
Pretreatment tracing of Fränkel patient number four, at 10.7 years of age. The posttreatment tracing is shown in Figure 20 (opposite).

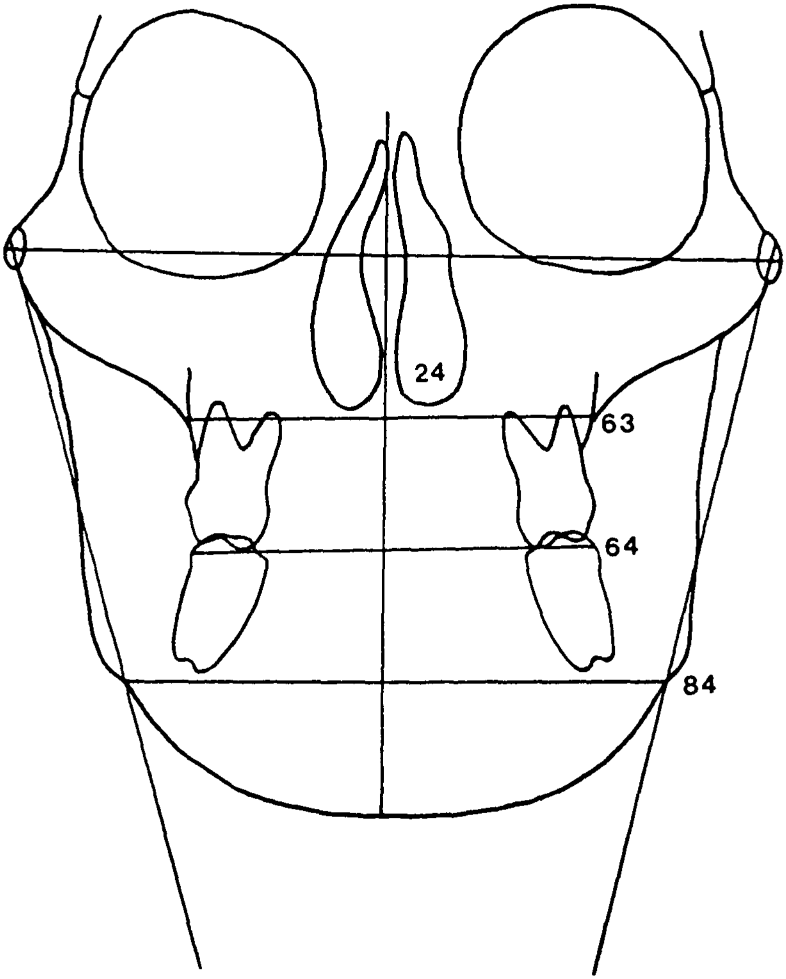

Figure 20
Posttreatment tracing of the Fränkel patient shown in Figure 19 (opposite) at 13.0 years of age.

to average growth changes, but Class II Edgewise treatment showed an increase in this angle. The reason for this unexpected change is unknown, but perhaps future research will provide the answer(s).

The mandibular expansion which occurs as an apparent result of the Fränkel appliance appears to be equally significant for both Class I and Class II patients. The frontal facial taper of the mandibular width is changed in both Class I and Class II patients at the $P<.001$ level of significance, which supports the concept of non-extraction treatment for more borderline cases.

Platou and Zachrisson (1983) report that ideal occlusion in Scandinavian school children tends to be more brachycephalic and more protrusive than most cephalometric analyses suggest, which also lends support for the possibility that these changes during Fränkel treatment will benefit the patient and tend to help achieve a more ideal occlusal result.

Reviewing magazine models, beauty contest winners and movie stars indicates that the public prefers mesocephalic and brachycephalic faces over dolichocephalic faces. It would appear, then, that there may also be an aesthetic benefit to patients undergoing Fränkel treatment due to the appliance's design to encourage a more brachyfacial type growth than other appliances.

At least three areas are suggested for future study:

1. Implant studies to document morphological changes in the transverse dimension using the Fränkel appliance,
2. EMG studies to elucidate the myofunctional changes which occur during functional regulator treatment, and
3. The correlation of hard and soft tissue changes in the transverse dimension.

— Summary —

1. Fifty patients from 5.9 to 13.8 years of age (mean 9.6 $\pm$1.54) were treated using the Fränkel appliance. These patients are compared to a similar control group that received Edgewise treatment. The control sample was selected on the basis of adequate before- and after-treatment records, and sex, age, and Angle relationships similar to the treatment sample. The resultant lateral expansion in the Fränkel group was compared to the changes in the Edgewise/control sample, as well as to the Bolton and FOR norms.

2. Although no statistical comparison was performed between the Edgewise sample and the Bolton or FOR samples, the changes in both the frontal facial taper and the mandibular width are similar. Although yet unproven, these two factors are apparently not influenced by Edgewise treatment, but for purposes of this study the control sample (Edgewise treatment sample) appears to be similar enough to untreated growth for comparison with Fränkel treatment.

3. The mandibular width was measured as the distance between the antegonial notches on the postero-anterior cephalograph. The Fränkel sample had a mean increase of 2.9mm per year ($\pm$1.3), while the Edgewise control sample had 1.1mm per year ($\pm$0.7). This difference in the increase in mandibular width is significant ($P<.001$).

4. Evaluating response of different Angle classifications, bigonial width in Class I Edgewise cases increased 0.9mm/year ($\pm$0.74), while Class I Fränkel cases increased 2.8mm/year ($\pm$1.27). Class II Edgewise cases increased 0.4mm/year

(±0.5), while the Class II Fränkel sample increased 3.0mm/year (±1.4). Both of these differences were significant at the $P < .001$ level.

5. The frontal facial taper angle is introduced. It is formed by the intersection of the line passing through the zygomatic arch (ZA) and the antegonial notch (AG) on one side of the frontal cephalograph with the same line (AZ–GA) on the opposite side. This angle decreased 0.13° per year (±.07°) in the Edgewise control sample, 0.16°/year in the Bolton norms, and 0.25°/year in the FOR norms. The Fränkel treatment sample decreased 1.8°/year (±1.3°), which is significant ($P < .001$).

6. Frontofacial angle in Angle Class I Edgewise cases decreased 0.61°/year (±0.52°), while Class I Fränkel cases decreased 1.41°/year (±0.83°). Class II Edgewise cases *increased* 0.29°/year (±0.61°), while the Fränkel Class II cases decreased 2.12°/year (±1.53°). Both of these differences are significant at the $P < .001$ level. The reason for the increase in the Class II control group is unknown, as both the Bolton and FOR norms decrease each year. This is open to future studies of muscle patterns, skeletal growth, and other possible differences from Class I cases.

7. The above findings suggest that the Fränkel appliance may tend to widen the mandible more than average growth or Edgewise treatment. This change toward a more brachyfacial skeleton and face may be of benefit to some patients. These changes in the frontal aspect must be considered in the light of function and facial balance and beauty, and the clinician must decide whether the changes would be beneficial or detrimental to the patient on an individual basis.

— Conclusions —

1. Edgewise treatment does not appear to increase the mandibular width more than average growth without treatment.

2. Fränkel treatment appears to increase the mandibular width significantly more than either Edgewise or average growth. This phenomenon is most likely due to the action of the vestibular shields, but the exact mechanism is yet unknown.

3. Fränkel treatment tends to make the patient more brachyfacial than average growth, as revealed by the frontal facial taper angle.

4. Brachyfacial individuals appear to have more ideal occlusions (Platou and Zachrisson (1983), and perhaps have better stability than less brachyfacial individuals.

5. Brachyfacial faces are more common among models, movie stars, and beauty contest winners than dolichofacial faces, suggesting that brachyfacial individuals have more pleasing esthetics than more narrow-faced people.

6. Untreated Class II individuals do not appear to grow as wide as untreated Class I individuals. The reason for this is unknown.

7. Each patient must be evaluated on an individual basis. Not all patients are good candidates for Fränkel treatment; those who are uncooperative, too young, too old, or otherwise unsuitable for FJO treatment should be treated by fixed appliances.

8. Nor is Fränkel treatment for all clinicians. Clinicians who use the Fränkel appliance (or other removable FJO appliances) must be able to motivate their patients to an adequate level of cooperation, or this approach is doomed.

9. Future studies are still needed to further elucidate the effects and the clinical applicability of these appliances. Such studies might include:

• Implants to document lateral expansion effects in both maxillary and mandibular bone and dentition resulting from Fränkel treatment,

• EMG studies to document any changes in muscle tonicity resulting from use of the functional regulator, and

• correlations among the skeletal and soft tissue changes in the sagittal and transverse dimensions.

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