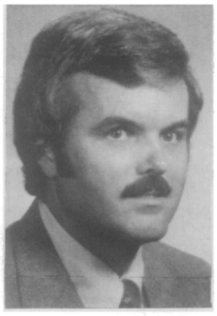
Dr. McNamara

# *Dentofacial adaptations in adult patients following functional regulator therapy*

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The purpose of this article is to describe three cases in which young adult patients were treated with the functional regulator of Fränkel. Each patient had a Class II malocclusion with a degree of mandibular skeletal and dental retrusion. Each patient wore a functional regulator (FR-2), and treatment times varied from a minimum of 1 year to a maximum of 3½ years. The length of the mandible did not increase significantly in any of the patients. In all cases, however, there were increases in vertical dimension. The analysis used in this study indicates that only minimal skeletal and dental adaptation occurred and that these adaptations were insufficient to completely resolve the patients' malocclusions.

**Key words:** Adaptation, adult treatment, Fränkel appliance, functional jaw orthopedics, temporomandibular joint

Over the last few years increasing numbers of clinicians have been advocating the use of functional appliances in adult patients, suggesting that these appliances can alleviate temporomandibular joint dysfunction and can correct minor or major skeletal and dental discrepancies. However, traditional attitudes of the American orthodontic community toward the lack of adaptability of the temporomandibular joint in the adult may suggest that the use of functional appliances in adult patients is inappropriate. Several previous experimental studies[1–4] indicate that the adult temporomandibular joint is resistant to significant adaptation. Pathologic changes have been reported in the adult animal in one study.[5] In a statement consistent with this view, Ramfjord and Ash[6] state that whenever an alteration occurs in the occlusion-temporomandibular joint relationship, the occlusion must adapt to the temporomandibular joint rather than the reverse.

My co-workers and I[7] have recently completed a study of temporomandibular joint adaptation to protrusive function in young adult rhesus monkeys. Twelve monkeys wore functional protrusive appliances for periods ranging from 2 to 24 weeks. A histologic analysis of the temporomandibular joint region demonstrated that six of the animals exhibited an altered tissue response in the mandibular condyle which was qualitatively similar to that noted in related studies using juvenile animals.[8] However, the degree of response in the young adult monkeys was less exuberant than that seen in juveniles and was not related to the duration of treatment. Three other experimental animals exhibited little or no detectable condylar response, and another three animals developed crossbites. A subsequent study by Hinton and McNamara[9] suggests that there is a correlation between the estimated age of the animal (as indicated by tooth wear) and the degree of condylar response. The older the animal, the less the degree of response and presumably the less the adaptation in the temporomandibular joint.

To date no clinical studies of dentofacial adaptation associated with functional appliance therapy in adults have been reported. The purpose of this article is to describe the skeletal and dental adaptations that occurred in young adult patients who were treated with the FR-2 appliance[10–13] for periods of time ranging from 1 to 3 years.

Five patients were scheduled to undergo functional appliance therapy. One patient decided to discontinue treatment because he found it impossible to wear the appliance on a full-time basis. A second patient who was treated with a functional regulator developed temporomandibular joint tenderness after 6 weeks and functional appliance treatment was discontinued. The records of the three remaining patients are reported here.

## CASE 1

The patient, a 20-year-old white male, had a Class II, Division 1 malocclusion characterized by skeletal mandibular retrusion (Figs. 1 to 3).

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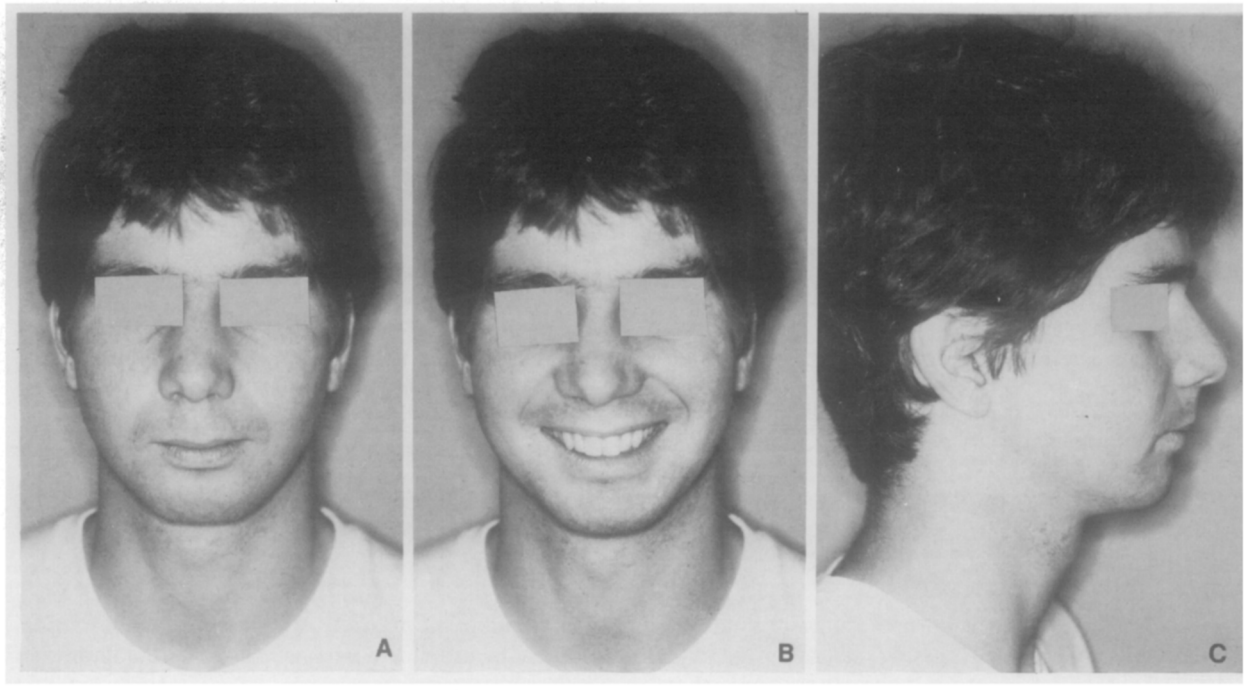


**Fig. 1.** Case 1. Extraoral photographs at beginning of treatment.

**Fig. 2.** Case 1. Intraoral photographs at beginning of treatment.

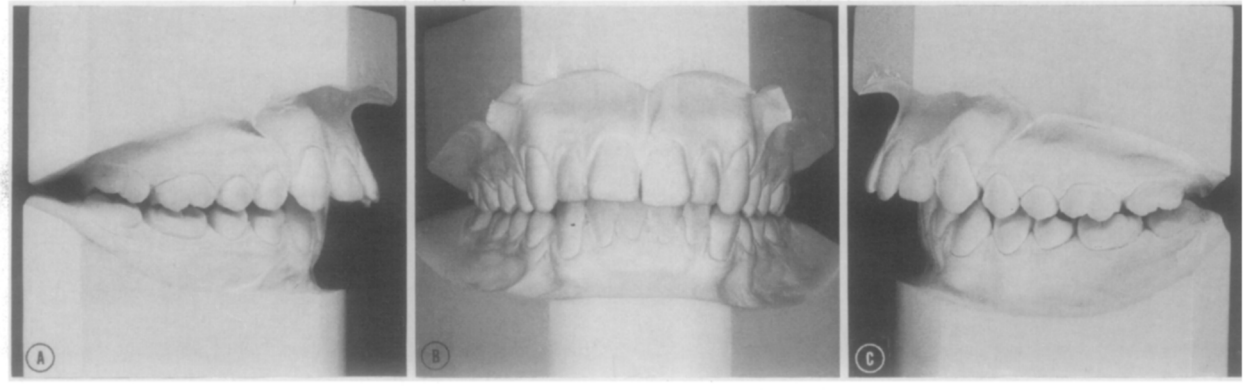

**Fig. 3.** Case 1. Study models made at beginning of treatment.

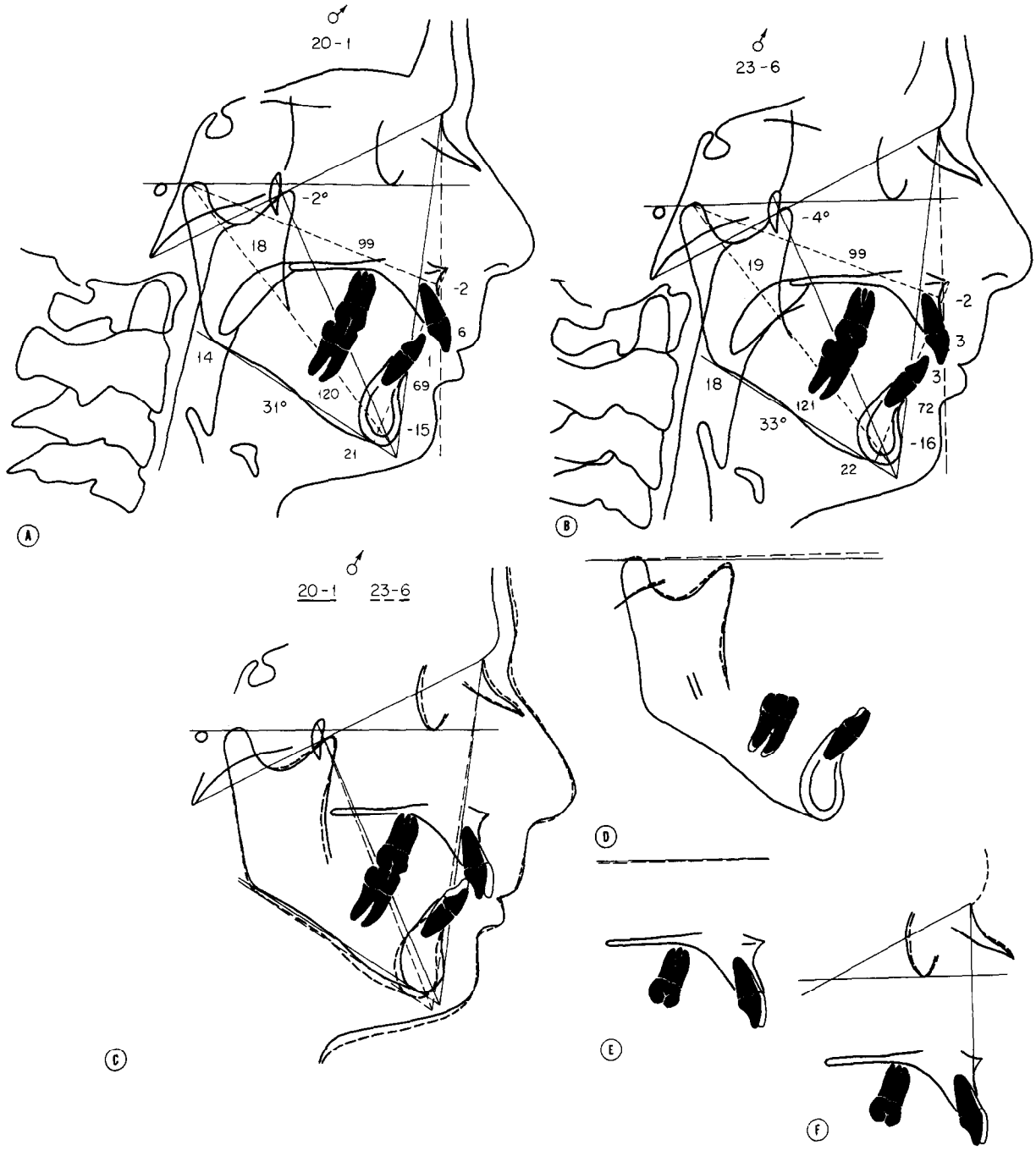


**Fig. 4.** Case 1. Cephalometric tracings. **A,** Tracing of initial lateral cephalogram. **B,** Tracing of cephalogram taken after 3½ years of FR-2 therapy. **C,** Superimposition of the tracings in **A** and **B** along the basion-nasion line at the pterygomaxillary fissure. **D,** Mandibular superimposition on internal structures. **E,** Maxillary superimposition on internal structures. **F,** Maxillary displacement. Superimposition is on the basion-nasion line at nasion.

The initial lateral head film (Fig. 4, *A*) was analyzed according to my usual cephalometric analytical procedures.[14] The maxilla was located posteriorly relative to the cranial base. Point A was 3 mm behind the nasion perpendicular (the ideal value is 1 mm in front of the nasion perpendicular for an adult).[14] The effective maxillary length (measured from condylion to point A) was 99 mm. In what I consider a balanced face, the corresponding effective mandibular length is 129

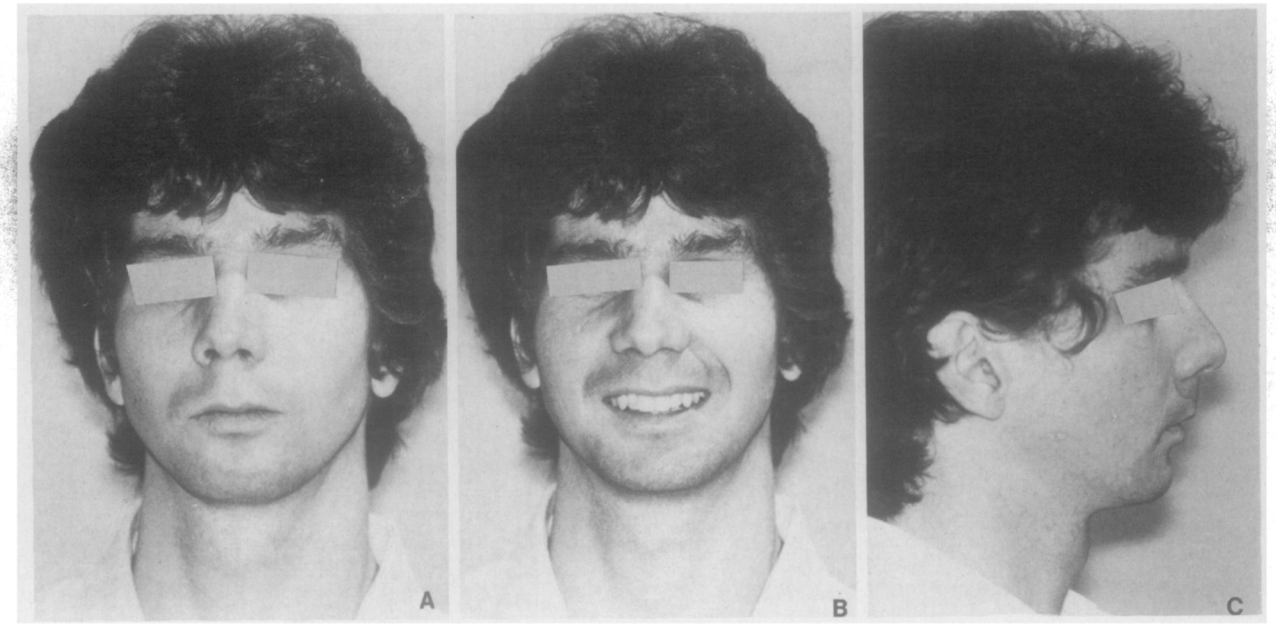


**Fig. 5.** Case 1. Extraoral photographs after 2 years of treatment.

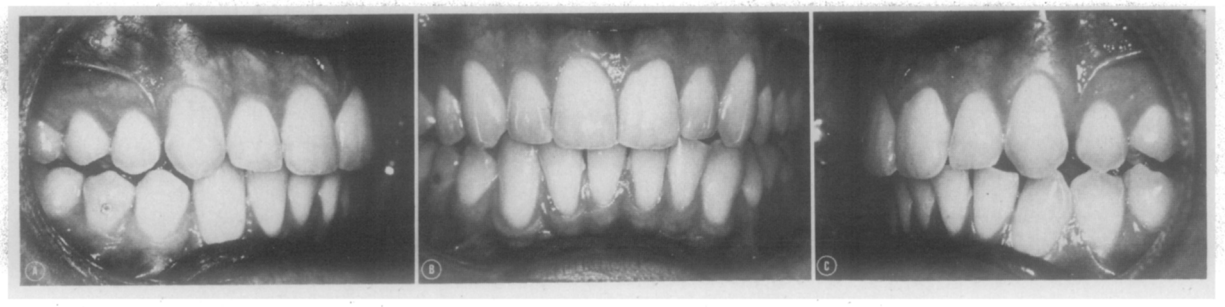

**Fig. 6.** Case 1. Intraoral photographs after 2 years of treatment.

mm.[14] Since the effective mandibular length in this patient was 120 mm, it can be assumed that the patient had a 9 mm deficiency in mandibular length.

The patient's lower anterior facial height was within normal limits (69 mm), but there was a deficiency in posterior facial height as indicated by the 31° mandibular plane angle.

The maxillary central incisors were slightly protrusive relative to the skeletal portion of the maxilla. The facial surface of the maxillary central incisors was 6 mm ahead of a line dropped vertically from point A (ideal = 4 mm).[14] The mandibular central incisors were 1 mm ahead of the A-Po line.

### Treatment progress

The impressions and construction bite for the Fränkel FR-2 were taken in accordance with my usual procedures.[13] The bite registration was taken so that the mandible was advanced 4 mm from centric occlusion. Within 1 month the patient had accommodated to the appliance and was able to wear it on a full-time basis (approximately 20 hours per day). After 15 months a new appliance was made with the incisors brought to an end-to-end relationship. Once again, the patient adapted readily to this new bite position.

The patient wore the appliance on a full-time basis for 2 years (Figs. 5 to 7) and then on a part-time basis (usually nights only) for an additional 1½ years (Figs. 8 and 9).

The patient remained enthusiastic during the course of treatment.

### Analysis of treatment results

Adaptations occurred in both the skeletal and dental relationships as observed in the analysis of the dental casts and the cephalometric radiographs.

*Analysis of dental casts.* A comparison of the initial dental casts (Fig. 3) with those taken after 2 years of functional therapy (Fig. 7) indicated that the overbite and overjet rela-

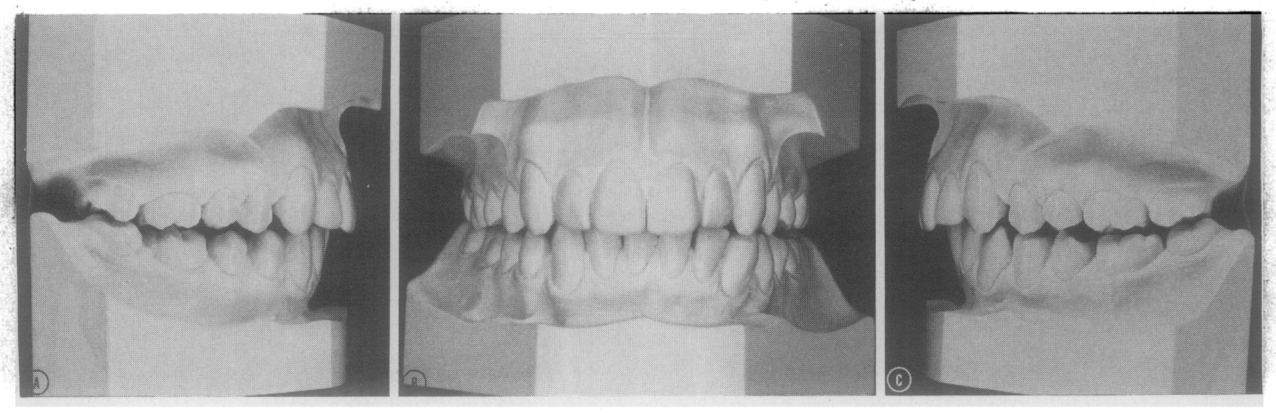

**Fig. 7.** Case 1. Study models after 2 years of treatment.

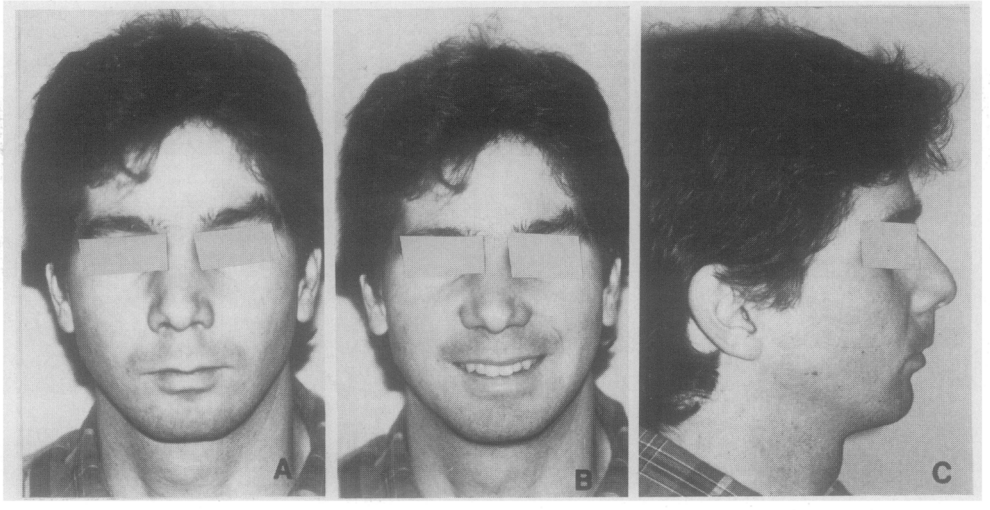


**Fig. 8.** Case 1. Extraoral photographs after 3½ years of treatment.

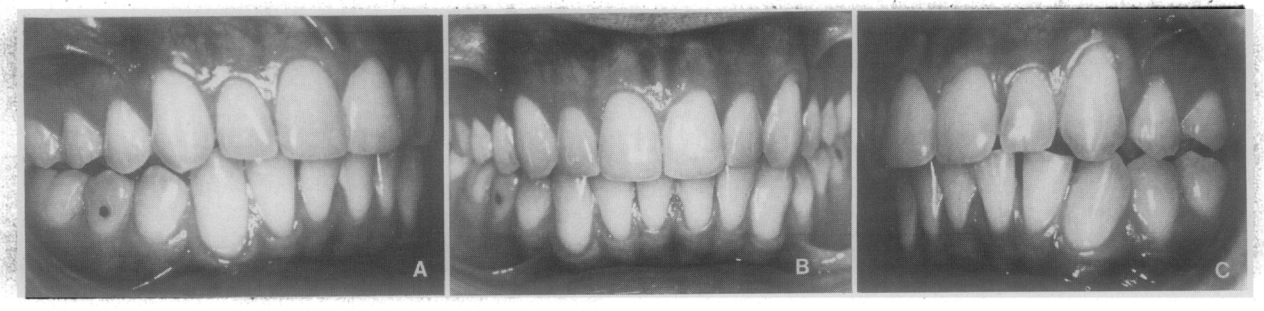


**Fig. 9.** Case 1. Intraoral photographs after 3½ years of treatment.

tionship had improved during treatment. However, little change had occurred in the anteroposterior relationships of the posterior teeth. There were significant adaptations in the transverse dimension, as indicated by a 4 mm increase in transverse width in the upper molars and a 3 mm increase in transverse width in the lower molars (Fig. 10).

*Analysis of cephalometric data.* Skeletal and dental adaptations occurring during the functional regulator treatment were determined by comparing the pretreatment cephalogram (Fig. 4, *A*) to one taken 3½ years later (Fig. 4, *B*). Tracings were made independently by one other investigator and myself. The difference in the position of major landmarks among the three sets of tracings was less than 1.0 mm.

During the 3½-year treatment period, there was no increase in the effective length of the maxilla, as measured from condylion to point A, and the effective mandibular length

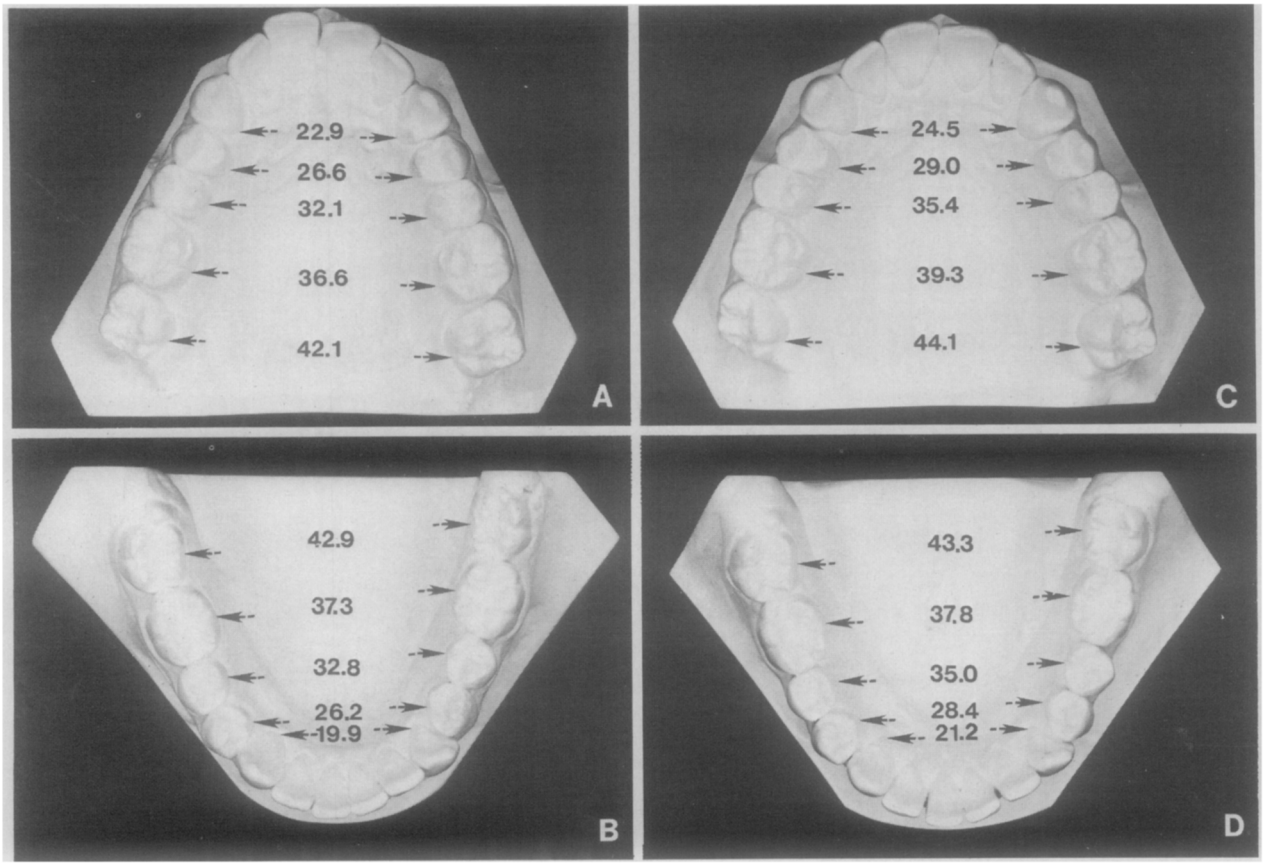


**Fig. 10.** Case 1. Arch expansion in the first patient after functional regulator therapy. **A** and **B,** Initial maxillary and mandibular casts. **C** and **D,** Maxillary and mandibular casts following 2 years of functional therapy. The arch widths measured from the lingual surface of the corresponding teeth on each side of the arch are indicated in millimeters. Note that maxillary and mandibular expansion occurred during the first 2 years of treatment.

increased by only 1 mm (Fig. 4, *B*). Lower anterior facial height increased by 3 mm, negating the anteroposterior effect of the 1 mm increase in mandibular length. In fact, pogonion became more posteriorly positioned relative to the nasion perpendicular.

Adaptations in the various regions of the craniofacial complex were analyzed according to the Ricketts[15] four-point superimposition.

*Cranial base superimposition (Fig. 4, C).* Superimposition along the basion-nasion line at its intersection with the pterygomaxillary fissure indicated that the mandible had rotated vertically and posteriorly. The position of the maxilla remained unchanged, although there was some lingual tipping of the maxillary central incisors.

*Mandibular superimposition (Fig. 4, D).* Superimposition on the internal structures of the mandible (that is, the inferior alveolar canal and symphysis) showed that little skeletal change occurred in this region. The most active site of remodeling was along the anterior border of the ramus. Some forward movement of the lower molar and lower incisors was also evident.

*Maxillary superimposition (Fig. 4, E).* Superimposition on the internal structures of the maxilla revealed a lingual tipping of the upper incisors. The position of the upper molars was unchanged.

*Maxillary displacement (Fig. 4, F).* Superimposition along the basion-nasion line at nasion showed that the position of the maxilla remained stable. The only noticeable change was a lingual tipping of the upper incisors.

*Summary.* This patient demonstrated skeletal and dental adaptations which, presumably, would not have occurred without treatment. Yet the degree of adaptation which did occur was not sufficient to allow correction of the underlying jaw malrelationship.

## CASE 2

This patient was a 23-year-old dental student who had a Class II, Division 1 malocclusion characterized by moderate

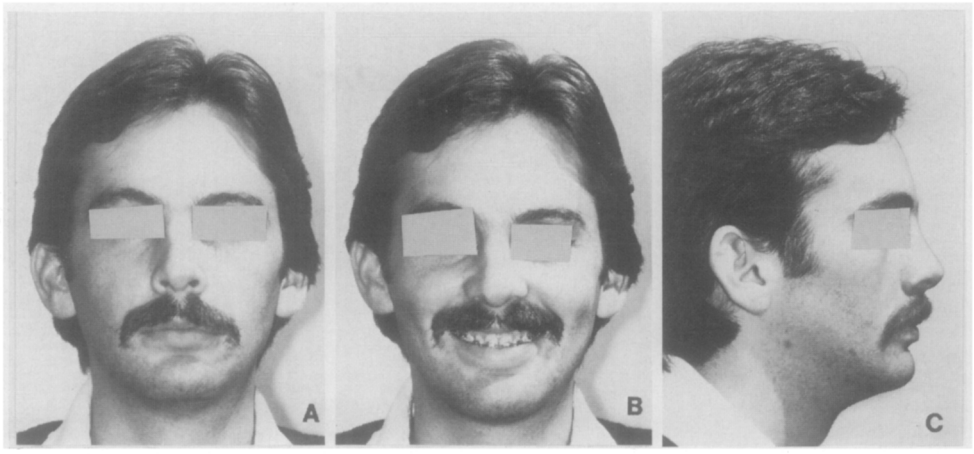


**Fig. 11.** Case 2. Extraoral photographs after 1 year of fixed appliance treatment.

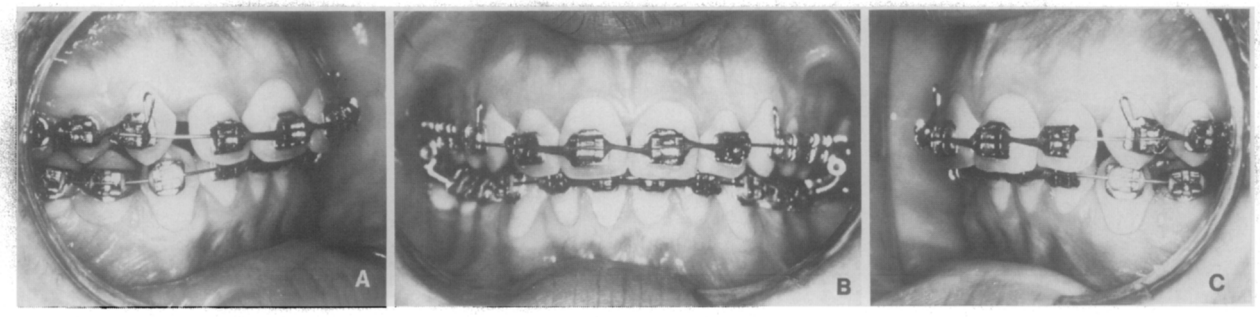


**Fig. 12.** Case 2. Intraoral photographs after 1 year of fixed appliance treatment.

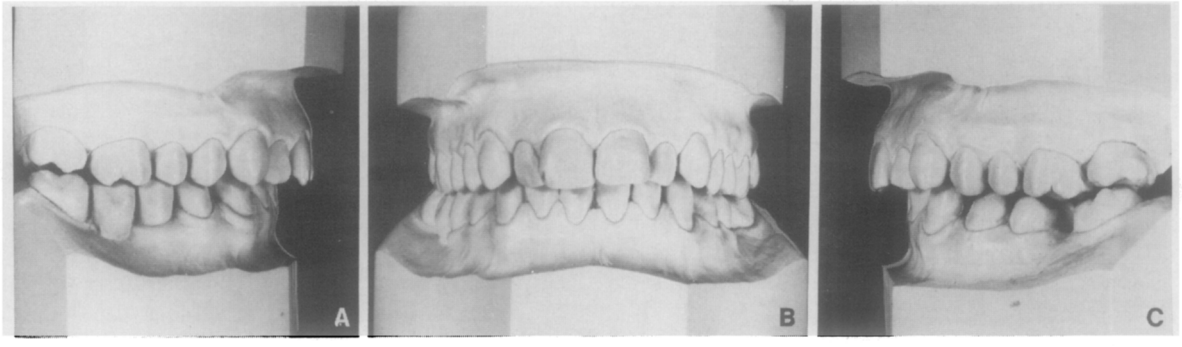


**Fig. 13.** Case 2. Study models made at beginning of treatment.

mandibular skeletal and dentoalveolar retrusion. After 1 year of fixed appliance treatment, progress records were taken. The main effect of the first year of treatment was alignment of the teeth within each dental arch.

At the end of the fixed-appliance phase, a Class II malocclusion remained (Figs. 11 to 13). Analysis of the cephalometric radiograph taken after the initial fixed appliance phase (Fig. 14, *A*) indicated that the maxilla was 2 mm posterior to its ideal position relative to the nasion perpendicular. The mandible was about 4 mm retrognathic, and lower anterior facial height was within normal limits. The mandibular incisors were 2 to 3 mm posterior to the ideal position relative to the A-Po line.

### Treatment progress

The FR-2 appliance was constructed so that the bite registration advanced the mandible into an end-to-end incisal relationship. The patient was highly motivated and wore the appliance on a full-time basis within the first month. He averaged more than 20 hours of appliance wear per day for 1 year.

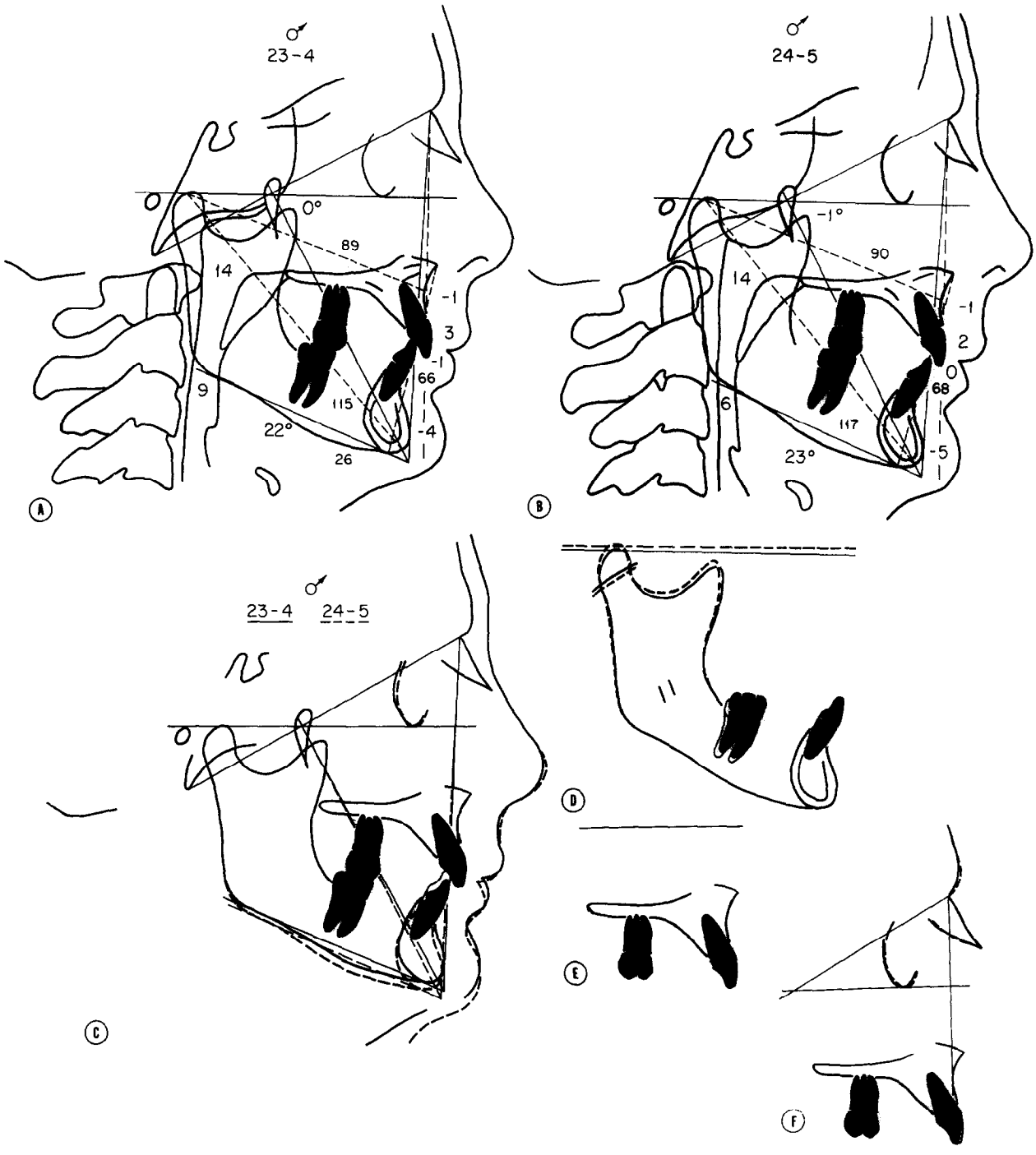


**Fig. 14.** Case 2. Cephalometric tracings, **A,** Tracing of cephalogram taken after 1 year of fixed appliance therapy. **B,** Tracing of cephalogram taken after 1 year of FR-2 therapy. **C,** Superimposition of cephalograms in **A** and **B** along the basion-nasion line at the pterygomaxillary fissure. **D,** Mandibular superimposition along internal structures. **E,** Maxillary superimposition along internal structures. **F,** Maxillary displacement. Superimposition is on the basion-nasion line at nasion. The position of the lower first molar is estimated on the basis of the position of adjacent teeth in the arch.

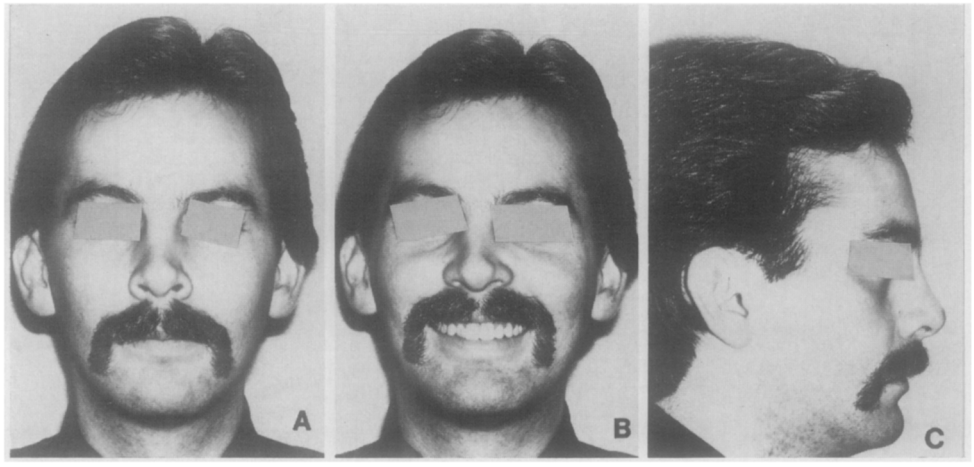


**Fig. 15.** Case 2. Extraoral photographs after 1 year of functional appliance therapy.

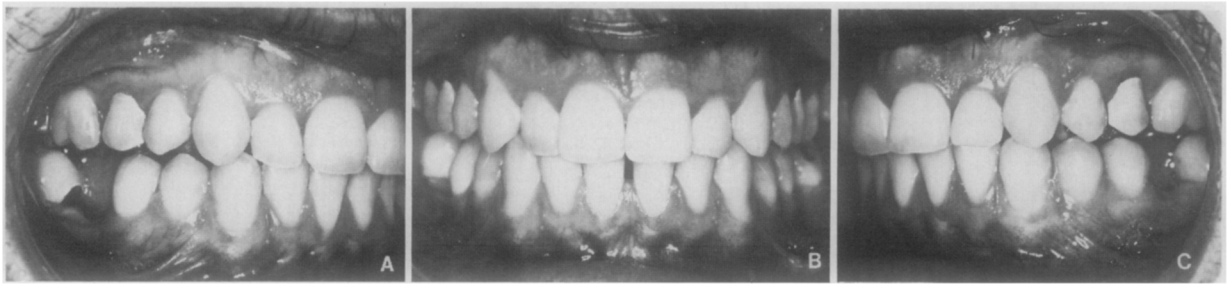


**Fig. 16.** Case 2. Intraoral photographs after 1 year of functional appliance therapy.

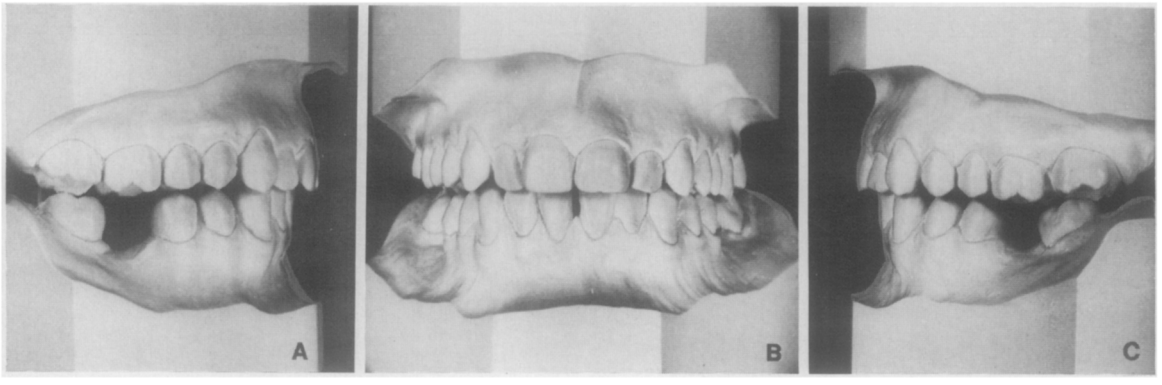


**Fig. 17.** Case 2. Study models after functional appliance therapy. The pontic replacing the lower right first molar was removed prior to the onset of orthodontic therapy.

**Analysis of treatment results**

The results of this patient's treatment were similar to those seen in case 1. Relatively little change was observed in the soft-tissue profile (Fig. 15) and in the relationship of the teeth (Fig. 16).

*Analysis of dental casts.* At the end of the 1-year treatment period, there was little change in the molar relationship, although the overjet relationship was improved (Figs. 13 and 17). There was an increase in the transverse dimension of the dental arches, including a 2 to 3 mm expansion in the upper molar region (Fig. 18).

*Analysis of cephalometric data.* At the end of the 1-year treatment period there was a 1 mm increase in the effective maxillary length and an increase of 2 mm in effective man-

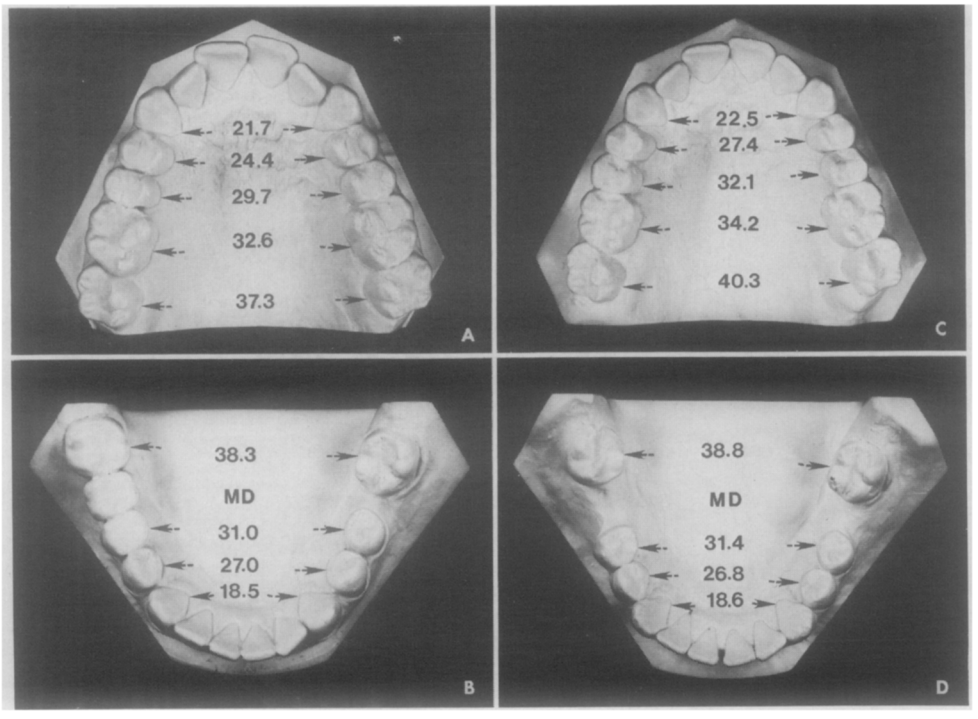


**Fig. 18.** Case 2. Arch changes after therapy. **A** and **B,** Initial maxillary and mandibular cast. **C** and **D,** Maxillary and mandibular casts after 1 year of fixed appliance and 1 year of functional appliance therapy.

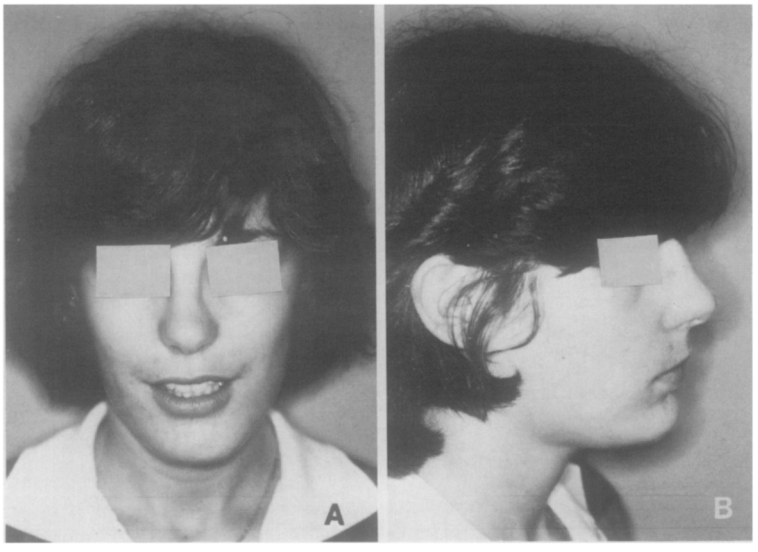


**Fig. 19.** Case 3. Extraoral photographs at the beginning of treatment.

dibular length (Fig. 14, *B*). Lower anterior facial height increased by 2 mm, which caused a downward and slightly backward rotation of the mandible.

*Cranial base superimposition (Fig. 14, C).* Superimposition along the basion-nasion line at its intersection with the pterygomaxillary fissure indicated that the mandible had dropped vertically and slightly posteriorly. There was no change in maxillary position, although there was a slight lingual tipping of the upper incisor teeth.

*Mandibular superimposition (Fig. 14, D).* Superimposition on the internal structures of the mandible showed a slight mesial movement of the lower incisors and an extrusion and slight mesial movement of the lower molars (as estimated from the position of the adjacent teeth).


**Fig. 20.** Case 3. Intraoral photographs at the beginning of treatment.

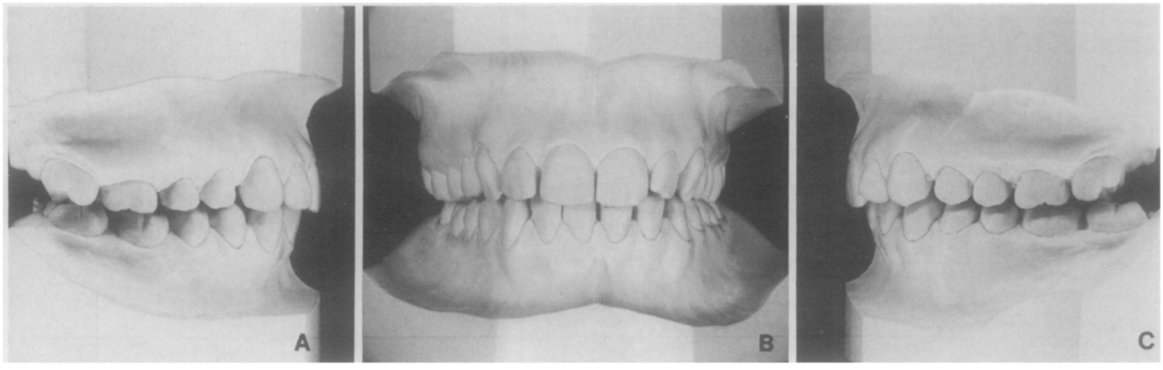


**Fig. 21.** Case 3. Study models taken at the beginning of treatment.

*Maxillary superimposition (Fig. 14, E).* Superimposition on the internal structures of the maxilla revealed a slight lingual tipping of the upper incisors. The position of the upper molars was unchanged.

*Maxillary displacement (Fig. 14, F).* The superimposition of serial tracings along the basion-nasion line at nasion demonstrated that the maxilla remained stable during the treatment period. Only the slight tipping of the upper incisor was noticeable.

*Summary.* This patient also demonstrated little skeletal adaptation after 1 year of full-time Fränkel appliance wear. Once again, the amount of skeletal and dentoalveolar adaptation achieved during treatment was not sufficient to correct the underlying malrelationship.

## CASE 3

This patient was a 17-year-old female with a Class II, Division 2 (subdivision left) malocclusion (Figs. 19 to 21). She had a hyperactive mentalis muscle which contributed to the appearance of a prominent chin.

The initial cephalometric evaluation (Fig. 22, *A*) indicated that both the maxilla and the mandible were slightly retruded relative to cranial base structures as indicated by their relationship to the nasion perpendicular. The lower anterior facial height was within normal limits, as was the anteroposterior position of the upper incisors. The lower incisors were in a retruded position relative to the A-Po line.

### Treatment progress

For 1½ years fixed appliances were used in order to align the teeth within each arch (Figs. 23 and 24). Fixed appliances were then removed and a Fränkel FR-2 appliance was constructed, producing an end-to-end incisal relationship. One of the purposes of the Fränkel appliance in this case was to inhibit the function of the mentalis muscle. It was thought that a reduction in mentalis muscle function might possibly lead to a forward movement of the lower dentition. The patient tolerated the appliance well and achieved full-time wear within 2 months. Treatment results were analyzed 18 months after the onset of functional therapy.

### Analysis of treatment results

The soft-tissue profile of the patient was improved during the 18 months of functional appliance wear (Figs. 19, 23, and 25), although some hyperactivity of the mentalis muscle was still present. The clinical appearance of the occlusion at the end of functional therapy indicated that the posterior occlusal malrelationship remained unchanged (Fig. 26).

*Analysis of dental casts.* The overbite and overjet relationship was improved when the initial dental casts (Fig. 20) were compared to the dental casts taken after functional appliance therapy (Fig. 27). As in the previous cases, however, there was no significant improvement in the posterior occlusal relationship.

A small amount of transverse expansion was evident

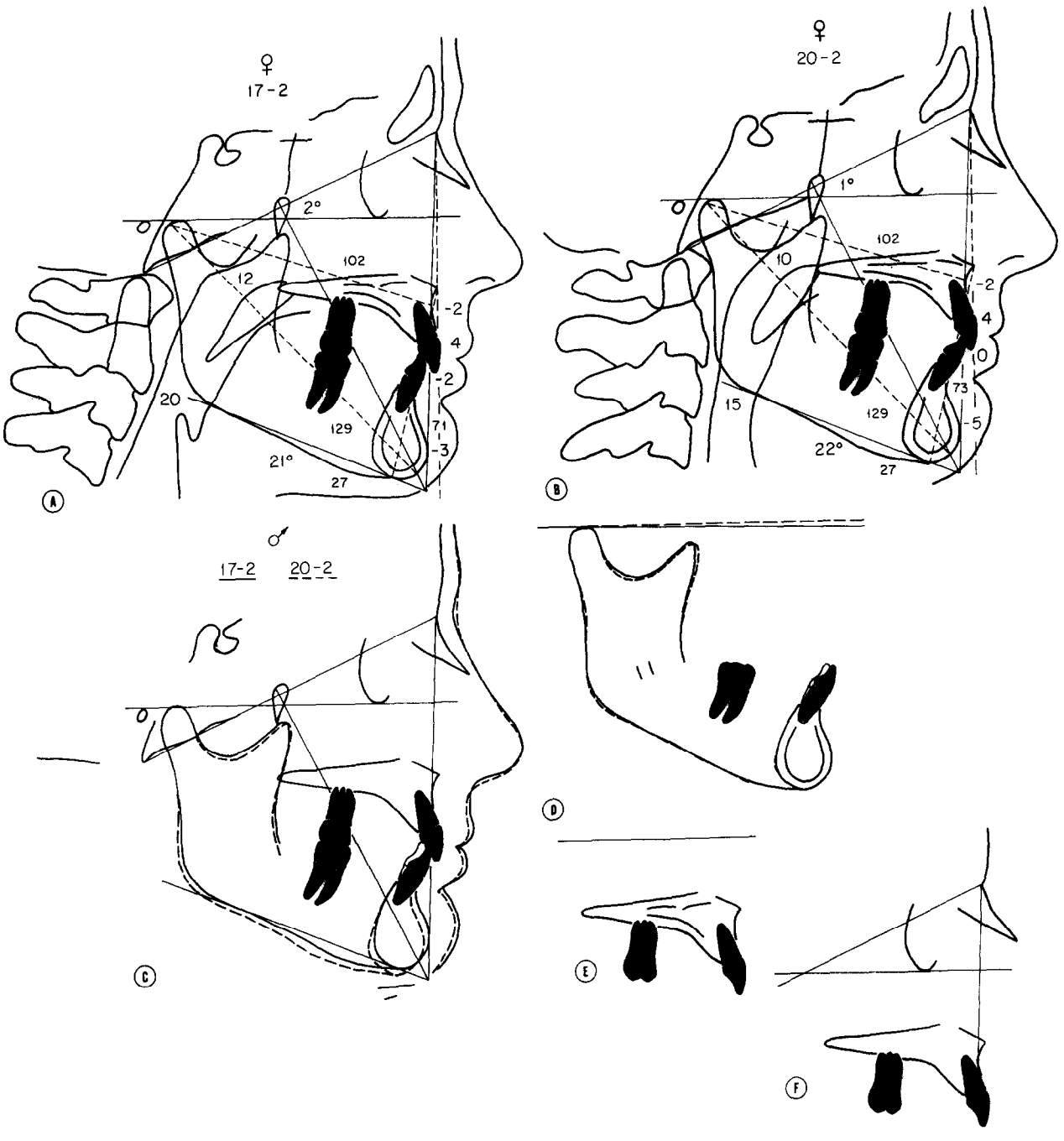


**Fig. 22.** Case 3. Cephalometric tracings. **A,** Tracing of initial lateral cephalogram. **B,** Tracing of cephalogram taken after 3 years of treatment. **C,** Superimposition of the tracings seen in **A** and **B** along the basion-nasion line at the pterygomaxillary fissure. **D,** Mandibular superimposition on internal structures. **E,** Maxillary superimposition on internal structures. **F,** Maxillary displacement. Superimposition is on the basion-nasion line at nasion.

when the transpalatal widths of the initial set of dental casts were compared with those of the casts taken after 18 months of fixed appliance therapy and the subsequent 18 months of functional appliance therapy (Fig. 28). More expansion occurred anteriorly than posteriorly.

*Analysis of cephalometric data.* No change in effective maxillary or mandibular length was observed when the tracing of the initial cephalogram (Fig. 27, *A*) was compared with the tracing of the patient made after 3 years of orthodontic treatment. Lower anterior facial height increased 2 mm, which resulted in a downward and backward rotation of the mandible.

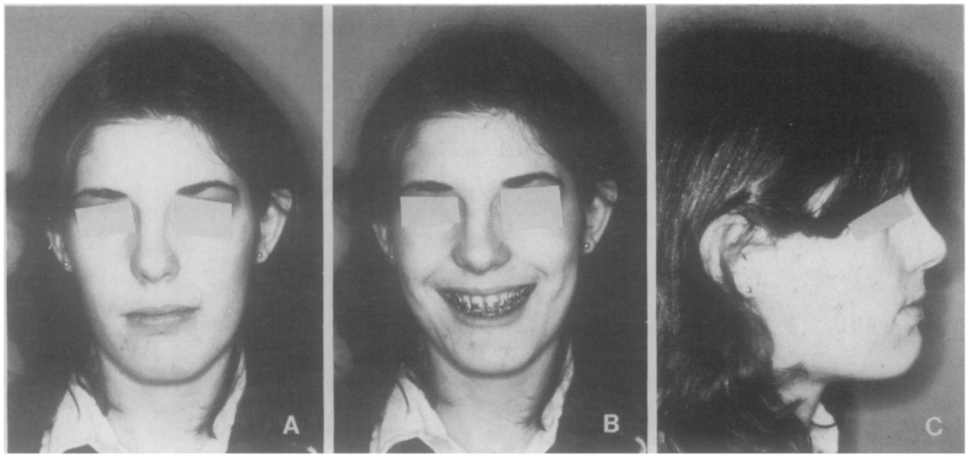


**Fig. 23.** Case 3. Extraoral photographs after 18 months of fixed appliance treatment.

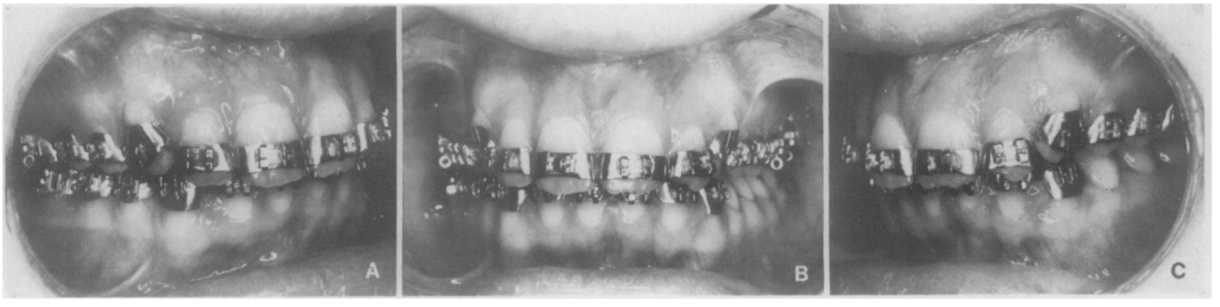


**Fig. 24.** Case 3. Intraoral photographs after 18 months of fixed appliance treatment.

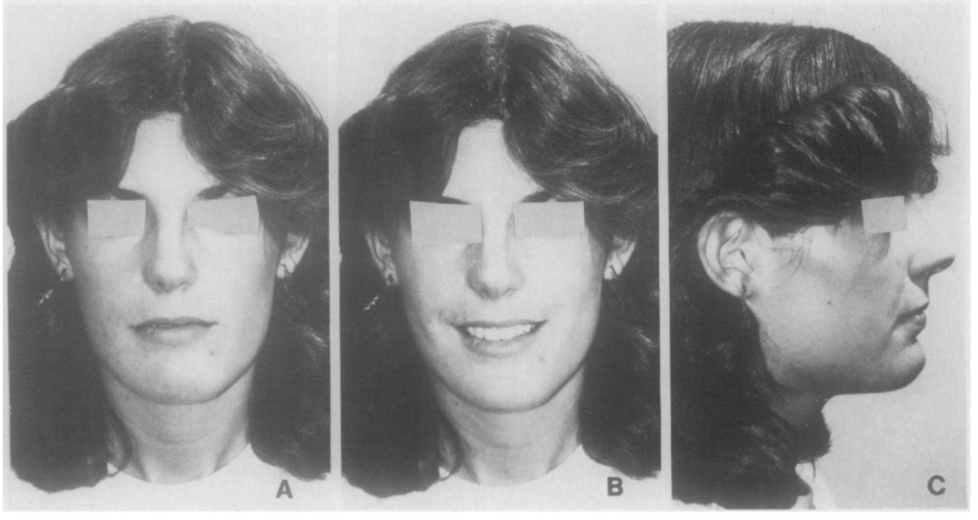


**Fig. 25.** Case 3. Extraoral photographs after 18 months of functional therapy.

*Cranial base superimposition (Fig. 24, C).* Superimposition along the basion-nasion line at nasion indicated that the mandible rotated inferiorly and posteriorly during treatment as lower anterior facial height increased. The position of the maxillary incisors was unchanged, but the mandibular incisors were tipped mesially.

*Mandibular superimposition (Fig. 24, D).* Superimposition on the internal structures indicated only moderate surface remodeling of the mandible. Anterior tipping of the lower incisors and a slight mesial migration of the lower molars also were observed.

*Maxillary superimposition (Fig. 24, E).* No change in the


**Fig. 26.** Case 3. Intraoral photographs after 18 months of functional therapy.

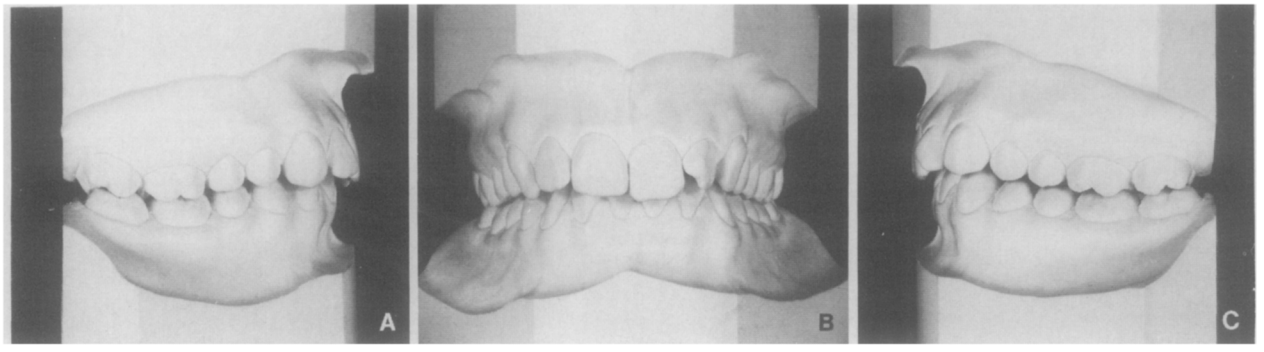


**Fig. 27.** Case 3. Study models taken at the end of the functional phase of treatment.

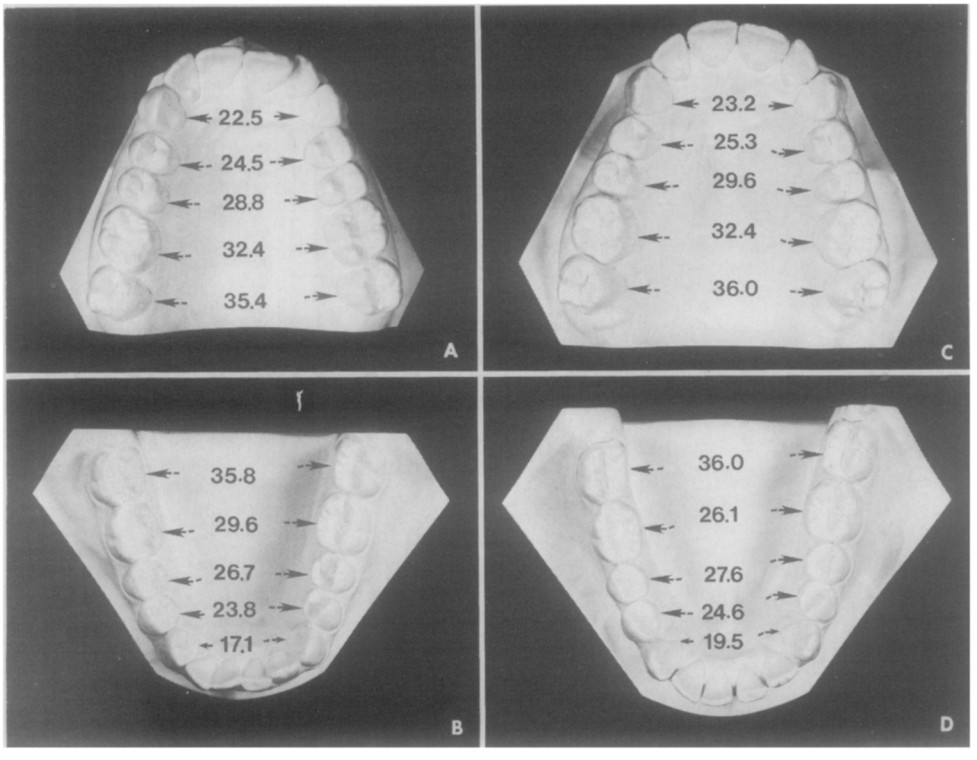


**Fig. 28.** Case 3. Arch dimensional changes after treatment. **A** and **B,** Initial maxillary and mandibular casts. **C** and **D,** Maxillary and mandibular casts taken after 18 months of fixed appliance therapy and 18 months of FR-2 therapy.

position of either the maxillary incisors or molars was noted.

*Maxillary displacement (Fig. 24, F).* Superimposition along the basion-nasion line at nasion revealed no change in maxillary skeletal and dental position relative to anterior cranial base structures.

*Summary.* Of the three patients considered, this patient demonstrated the least amount of skeletal adaptation. The increase in lower anterior facial height was only 2 mm, and mesial tipping of the lower incisors was moderate.

## DISCUSSION

This article describes the skeletal and dental adaptations occurring in three adult patients treated with the functional regulator (FR-2) of Fränkel. Although some improvement in the overbite and overjet relationships were observed in all three cases, there was little if any improvement in the underlying skeletal and posterior dental relationships. The malocclusion present at the beginning of treatment was, for the most part, still present at the end of functional appliance therapy.

The results of the cases reported in this study can be construed only as negative evidence; that is, a specific type of functional appliance did not completely correct an underlying malocclusion in a given group of patients. This does not mean that temporomandibular joint adaptation cannot occur in a human adult population. It means only that it has yet to be shown. The monkey experiments described earlier have clearly demonstrated that some amount of temporomandibular joint adaptation occurred in a majority of the young adult animals studied. However, the mere presence of histologic evidence of adaptation must also be correlated with the presence or absence of significant cephalometric evidence of adaptation in both experimental and clinical situations. To date, no such clinical evidence has been provided.

Keeping these findings in mind, a degree of caution is urged when one is prescribing functional orthopedic appliances for adult patients. Once an adult patient undergoes functional jaw orthopedic treatment for an extended period of time and does not have a complete resolution of the original orthodontic problem, serious concerns may arise. The patient and the clinician may be faced with yet another prolonged treatment period with fixed appliances and possibly an orthognathic surgical procedure, while the enthusiasm for treatment and the patient's ability to cooperate may be severely compromised.

## SUMMARY

As stated earlier, the purpose of this report was to demonstrate the treatment results obtained in three prospectively selected patients who agreed to undergo functional jaw orthopedic therapy. Patient cooperation was excellent and adequate records were obtained. The analysis used in this study indicates that only minimal skeletal and dental adaptation occurred and that these adaptations were insufficient to completely resolve the patient's malocclusions.

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