Maxillary Incisolabial Responses in Class II, Division 1 Treatment With Fränkel and Edgewise

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Fifty patients treated with Fränkel and fifty treated with Edgewise appliances are compared, finding Edgewise more effective in maxillary retraction and torque control, and Fränkel producing less undesirable lip retraction.

KEY WORDS: • EDGEWISE • LIP • FRÄNKEL • MALOCCLUSION, CLASS II •

Class II, Division 1 malocclusions are the most common type of problems seen in the average orthodontic office. Class II[1] malocclusions with a protrusive maxilla have been effectively treated by multibanded therapy for many years. Class II[1] patients with normal and retrusive upper lips present a special problem because the dental correction can possibly "dish in" the upper lip and face. Correcting the overjet without over-retracting the upper lip can be of considerable esthetic benefit to these patients.

This report explores the response of the maxillary incisors and lip in Class II[1] patients who have undergone treatment using a Fränkel appliance. FRÄNKEL (1969 AND 1974) contends that the functional regulator has a significant myofunctional effect which tends to balance the facial muscles, and this view seems to be supported by FREELAND (1979). If it is possible to avoid excessive retraction of the maxillary lip in patients who have a normal or obtuse nasolabial angle, then the technique would appear to be worthy of consideration by any clinician.

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— Literature Review —

Soft-tissue balance and esthetics have been stressed since the early twentieth century by ANGLE (1907), CASE (1921), AND HELLMAN (1927). One of the earliest to make a serious attempt at evaluating the upper lip-to-nose relationship was HERZBERG (1952). He proposed a subnasale vertical to which both lips and the chin were all tangent. REIDEL (1957) said that 50% of esthetically pleasing profiles have the upper lip, lower lip, and chin in a straight line. RICKETTS's (1957) "E-line" was proposed to evaluate the soft-tissue profile, but it does not provide information about the relationship of upper lip and nose.

Whether the soft-tissue drapery closely follows the changes in the dentoskeletal structures or not is still an unresolved question. Several investigators (REIDEL 1957, SUBTELNY 1959, BAUM 1961, BLOOM 1961, DENEKE AND MEYER 1967, CLEMENTS 1969, FOMON AND BELL 1970, ANDERSON ET AL. 1973, AND LO AND HUNTER 1982) have all reported that the soft tissues generally reflect the underlying hard tissues, and changes in the hard tissues produce a reasonably proportional change in the corresponding soft tissues. Other investigators (GOLDMAN 1959, NEGER 1959, SUBTELNY 1961, RUDEE 1964, BURSTONE 1967, MCNULTY ET AL. 1968, COX 1971, HERSHEY 1972, GARNER 1974, WISTH 1974, ROOS 1977, FIELDS 1982, OLIVER 1982, WALDMAN 1982, AND RAINS 1982) report finding that the soft tissue does not necessarily follow the underlying hard tissues in a predictable or repeatable fashion.

Published norms for the nasolabial angle to range from 90° to 120°. Examples include 90°–110°±10° according to BROWN AND MCDOWELL (1951) and CONVERSE (1964), 105°±8° according to CROWE (1980), and 106°±12° as reported by LO AND HUNTER (1982). LUSTERMAN 1963, BURSTONE 1967, DENEKE 1967, FOMON 1970, AND REES 1973) have also reported similar values.

Because of the large standard deviations, Holdaway (1976) and Legan (1980) suggest that the nasolabial angle is of little diagnostic value.

CROWE (1980) reports the norm for the upper lip to Frankfort horizontal (upper lip drape) to be 98°±4°. LO AND HUNTER (1982) mention the same angle, or Frankfort/Labial Angle, although no values were given.

In view of the various reports in the literature placing importance on soft-tissue balance, particularly the upper lip, this study was designed to investigate the effects of the functional regulator on the upper lip when used to correct a Class II[1] malocclusion. It has been hypothesized that the Fränkel should cause less undesirable change in an obtuse nasolabial angle than is sometimes seen with fixed appliances. If the functional regulator can adequately correct a Class II, Division 1 malocclusion and at the same time not over-retract the upper lip, then this could be a desirable alternative for treatment.

— Methods and Materials —

Fifty patients with a Class II, Division 1 malocclusion whe were treated in the Author's practice using the Fränkel appliance comprised one study group. All presented originally with more than 5mm overjet, with an overall mean of 7.5±2.0mm overjet. All were Caucasian, 26 females and 24 males.

Average age at the start of treatment was 9.16±1.52yr, with a range from 6.3 to 13.9 years. Average treatment time was 21.5±8mo. All were treated without extraction. All were told the Fränkel treatment would be the first phase of their overall treatment, to be followed with regular braces at about the time of second permanent molar eruption.

The second study group of fifty patients with Class II[1] malocclusions were treated in the Author's practice using Edgewise mechanics. The average overjet was 8.0±2.5mm, with the minimum overjet also 5mm. Twenty-five patients were female and twenty-five patients were male.

The average age at the start of treatment was 11.50±1.53yr, ranging from 7.11yr to 16.2yr. Treatment time averaged 27.5±6mo. The long average treatment time was because this group included 22 two-phase patients who went from phase one immediately into phase two treatment. Thirty-three of these patients wore extraoral traction to reduce the overjet. Four first bicuspids were removed in 16 of these patients, and maxillary first bicuspids only were removed in 6.

Pre- and posttreatment lateral cephalographs were taken on all patients in a natural head position according to HERZBERG (1952) with the lips lightly closed. The target-to-midsagittal plane distance was 5 feet, and midsagittal plane to film 150mm. The Fränkel sample headfilms were originally traced by Rocky Mountain Data Systems, Inc. and retraced by the Author. This was done so that the landmark identification used in the Edgewise sample would be as close as possible to the Fränkel sample. It should be noted that rarely were there any significant discrepancies between the RMDS and Author's tracings; however, when there were any discrepancies, the Author's tracing was used.

The twelve measurements used are shown in Fig. 1. Four of these use the nasion perpendicular as the basic reference line (Fig. 1A). The nasion perpendicular is dropped from nasion to Frankfort horizontal (MCNAMARA 1981). Measurements 5 and 6 use N-A as the basic reference line (Fig. 1B).

The twelve measurements used in this study are:

1 Nasion vertical to maxillary incisor (°)
The angle formed between nasion perpendicular and the long axis of the maxillary incisor

2 Nasion vertical to point A (mm)
The distance between nasion perpendicular and subspinale

3 Nasion vertical to upper lip (mm)
The distance between nasion perpendicular and labiale superiorus

4 Nasion vertical to incisor (mm)
The distance between nasion perpendicular and incisor superiorus

5 N-A to maxillary incisor (°)
The angle formed between N-A and the long axis of the maxillary incisor

6 N-A to maxillary incisor (mm)
The distance between N-A and labiale superiorus

7 Upper lip thickness (mm)
The distance between labial surface of maxillary incisor and labiale superiorus

8 Upper lip drape or Frankfort/labial angle
The angle formed by the long axis of the maxillary incisors and Frankfort horizontal

9 Upper lip length
The distance from ANS to the lip embrasure

10 Nasolabial angle
The angle formed by the tangents to the columella of the nose and the upper lip

11 Subnasale to upper lip
The horizontal distance between a perpendicular line from subnasale to Frankfort horizontal and labiale superiorus

12 Overjet

Measurements 1, 2, 3, 4, 8, and 11 are directly involved with the Frankfort horizontal. Frankfort horizontal has been reported to be a reliable reference line when using true porion (RICKETTS 1975, 1976 AND ENGLE 1980). Measurements 8, 10, and 11 use subnasale, and occasionally subnasale is on a gradual contour that makes it difficult to locate precisely. Figure 2

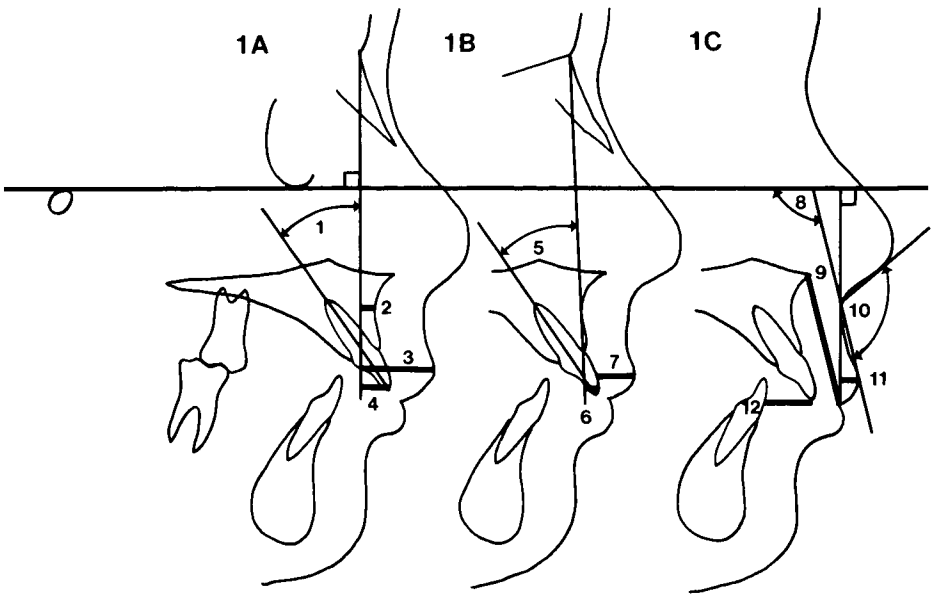

Fig. 1 Measurements used in this study

1A
Those measurements using nasion vertical
1 Nasion vertical to maxillary incisor (degrees)
2 Nasion vertical to point A
3 Nasion vertical to labiale superiorus
4 Nasion vertical to incisor superiorus (mm)

1B
Measurements using N-A
5 N-A to maxillary incisor (degrees)
6 N-A to maxillary incisor (mm)
7 Upper lip thickness.

1C
8 Upper lip drape
9 Upper lip length
10 Nasolabial angle
11 Subnasale vertical to labiale superiorus
12 Overjet

shows the method of locating subnasale (CROWE 1980).

Table 1 shows applicable norms reported in the literature, along with pretreatment values from this study. Tests showed there was not homogeneity of variance between the two groups, hence the term "reference" sample. However, the difference was not great, and with an equal sample size for each group, the test for equality is fairly insensitive to nonhomogeneity. For variables 2 and 4, the univariate Smith-Satterthwaite test was used, and the resulting significance level was only negligibly different from that found with the original test, MANOVA.

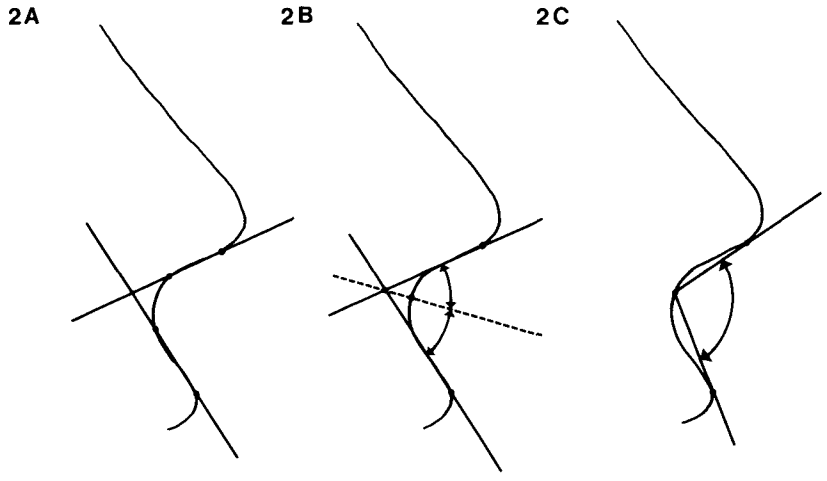

Fig. 2 Location of Subnasale

When the subnasal area is characterized by gradual curve, subnasale must be located in two steps (A and B):

A — Draw tangents to the upper lip and the columella of the nose.

B — Bisect this angle and project this line to the soft tissue to locate the constructed subnasale.

C — The Nasolabial angle drawn to the constructed subnasale

after Crowe, 1980

— Results —

A multivariate analysis was run against the Edgewise reference group and the Fränkel group, and a significant difference was found between the groups (overall $P < .001$, Hotellings T^2 or approximate $F = 12.79$ with 13, 18 d.f.). Tables 2-13 present the descriptive statistics for all twelve variables.

Overjet — Factor 12

In the Edgewise sample, the mean overjet was reduced from 8.04 ± 2.5mm at the beginning of treatment to 2.5 ± 0.6mm at the end of treatment. In the Fränkel sample, the overjet was reduced from 7.5 ± 2.0mm at the start of treatment to 2.3 ± 0.7mm at the end of active wear. The net overjet reduction for the Edgewise sample was 5.6 ± 2.4mm, while it was 5.2 ± 1.9mm for the Fränkel sample. The difference between the two samples was not significant, suggesting that we are comparing reasonably similar morphological corrections.

Maxillary Incisors — Factors 1, 4, 5, 6

In relation to the nasion vertical, the maxillary incisors were retracted an average of 4.9 ± 4.1mm and reclined $3.8 \pm 10.0°$ during Edgewise treatment, while during Fränkel treatment, the incisors were retracted only 1.9 ± 2.7mm and reclined $5.9 \pm 6.1°$. The difference in factor 1, incisor inclination, was not significant, and factor 4, the horizontal movement, was significant at the $p < .001$ level.

Table 1

Norms and Pretreatment Values
±Standard deviation

Factor	Norm	Edgewise Pretreatment	Fränkel Pretreatment
1 Nasion Vert to $\underline{1}$°	– –	26.3±8.6	26.6±7.0
2 Nasion Vert to A (mm)	1±3.0	2.3±3.4	1.8±3.0
3 Nasion Vert to Upper Lip (mm)	– –	18.4±4.3	17.8±4.2
4 Nasion Vert to $\underline{1}$ (mm)	5-6 –	8.7±4.6	6.9±4.3
5 N–A to $\underline{1}$°	22±4.0	24.5±8.3	25.0±6.7
6 N–A to $\underline{1}$ (mm)	4±2.0	5.8±3.0	4.9±2.1
7 Upper Lip Thick (mm)	– –	10.8±2.2	11.3±1.8
8 Upper Lip Drape°	98±5.0	95.2±8.8	100.6±7.3
9 Upper Lip Length (mm)	24±2.0	26.3±2.7	25.1±2.6
10 Nasolabial Angle	105±8.0	117.4±9.3	110.9±9.1
11 Subnasale Vert to Up Lip (mm)	2±1.7	1.2±2.4	2.3±1.6
12 Overjet (mm)	2.5±2.5	8.0±2.5	7.5±2.0

2, 4 — McNamara 1981
5, 6 — Steiner 1953
8, 10 — Crowe 1964
9 — Ricketts 1982
11 — Spradley et al. 1981

Table 2

Nasion Vertical to Maxillary Incisor
Factor 1 — (degrees)

	Mean ± S. D.	S. E.
Edgewise Group		
Pretreatment	26.3±8.6	1.2
Posttreatment	22.6±5.6	0.8
Difference	−3.8±10.	1.4
Fränkel Group		
Pretreatment	26.6±7.0	1.0
Posttreatment	20.8±5.5	0.8
Difference	−5.9±6.1	0.9

Table 3

Nasion Vertical to Subspinale (Point A)
Factor 2 — (mm)

	Mean ± S. D.	S. E.
Edgewise Group		
Pretreatment	2.29±3.36	0.48
Posttreatment	−0.7±3.1	0.4
Difference	−3.0±2.4	0.4
Fränkel Group		
Pretreatment	1.9±3.0	0.4
Posttreatment	1.1±3.3	0.5
Difference	−0.8±1.8	0.3

Table 4

Nasion Vertical to Labiale Superiorus
Factor 3 — (mm)

	Mean ± S. D.	S. E.
Edgewise Group		
Pretreatment	18.4±4.3	0.6
Posttreatment	16.5±3.7	0.5
Difference	−1.9±4.0	0.6
Fränkel Group		
Pretreatment	17.8±4.2	0.6
Posttreatment	18.0±4.6	0.7
Difference	0.2±2.5	0.4

Table 5

Nasion Vertical to Maxillary Incisor
Factor 4 — (mm)

	Mean ± S. D.	S. E.
Edgewise Group		
Pretreatment	8.7±4.6	0.7
Posttreatment	3.8±3.3	0.5
Difference	−4.9±4.1	0.6
Fränkel Group		
Pretreatment	7.0±4.3	0.6
Posttreatment	5.0±4.6	0.7
Difference	−1.9±2.7	0.4

Table 6

N–A to Maxillary Incisor
Factor 5 — (degrees)

	Mean ± S. D.	S. E.
Edgewise Group		
Pretreatment	24.5±8.3	1.2
Posttreatment	22.9±5.7	0.8
Difference	−1.6±9.8	1.4
Fränkel Group		
Pretreatment	25.0±6.7	1.0
Posttreatment	19.4±5.3	0.7
Difference	−5.6±5.7	0.8

Table 7

N–A to Maxillary Incisor
Factor 6 — (mm)

	Mean ± S. D.	S. E.
Edgewise Group		
Pretreatment	4.9±2.1	0.2
Posttreatment	3.5±2.0	0.3
Difference	−1.4±1.9	0.3
Fränkel Group		
Pretreatment	5.8±3.0	0.4
Posttreatment	4.5±1.9	0.3
Difference	−1.3±2.7	0.4

Table 8

Upper Lip Thickness
Factor 7 — (mm)

	Mean ± S. D.	S. E.
Edgewise Group		
Pretreatment	10.8±2.2	0.3
Posttreatment	13.5±2.0 0.3	
Difference	2.7±2.4	0.4
Fränkel Group		
Pretreatment	11.3±1.8	0.3
Posttreatment	12.8±2.3	0.3
Difference	1.5±1.9	0.3

Table 9

Upper Lip Drape
Factor 8 — (degrees)

	Mean ± S. D.	S. E.
Edgewise Group		
Pretreatment	95.2±8.8	1.3
Posttreatment	86.2±8.7	1.2
Difference	−9.0±7.3	1.0
Fränkel Group		
Pretreatment	100.6±7.3	1.0
Posttreatment	101.8±7.1	1.0
Difference	1.2±3.9	0.6

Table 10

Upper Lip Length
Factor 9 — (mm)

	Mean ± S. D.	S. E.
Edgewise Group		
Pretreatment	26.4±2.7	0.4
Posttreatment	26.6±2.9	0.4
Difference	0.3±2.0	0.3
Fränkel Group		
Pretreatment	25.1±2.6	0.4
Posttreatment	26.6±2.5	0.4
Difference	1.4±1.4	0.2

Table 11

Nasolabial Angle
Factor 10 — (degrees)

	Mean ± S. D.	S. E.
Edgewise Group		
Pretreatment	117.4±9.3	1.4
Posttreatment	120.2±7.8	1.1
Difference	2.8±6.8	1.0
Fränkel Group		
Pretreatment	110.9±9.1	1.3
Posttreatment	106.8±7.1	1.0
Difference	−4.1±6.0	0.8

Table 12

Subnasale Vertical to Labiale Superiorus
Factor 11 — (mm)

	Mean ± S. D.	S. E.
Edgewise Group		
Pretreatment	1.2±2.4	0.4
Posttreatment	−1.9±2.2	0.4
Difference	−2.4±2.1	0.3
Fränkel Group		
Pretreatment	2.2±1.6	0.2
Posttreatment	2.3±1.5	0.2
Difference	0.6±1.1	0.2

Table 13

Overjet
Factor 12 — (mm)

	Mean ± S. D.	S. E.
Edgewise Group		
Pretreatment	8.0±2.5	0.4
Posttreatment	2.5±0.6	0.1
Difference	−5.6±2.4	0.4
Fränkel Group		
Pretreatment	7.5±2.0	0.3
Posttreatment	2.3±0.7	0.1
Difference	−5.2±1.9	0.3

The same measurements were also made in relation to N-A for comparison purposes. Measured to N-A, the maxillary incisors were retracted 1.4±1.9mm and tipped lingually 1.6±9.8° during Edgewise treatment. With Fränkel treatment they were retracted 1.3±2.7mm and reclined 5.6±5.7°. Neither of these differences are statistically significant.

Maxillary Orthopedic Change — Factor 2

The maxillary orthopedic response was measured from nasion perpendicular to point A. In the Edgewise sample, point A was retracted 3.0±2.4mm, while the mean retraction in the Fränkel sample was 0.8±1.8mm. The difference is significant at the $p < .001$ level.

Upper Lip Retraction — Factor 3

The upper lip *retraction* as measured from the nasion perpendicular was 1.9±4.0mm in the Edgewise sample, but only 0.2±2.5mm in the Fränkel group. A comparison of the amount of maxillary incisor retraction with the upper lip retraction is shown in Table 14.

Upper Lip Thickness — Factor 7

The upper lip thickened 2.7±2.4mm during Edgewise treatment and 1.5±1.9mm during Fränkel treatment. The difference is not significant.

Upper Lip Angle — Factor 8

The angle formed by a line through labiale superiorus and subnasale with the Frankfort horizontal measured the angle of the upper lip. This angle has been called the "upper lip drape" by Crowe (1980) and the FLA or "Frankfort labial angle" by Lo and Hunter (1982). The upper lip becomes flatter as the value of the upper lip drape decreases. The Edgewise group had a reduction of 9.0±7.3°, while the Fränkel group showed a reduction of only 1.2±3.9°. These were significant at the $p < .001$ level.

Upper Lip Length — Factor 9

The upper lip length measured from ANS to the embrasure increased 0.3±2.0mm during the Edgewise treatment and 1.4±1.4mm during Fränkel

treatment. This difference is not significant.

Nasolabial Angle — Factor 10

The nasolabial angle *increased* an average of $2.8 \pm 6.8°$ during Edgewise treatment, and *decreased* an average of $4.1 \pm 6.0°$ during Fränkel treatment. This difference is significant at the $p < .001$ level.

Subnasale Vertical — Factor 11

The subnasale vertical is a perpendicular dropped from Frankfort horizontal through subnasale, providing a baseline for measurement of the position of the upper lip. In the Edgewise sample, the upper lip was *retracted* $2.4 \pm 2.1mm$ in relation to the subnasale vertical, while in the Fränkel sample it *advanced* $0.1 \pm 1.1mm$. This difference is significant at the $p < .001$ level.

Univariate F-tests

Table 15 shows a summary of the univariate F-tests and their significance for each variable.

Table 14

Upper Lip Retraction Ratio

	Maxillary Incisor Retraction to Nasion Vertical	Upper Lip Retraction to Nasion Vertical	Ratio	Sig.
Edgewise Sample	4.9 ± 4.1	-1.9 ± 4.0	2.6:1	
Fränkel Sample	1.9 ± 2.7	0.2 ± 2.5	9.5:1	.001

Table 15

Univariate F-Tests

Factor	F	df	Sig.
1 Nasion Vert to $\underline{1}$°	1.64	1,97	NS
2 Nasion Vert to A (mm)	26.99	1,97	<.001
3 Nasion Vert to Upper Lip (mm)	9.98	1,97	NS
4 Nasion Vert to $\underline{1}$ (mm)	19.22	1,97	<.001
5 N–A to $\underline{1}$°	6.34	1,97	NS
6 N–A to $\underline{1}$ (mm)	0.06	1,97	NS
7 Upper Lip Thick (mm)	6.95	1,97	NS
8 Upper Lip Drape°	75.96	1,97	<.001
9 Upper Lip Length (mm)	10.72	1,97	NS
10 Nasolabial Angle	29.04	1,97	<.001
11 Subnasale Vert to Up Lip (mm)	55.25	1,97	<.001
12 Overjet (mm)	0.99	1,97	NS

— Discussion —

Two treatment samples from the Author's practice were compared to evaluate the effects of Fränkel and Edgewise therapy. Initial overjet and overjet correction was similar in both groups, indicating a valid basis for comparison of changes related to overjet reduction in the two groups.

Angular and linear values measuring incisor changes (factors 1, 4, 5, 6) showed that the Edgewise treatment was more effective in retracting the maxillary incisors and subspinale than the Fränkel treatment (Tables 2, 5, 6, 7). Subspinale was retracted 3.0 ± 2.4mm in relation to nasion vertical during Edgewise treatment, and only 0.8 ± 1.8mm during Fränkel treatment a difference significant at the $p < .001$ level.

If maxillary orthopedic retraction is a treatment goal, then Edgewise mechanics (with or without extraoral forces) is significantly more effective than Fränkel treatment.

This provides another opportunity for the clinician to choose the appliance most appropriate to the goals of treatment. Adding the orthodontic and orthopedic retraction together (factors 2 and 4), Edgewise made a total retraction of the maxillary incisor of $3.0 + 4.9 = 7.9$mm, while the Fränkel appliance accomplished a total average retraction of $0.8 + 1.9 = 2.7$mm.

If the treatment goal is retraction of the maxilla and/or maxillary incisors, then Edgewise therapy (with or without extraoral traction) appears to be the more effective option.

On the other hand, if the goal is to maintain the pretreatment position of the maxillary incisors and/or maxilla, then the Fränkel appears to be most effective.

Considering McNamara's (1981) study on Class II malocclusions, it would appear that it may often be the goal to preserve the pretreatment position of the maxillary incisors rather than retract them. Extraoral traction is obviously designed to retract, whereas the functional regulator is designed to promote mandibular growth if possible.

Edgewise treatment also appears to be somewhat more effective in maintaining the torque of the maxillary incisors than Fränkel treatment (factors 1 and 5). The Fränkel group experienced $5.9 \pm 6.1°$ lingual tipping and the Edgewise group $3.8 \pm 10.0°$ as measured to nasion vertical. Although the ranges are high and angular changes not significantly different, the means and the raw data suggest a slight tendency for the maxillary incisors to be tipped lingually more with Fränkel than with Edgewise treatment.

That difference is understandable, in that no removable appliance therapy provides the level of torque control as Edgewise appliances.

Since torque control is important (Andrews (1972), care must be exercised to avoid excessive maxillary incisor tipping during Fränkel treatment. Inadequate anterior torque control is a frequent reason for a second phase of treatment.

It should be noted that early Fränkel treatment in the United States probably resulted in more lingual tipping of the maxillary incisors than at present. Notching of maxillary deciduous teeth and keeping the labial bow out of contact with the maxillary incisors can both help to reduce lingual force on the incisors while the patient is sleeping and the posterior temporalis muscle tends to return to its resting length. This phenomenon has been described previously (Owen 1983) previously.

Gianelly and Dietz (1982) have pointed out a problem in making a diagnosis on the basis of the lower incisors, which can lead to an excessively obtuse nasolabial angle. Lo and Hunter (1982) have also

pointed out this potential problem. The maxillary lip is an important consideration in the diagnosis and treatment plan, particularly in Class II[1] cases with normal or obtuse nasolabial angles.

Lo and Hunter (1982) found that the nasolabial angle does not change with growth. They also found a high correlation between maxillary incisor retraction and increase in the nasolabial angle as seen on lip- relaxed cephalographs. As the nasolabial angle increases with maxillary incisor retraction, 90% of the change was due to upper lip flattening and only 10% due to columellar changes. In the present study, the nasolabial angle appeared to follow the maxillary incisor movement in the Edgewise sample. However, the nasolabial angle *decreased* in the Fränkel group, even though there was some retraction of the maxillary incisors. It appears that the Fränkel appliance help to preserve the pretreatment position of the upper lip.

The nasolabial angle was rejected by Holdaway (1976) and Legan (1980) because of the high standard deviation. To bypass this variability, Crowe (1980) measured the angle of the upper lip to Frankfort Horizontal (upper lip drape), and Lo and Hunter (1982) mention the same angle as the Frankfort labial angle. Both studies show that the angle of the upper lip is both diagnostically useful and highly responsive to changes in the maxillary incisors.

In the present study, as the maxillary incisors in the Edgewise group were retracted 4.9±4mm in relation to nasion perpendicular, the upper lip drape angle decreased from 95.2° to 86.2° (±8.7), a net decrease of 9.0°. This great retraction of the upper lip may be due to the extraoral anchorage, extractions, or other factors. In contrast, the increase in the upper lip drape from 100.6° to 101.8±7.1° in the Fränkel group appears to corroborate the finding on the nasolabial angle and suggest the Fränkel appliance is more likely to protect the upper lip angle during Class II[1] treatment.

However, these measurements also identify a significant difference between the pretreatment lip drape in the two groups. This, together with the fact that the maxillary incisors were not retracted as far with Fränkel treatment points to the need for additional study.

The apparent forward movement of the upper lip may be explained by a thickening of the lip. Subtelny (1959) reported the upper lip thickness increased up to age 14 in females and 18 in males. Oliver (1982) also reported that patients with thinner lips and/or high lip strain correlated highly with changes in the dentoalveolar structures.

The present study found pretreatment values for the vermilion lip thickness of 10.8±2.2mm for the Edgewise sample and 11.3±1.8mm for the Fränkel sample. These values increased to 13.5mm (±2.0) and 12.8mm (±2.3) respectively after active treatment was completed. The vermilion lip thickness increased a net 2.7mm (±2.4) in the Edgewise sample and only 1.5mm (±1.9) in the Fränkel sample. This may be explained by Ricketts (1968), who reports a thickening of the lip by approximately one-third of the distance the maxillary incisor is retracted. Since the upper teeth were not retracted as far with Fränkel treatment, it would follow the lip would not thicken as much as in those patients with more incisor retraction.

Various ratios of incisor retraction:lip retraction have been reported. Rudee (1964) reported a ratio of 2.9:1, Wisth (1974) 3:1, Roos (1977) 2.5:1, Waldman (1982) 3.8:1, and Lo and Hunter (1982) 2.5:1. The present Edgewise sample ratio is 2.13:1, which is in general agreement

FH = Frankfort horizontal
NP-1° = nasion perpendicular to maxillary incisor (degrees)
NA-1° = N-A to maxillary incisor (degrees)
ULD° = upper lip drape angle
NP-A = nasion perpendicular to point A
NL° = nasolabial angle
NP-UL = nasion perpendicular to upper lip
ULT = upper lip thickness
SbnV = subnasale vertical to labiale superiorus
OJ = overjet
NP-1 = nasion perpendicular to maxillary incisor (mm)
NA-1 = N-A to maxillary incisor (mm)
ULL = upper lip length

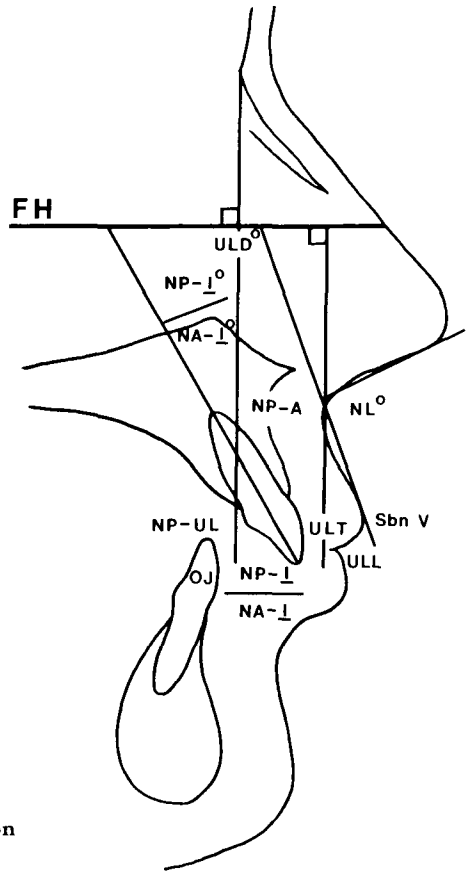

Fig. 3 Key to location of Measurements on cases illustrated in Figs. 4–7

nificantly different from the usual response at $p < .001$.

These findings compare favorably with those of REMMER ET AL. (1985), where the upper lip was retracted during Class II[1] treatment with Edgewise mechanics, while the lip was advanced slightly during Fränkel therapy.

While this finding supports previous reports by OWEN (1981 AND 1983) and others who suggest that the Fränkel appliance preserves the contour of the upper lip significantly better than multibanded approaches in the correction of excessive overjets in Class II[1] malocclusions, the proximity of all of these values to zero makes their ratios so sensitive to small changes that their clinical significance may be limited.

None of the changes in lip length approached meaningful values.

Case Histories

Two case histories from the Edgewise reference group and two from the Fränkel group are presented to illustrate these findings. Figure 3 shows where the various values are located on the tracings.

Figure 4 shows an 11.1yr-old male treated with the Edgewise appliance sup-

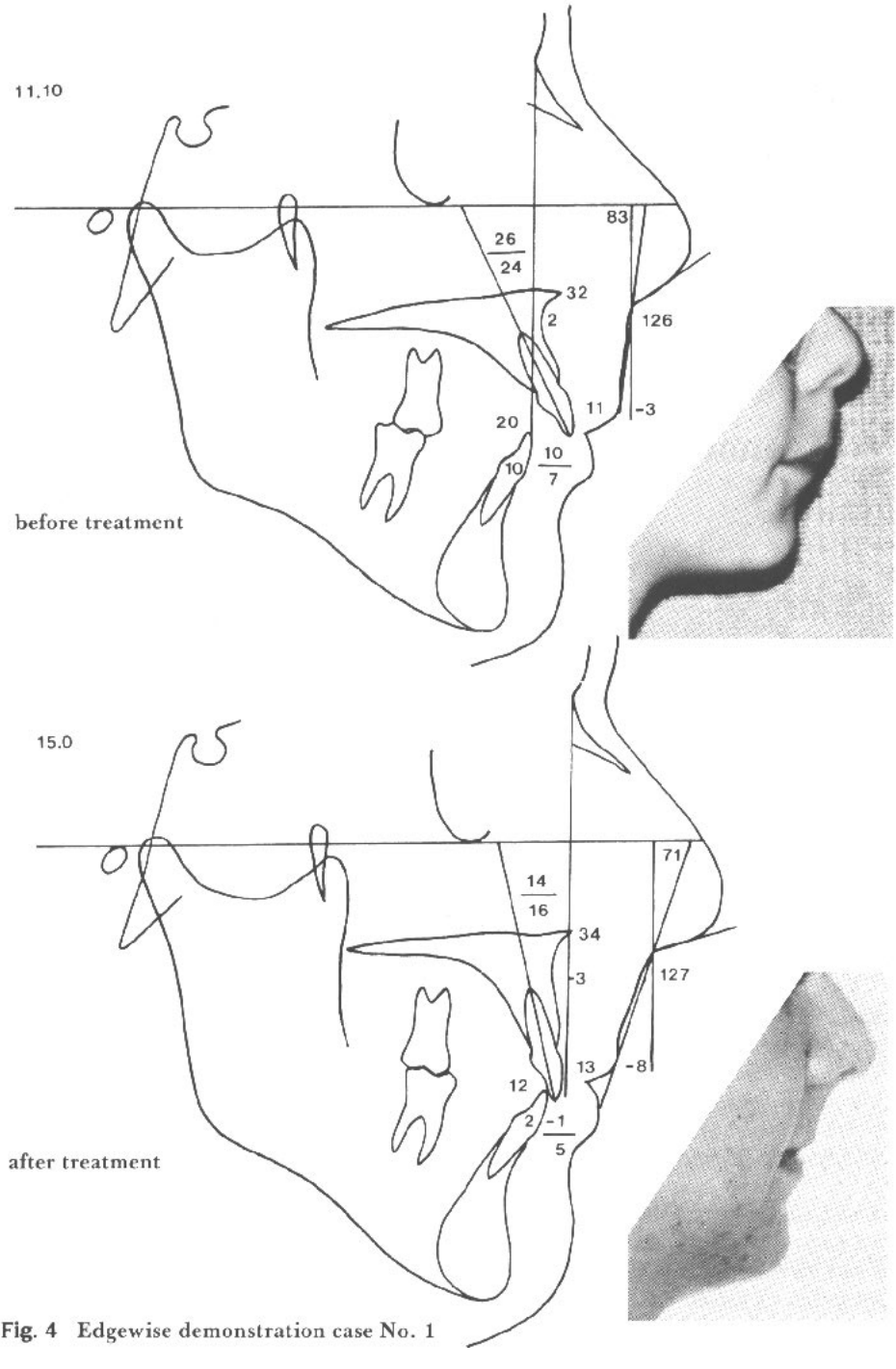

Fig. 4 Edgewise demonstration case No. 1

plemented by four bicuspid extractions and occipital facebow. His treatment required 35 months, and was successful dentally but did not achieve all of the desired esthetic goals.

Figure 5 shows an 11.9yr-old female at the start of treatment. Her treatment included four bicuspid extractions and combination occipital- cervical extraoral anchorage. Her treatment required 27 months. The dental result is acceptable, but she also demonstrates esthetic limitations.

Figure 6 shows a 10.8yr-old male from the Fränkel group. His treatment of 24 months produced favorable dental and soft tissue results.

Figure 7 shows a 10.2yr-old female from the Fränkel sample with a more severe overjet (13mm). The posttreatment photos show a reasonable correction of the dental problem and a reasonably good esthetic result. It was felt that the profile would not be improved with further Fränkel treatment, so a second phase with fixed appliances followed.

— Summary and Conclusions —

Class II, Division 1 patients with a normal or obtuse nasolabial angle present a special problem in orthodontic treatment. Correction of the excessive overjet by retracting the maxillary incisors tends to cause esthetically undesirable changes in the nasolabial angle and the drape of the upper lip.

Patients with an acute nasolabial angle, or a protrusive upper lip, can benefit from retraction of the upper lip. Bicuspid extractions and/or extraoral traction are the most common and successful modalities for maxillary orthopedic and incisor retraction.

In those cases where the upper lip is already acceptable, or excessively recessive, retraction of the maxillary dentition can cause esthetically detrimental effects. The functional regulator presents a possible alternative for correction of Class II[1] malocclusion, and would appear to be indicated wherever retraction of the maxillary incisors and upper lip are not required. Overjet correction with the Fränkel appliance appears to have less effect on the upper lip, thereby resulting in more acceptable soft as well as hard tissue changes.

This study deals only with the Fränkel appliance. The findings *cannot* be assumed to apply to other FJO appliances. The vestibular shields and labial pads of the Fränkel appliance appear to have greater potential for myofunctional change and overall soft tissue balance than other FJO appliances. Further research using other FJO appliances will be necessary to develop similar information.

Lo and Hunter (1982) report that the nasolabial angle increases at the same proportional rate with either large or small values of incisor retraction. This finding should make the clinician aware of the possible iatrogenic effects of treatment if the upper lip is not included in diagnosis and treatment planning, in minor as well as in major corrections.

The following findings are pertinent:

- Fränkel treatment tends to retract the maxillary incisors less than Edgewise in Class II[1] treatment.
- Edgewise treatment is more effective in maintaining the torque of the maxillary incisors than Fränkel treatment. and this in part can account for minimizing any excessive retraction of the upper incisors during Edgewise treatment.
- Fränkel treatment tends to retract the maxilla (A point) less than does multibanded therapy. If a patient has a Class

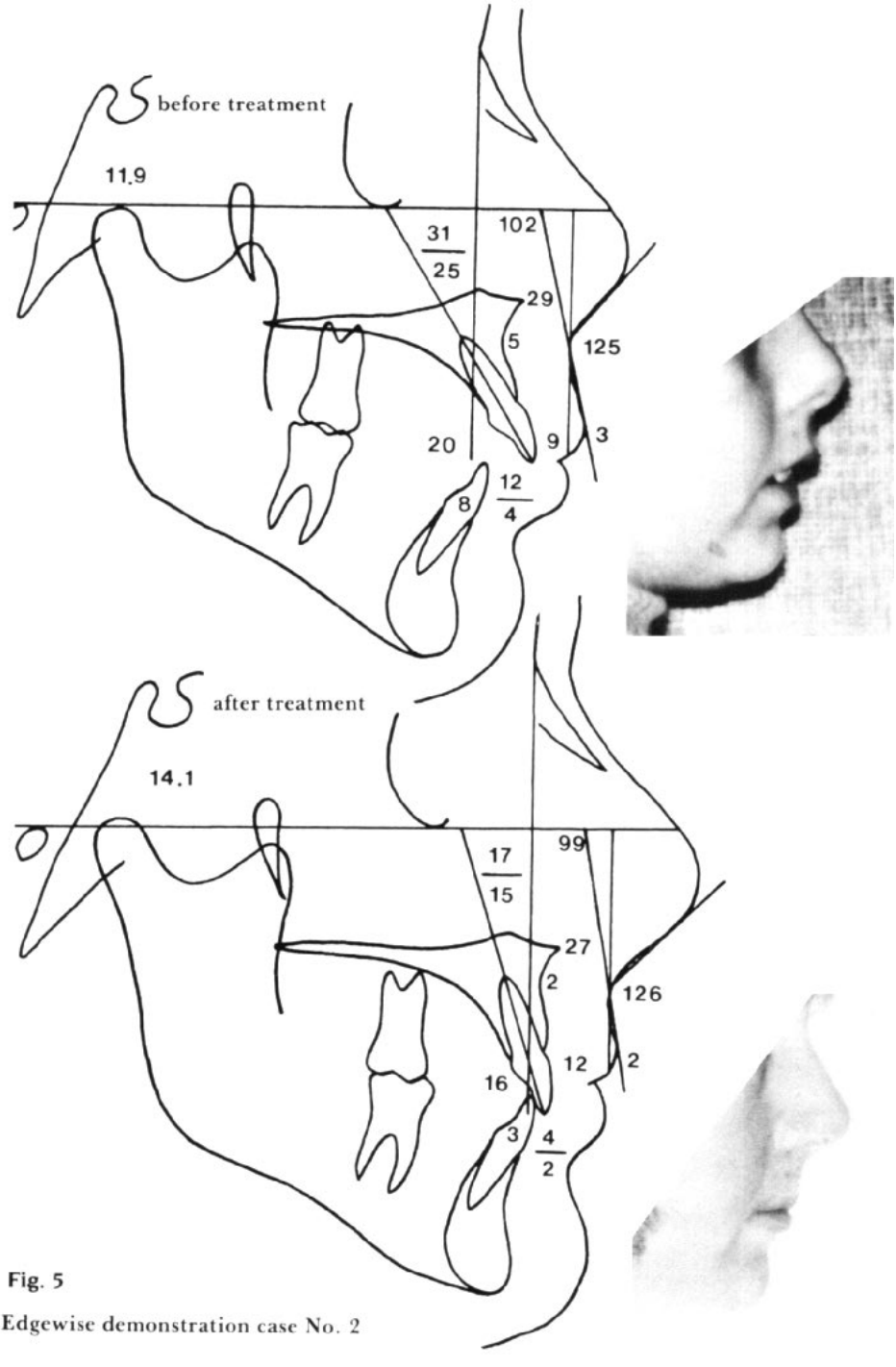

Fig. 5

Edgewise demonstration case No. 2

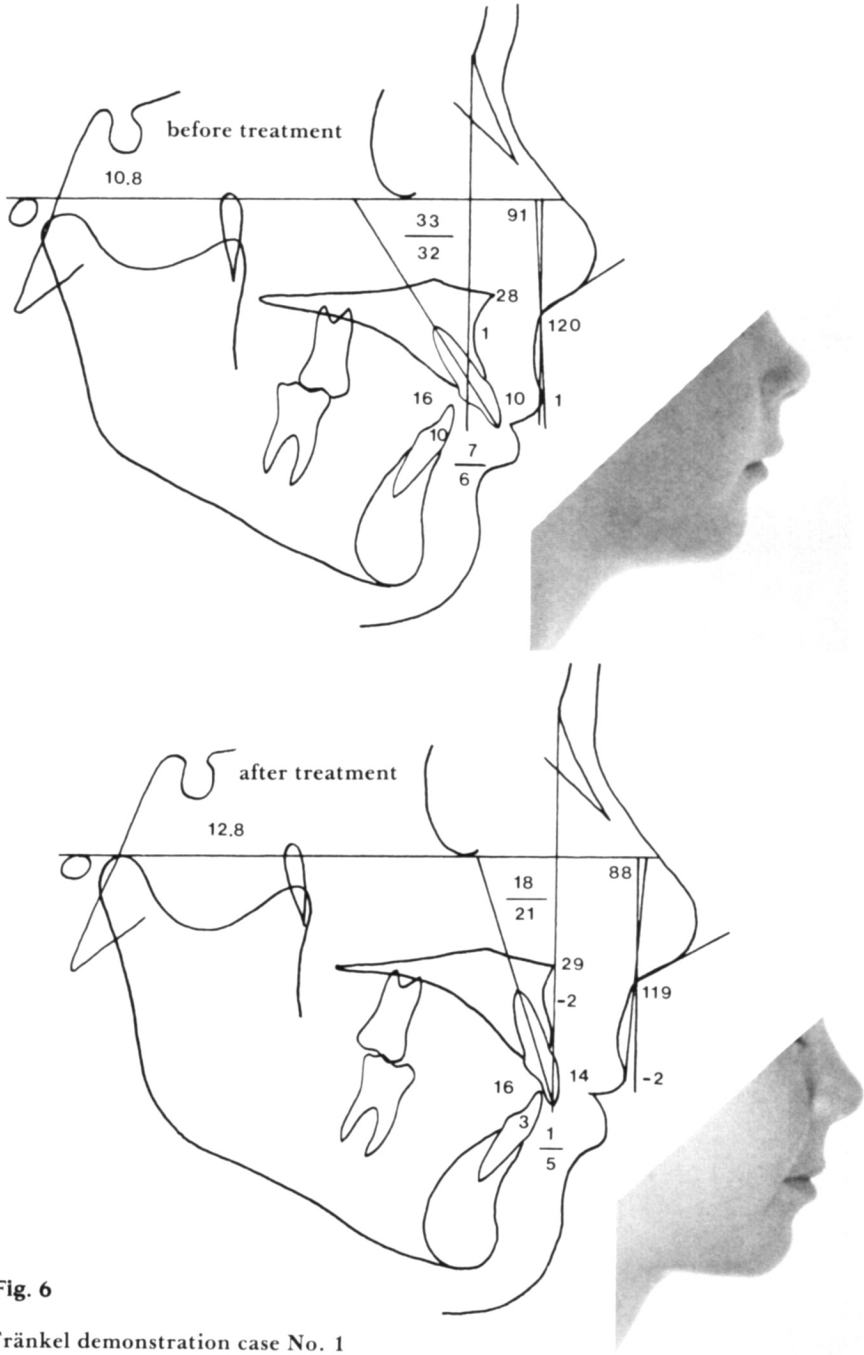

Fig. 6

Fränkel demonstration case No. 1

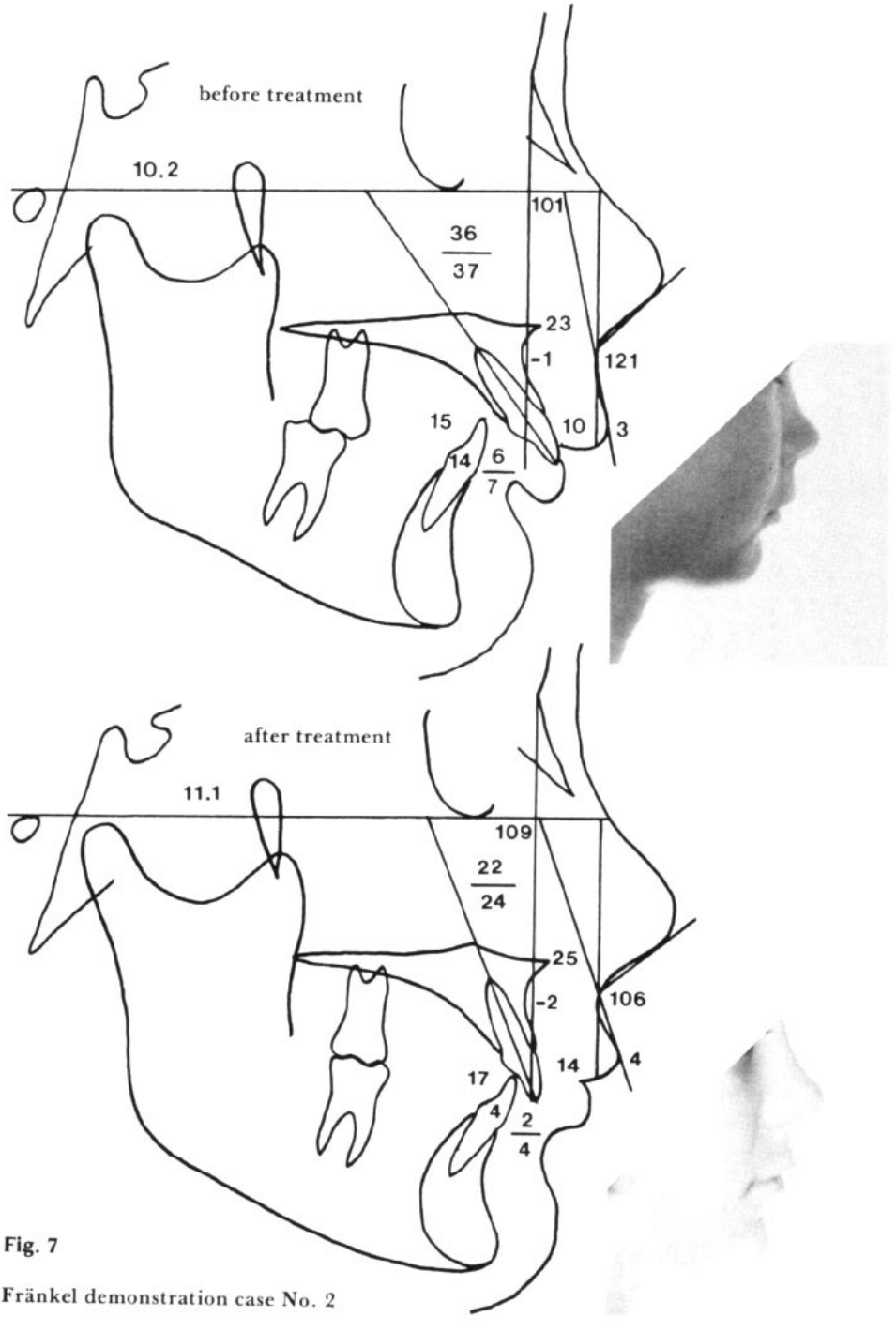

Fig. 7

Fränkel demonstration case No. 2

II[1] malocclusion with maxillary skeletal and dental protrusion, then multibanded appliances are a much better choice than the Fränkel. If, however, the patient has a normal maxilla with mandibular dental or skeletal retrusion, then Fränkel treatment would appear to be a better treatment choice.

From the present study, this would appear true even if there is no additional condylar growth during the Fränkel treatment as suggested by CREEKMORE AND RADNEY (1983).

- The upper lip actually tended to move forward during overjet correction with Class II Fränkel treatment, and backward with fixed appliance therapy. These findings are in close agreement with those of REMMER ET AL. (1985), where the upper lip advanced during Fränkel therapy even though the maxillary incisors were retracted. Perhaps this is due to the myofunctional effects of the appliance rather than underlying morphological changes.

This point is underscored by FRÄNKEL (1969, 1974) in his selection of the term *Functional Regulator* to describe the action of the appliance.

- The nasolabial angle tends to become more obtuse during Edgewise treatment, while it stays more near pretreatment values during Fränkel treatment.

- The FJO results reported in this study were all based on treatment using a Fränkel appliance. There is no basis for extending any conclusions to other FJO appliances (Bionator, Herbst, Activator, etc.).

- Results with the Fränkel appliance require patient motivation and cooperation. If adequate wear time is not achieved, then the results will be disappointing.

- Further studies are indicated, using implant markers to evaluate the hard tissue changes during treatment and EMG studies to ascertain the myofunctional changes during treatment.

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