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Long-term Soft Tissue Changes after Orthodontic and Surgical Corrections of Skeletal Class III Malocclusions

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Abstract

Objective—To evaluate long-term soft tissue changes after orthodontic and surgical corrections of skeletal Class III malocclusions.

Materials and Methods—Postoperative cephalometric radiographs at 1 year and at 5 years or more after treatment were digitized for 92 patients who had surgical correction of their Class III problem by LeFort I maxillary advancement (n = 48), mandibular setback (n = 12), or a combination of the two procedures (n = 32) and for 25 patients who received orthodontic treatment only.

Results—For all groups, the mean changes were quite small. For most measurements, fewer than 20% of patients experienced long-term changes from 2 mm to 4 mm, and fewer than 10% experienced long-term changes greater than 4 mm.

Conclusions—A smaller percentage of surgically treated Class III patients showed long-term soft tissue changes than did surgically treated Class II patients, but compared with both Class II patients and untreated adults they experienced greater long-term forward projection of the soft tissue chin.

Keywords

Class III long-term; Soft tissue

INTRODUCTION

In the United States, the majority of orthognathic surgery patients present with a Class II skeletal problem, but the relative number of skeletal Class III patients seeking surgery has steadily increased since the early 1980s. This likely reflects the improvement in diagnosis and treatment for Class III problems. In the University of North Carolina (UNC) Dentofacial Program, Class III patients currently comprise about one-third of the program's population.[1]

Most studies assessing stability after orthognathic surgery have reported on the positions of the hard tissues, though several have attempted to quantify the relationships between the

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hard and soft tissues.[2–4] The results have been inconsistent, possibly because of the variability related to the ethnic and gender composition of the samples. Generally, the changes at the superior and inferior aspects of the profile, such as nasion and pogonion, have shown more predictable patterns than those of the midface areas, such as the nose and lips. Soft tissue thickness or the muscular tonicity in the midface region could account for localized differences.[5,6] Although edema and muscular readaptation are expected to resolve by 6 to 12 months, soft tissue changes of the lower lip and chin continue to occur up to 3 years postsurgically after mandibular advancement.[7]

To date, very few studies have focused on the soft tissue changes that occur beyond 1 year after orthognathic surgery for a skeletal Class III malocclusion. The purpose of the current investigation was to compare the long-term soft tissue changes in Class III patients treated with orthodontics alone with those who had surgery to correct the problem, either by advancement of the maxilla, mandibular setback, or a two-jaw procedure.

MATERIALS AND METHODS

A database search of the clinical records from the Dentofacial Program and Graduate Orthodontic Clinic of the UNC School of Dentistry, approved by the university's Institutional Review Board, was used to identify potential subjects. Only Caucasians were included to minimize the potential confounding effects of race on soft tissue thickness and changes. The selection criteria for the surgical group included the following: (1) skeletal Class III treated with maxillary advancement by a LeFort I osteotomy, mandibular setback by a bilateral sagittal split ramus osteotomy, or combined maxillary and mandibular procedures; (2) surgical movement of at least 2 mm; (3) presence of a developmental deformity only, with no pathological problems, recognized syndromes, or trauma and no other surgery performed except genioplasty; and (4) available presurgery lateral cephalometric radiographs and postoperative follow-up lateral cephalometric radiographs at 1 year and at 5 years or more after treatment in natural head position. Genioplasty using the patient's own bone is very stable,[8] and soft tissue changes beyond 1 year would not be affected by the procedure. The selection criteria for the Class III patients treated with orthodontic appliances only included: (1) a Harvold unit difference of 29 mm or more (norm = 26 mm) and (2) available pretreatment and deband and at least 5 years posttreatment follow-up lateral cephalometric radiographs taken in natural head position.

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Cephalometric radiographs for each patient were traced and digitized by a highly experienced single research technician with the UNC 139-point model with an X-Y coordinate axis established to analyze changes in cephalometric soft tissue landmark positions. The method error has been documented in previous publications from our laboratory.[9] A horizontal line through the sella rotated down 6° anteriorly from the sella-nasion line (which approximates the true horizontal) was used as the horizontal reference axis, and a vertical line perpendicular to it through the sella was used as the vertical reference axis. Rare earth filters in the x-ray beam were used to clarify the soft tissue profile image, and soft tissue points were clearly visible on all radiographs. X and Y coordinate changes of selected soft and hard tissue landmarks (Figure 1) were calculated for each patient.

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A one-way analysis of variance was performed initially to compare the mean age and length of follow-up among the four treatment groups. Both the average length of follow-up ($P = .0001$) and the average age ($P = .002$) were significantly different among the four groups. The orthodontics-only group was younger (mean = 16.3 years, SD = 7.58) and had a longer follow-up (mean = 9.9 years, SD = 3.14) than did the surgery groups, which did not differ

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significantly among themselves (combined surgery groups: mean age = 24.5 years, SD = 10.46; mean follow-up = 6.9 years, SD = 2.61; $P > .05$).

An analysis of covariance (ANCOVA) with gender and treatment group as explanatory variables, the interaction between gender and treatment group, and age and length of follow-up as covariates was performed separately for each soft tissue change. Length of follow-up was not statistically significant for any of the change measures and was removed from the model. For those measures with a statistically significant interaction of gender and treatment type, an ANCOVA was performed separately for males and females. The level of significance was set at .05 for all analyses.

The percentage of patients who experienced changes of 2 mm to 4 mm or greater than 4 mm was calculated as an assessment of the proportion of the treatment groups who experienced changes that would be considered clinically significant.

RESULTS

The demographics of the four treatment groups are summarized in Table 1. The majority of the sample was female. In the surgery groups, the maxilla was segmented in over half of the sample, and fewer than 25% had a concurrent genioplasty. All the patients had a Harvold unit difference of at least 29 mm. The mean in the orthodontic group was 35.3 mm (SD = 5.11), whereas the mean in the combined surgery group was 37.0 mm (SD = 5.32), indicating a greater severity of malocclusion in the surgery group.

A summary of mean changes from posttreatment to long-term follow-up for the four groups is shown in Table 2, and the mean changes are illustrated in the composite superimpositions of the soft tissue profiles for each group.

Orthodontics Only (n = 25)

The mean long-term changes (from debanding to longest recall) in the group who had orthodontics only were quite small (Table 2), with no mean change greater than 2 mm or 2°. As would be expected from normal aging, mean maxillary tooth display decreased; surprisingly, mandibular tooth display also decreased in the females. As the composite superimposition (Figure 2) shows, on average there were minimal changes in lip positions and an increase in face height that was greater for the soft tissues than for the hard tissues.

Figure 3 shows the percentage of the orthodontics-only group with changes in soft tissue dimensions. In 25% of the patients, the thickness of the soft tissue chin decreased 2 mm to 4 mm, and 20% had a 2- to 4-mm increase in the horizontal distance from the mandibular incisor to the prominence of the lower lip. The SN–soft tissue menton angle increased more than 4° in 25% of the patients. Gender differences were noted in the percentages with change: one-third of the males but none of the females had more than a 2-mm decrease in overjet, and the skeletal change was reflected in a higher percentage of males with an increase in the SN–soft tissue menton angle.

Maxillary Advancement (n = 48)

In the years after surgery, statistically significant mean decreases were observed in maxillary ($P = .007$) and mandibular ($P = .039$) lip thickness at vermilion and in maxillary tooth display ($P = .0009$). The lip thickness variables also had the largest mean horizontal changes (Table 2). For the variables that showed an interaction between gender and surgery type, only SNB demonstrated a statistically significant increase long-term for the male patients. The composite superimposition (Figure 4) illustrates these changes, showing the vertical drop in the soft tissues of the lip and chin relative to the hard tissue.

As Figure 5 shows, one-third of the patients had more than a 2° change in the SN–soft tissue menton angle, but in contrast to the orthodontics-only group twice as many had a decrease than an increase. Horizontal landmark changes in this surgery group occurred to a much smaller extent than in the orthodontics-only group. The excellent stability of the hard tissues was reflected in the smaller amount of soft tissue change.

Mandibular Setback (n = 12)

In the patients who had mandibular setback only, the small sample size and considerable variability within the sample must be kept in mind when the mean changes shown in Table 2 and the composite superimposition (Figure 6) are viewed. There was a statistically significant mean decrease in maxillary lip thickness of 0.79 mm ($P = .03$), and one-third of the patients had a decrease of 2 mm to 4 mm (Figure 7). One-third of the patients had an increase in mandibular tooth display (vertical distance from the mandibular incisor to the superior contour of lower lip).

Maxillary Advancement and Mandibular Setback (n = 32)

For these patients, both the mean decrease in maxillary lip thickness and the mean increase in chin thickness were statistically significant ($P = .05$ and $P = .004$, respectively). As Figure 8 shows, the mean increase in prominence of the chin was attributed almost totally to the soft tissue change, and 20% of the patients had an increase in soft thickness at the chin of 2 mm to 4 mm (Figure 9). There also was a statistically significant mean decrease in maxillary incisor display, which the composite superimposition shows as attributed more to an upward change in the position of the maxillary incisors rather than to a downward movement of the lip. The mandibular plane angle increased in one-third of these patients, but this did not necessarily lead to forward projection of the chin: the SN–soft tissue menton angle increased more than 2 mm in about 25% of the patients and decreased more than 2 mm in another 25%.

Differences among Groups

In all the groups, the mean changes were quite small, less than 1.3 mm for the surgery groups and less than 1.6 mm for the orthodontics-only group. The considerable variability in the groups, however, is reflected in standard deviations as high as 2.6 (Table 2). For every group, long-term vertical changes were on average greater than the anteroposterior changes. The orthodontics-only group overall experienced more change, probably because of their younger age at treatment and longer follow-up. Among the three surgery groups, no significant difference in soft tissue stability was found except for the increased long-term prominence of the soft tissue pogonion when the mandible was set back. Interestingly, this was attributed more to a change in soft tissue thickness at the chin rather than to forward growth of the mandible.

DISCUSSION

A source of potential bias in any retrospective cephalometric study is that the recall sample may not be representative of the larger population of that type of patients, which could have occurred with the Class III surgery and orthodontic patients treated at UNC. Evidence exists that patients who are particularly satisfied (or dissatisfied) with the outcome of their treatment are more likely to respond to a request for follow-up than those who have no emotional involvement in their experience. This bias can be a major problem for all studies that use long-term recall.[10]

In this study, it was possible to contact only 27 of the 183 skeletal Class III patients who were treated with orthodontics alone and had initial and final cephalometric radiographs.

The difficulty in contacting these patients was primarily because they had completed orthodontic treatment from 5 to 20 years previously, and most of their telephone numbers had been disconnected. Of the 27 patients contacted, one was disqualified because of her race, and one did not wish to make the 2-hour drive for a follow-up radiograph. The 25 patients who did present for follow-up were enthusiastic about enrollment in the study, despite the fact that many were driving from great distances or taking time off from work to participate. Because all but one of the patients in the orthodontic group who were located agreed to return for follow-up, probably neither willingness to participate nor patient satisfaction biased the physical outcomes.

The surgery patients were enrolled in the Dentofacial Program database, which is used for research purposes, and were recalled for follow-up evaluation at 2 and 5 years postsurgery. About half the patients returned for the 5-year records. All who responded to the routine recall were included in this sample.

Studies using cephalometric radiographs to evaluate soft tissue are technically difficult because the soft tissue contours of the face may be difficult to visualize accurately and landmark locations are affected by the tension in the face while the image is obtained. In this study, rare earth filters were used, allowing for relatively clear soft tissue outlines, but some variability was certainly introduced in both identification of soft tissue landmarks and the tracing. Based on previous studies of the errors in locating landmarks,[9] a 2-mm or 2° cephalometric change was considered outside the random error inherent in the cephalometric method.

There are three distinct possibilities for long-term soft tissue changes in surgically treated patients: (1) resolution of edema or other soft tissue change related to the surgery itself; (2) postsurgical growth and remodeling of hard tissue landmarks, which would be reflected in changes in the overlying soft tissue; and (3) soft tissue changes as a result of maturation and aging.

In the present study, it is highly unlikely that residual edema existed at 1 year postsurgery and that resolution of edema could have affected changes between then and long-term recall. Long-term hard tissue changes have been studied previously, and the hard tissue changes seen in these patients were quite similar to those changes found by Busby et al.[11]

In the normal aging process, changes in the facial soft tissues are obvious. Significant typical changes include thinning of the lips and downward movement of the lips relative to the teeth so that maxillary incisor display decreases and mandibular incisor display increases, an apparent lengthening of the lower face, and flattening of the upper lip on profile view. In males the profile straightens and the lips become more retrusive, the nose increases in size in all dimensions, and soft tissue thickness at pogonion increases. In contrast, in females the profile does not straighten and the lips do not become more retrusive, the nose does not increase in size as much as in males, and the soft tissue thickness at pogonion decreases.[12]

When soft-tissue changes in Class III patients are compared with the typical changes in untreated adults,[13] it is interesting that the younger orthodontics-only group showed the typical aging changes, whereas in several ways the surgery patients did not. One of the primary differences between the orthodontics-only and surgical treatment groups was the tendency for an increase in prominence of the soft tissue chin for the surgery groups, especially those with two-jaw surgery patients, which occurred in females as well as males. Beyond 1 year postsurgery, there also was less flattening of the lips in the surgery patients than would have been expected without treatment; less downward sag of the soft tissue profile; and, in those who hadmandibular surgery, less increase in soft tissue face height.

From the stability studies at UNC over the past decade,[14] it appears that the pattern of change with Class III treatment is different from that seen with surgical Class II treatment. Although the skeletal Class II patients have very little net change during the first postsurgical year, a surprisingly larger number show skeletal and associated soft tissue changes beyond 1 year. The Class III patients are less stable during the first year but show fewer changes in hard tissue measurements beyond that point.[15] This appears to hold true for the soft tissue measurements as well, as fewer than 20% of patients in our study experienced significant soft tissue change from 1 year to 5 years or more.

CONCLUSIONS

a. In general, skeletal Class III patients who were treated with orthognathic surgery experienced minimal change in soft tissues between 1 and 5 years or more postsurgery. No mean changes were greater than 2 mm or 2°, and fewer than 20% of variables showed statistically significant mean changes.

b. Patients treated with orthodontics only also experienced minimal change in soft tissues at 5 years or more after orthodontics, but these patients had a greater increase in chin projection than did the surgery patients, which may be attributed to a younger age at completion of treatment and subsequent continued mandibular growth.

c. The orthodontics-only patients showed the facial soft tissue changes that are typical of aging in untreated individuals, but the surgery patients differed in that both genders tended to have an increase in soft tissue thickness at the chin and did not show as much thinning of the lips or downward sag of the soft tissue profile as would be expected without treatment. Patients with mandibular surgery did not show the expected increase in face height.

Acknowledgments

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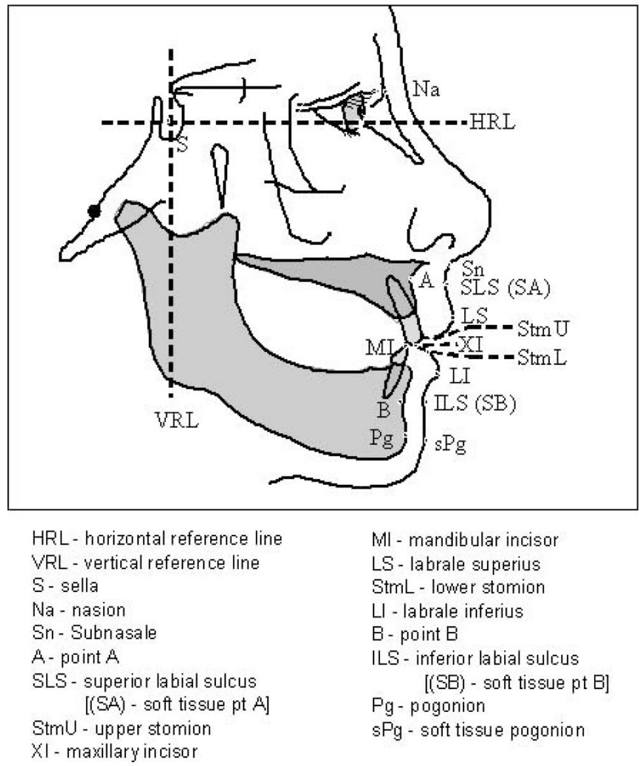

Figure 1.
Pertinent hard and soft tissue cephalometric landmarks.

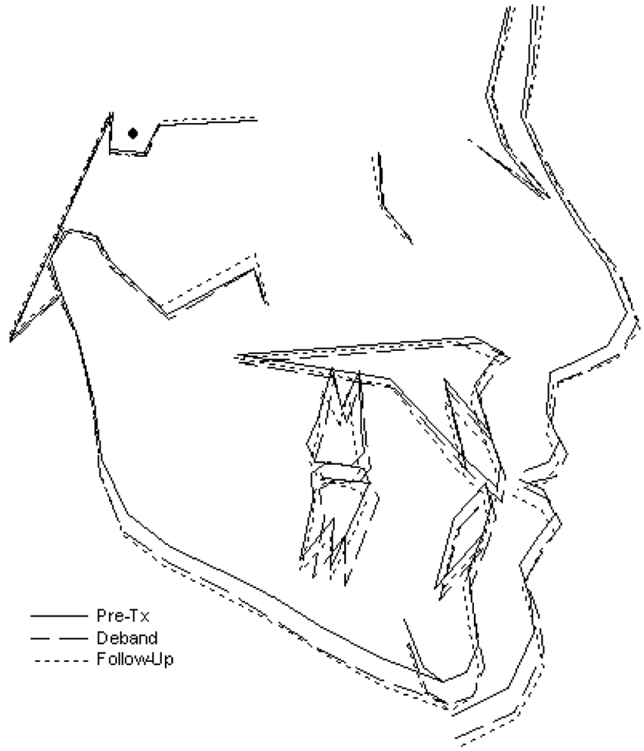

Figure 2.
Composite tracing demonstrating preorthodontics, deband, and long-term follow-up for the orthodontics-only patients.

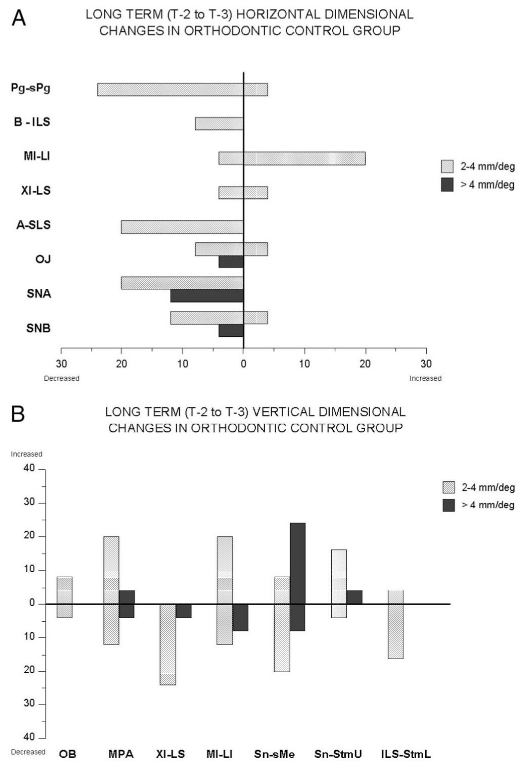

Figure 3.
(A) Long-term change (T2 to T3) horizontal dimensional changes in orthodontic control group. (B) Percentage of the orthodontics-only patients with horizontal and vertical changes of greater than 2 mm from deband to longest follow-up.

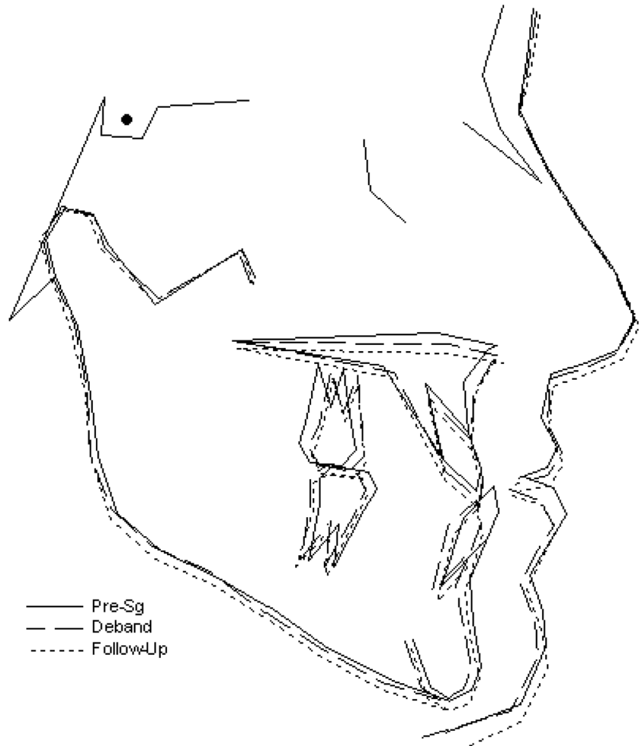

Figure 4.
Composite tracing demonstrating presurgery, postsurgery, and long-term follow-up for the LeFort I maxillary advancement patients.

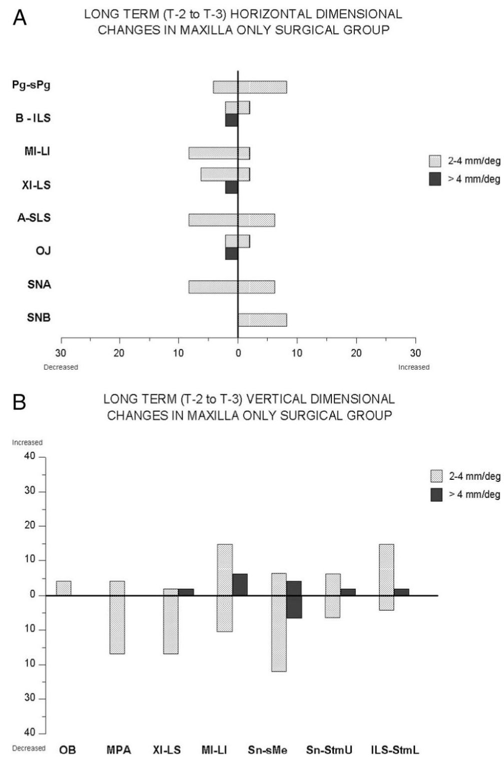

Figure 5.

(A) Long-term change (T2 to T3) horizontal dimensional changes in maxilla only surgical group. (B) Percentage of the LeFort I maxillary advancement patients with horizontal and vertical changes of greater than 2 mm from 1 year postsurgery to longest follow-up.

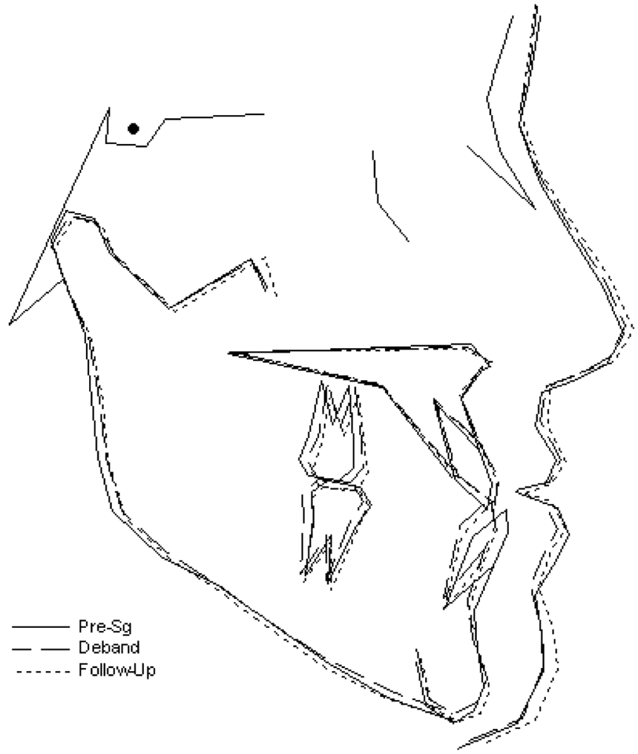

Figure 6.
Composite tracing demonstrating presurgery, postsurgery, and long-term follow-up for mandibular setback patients.

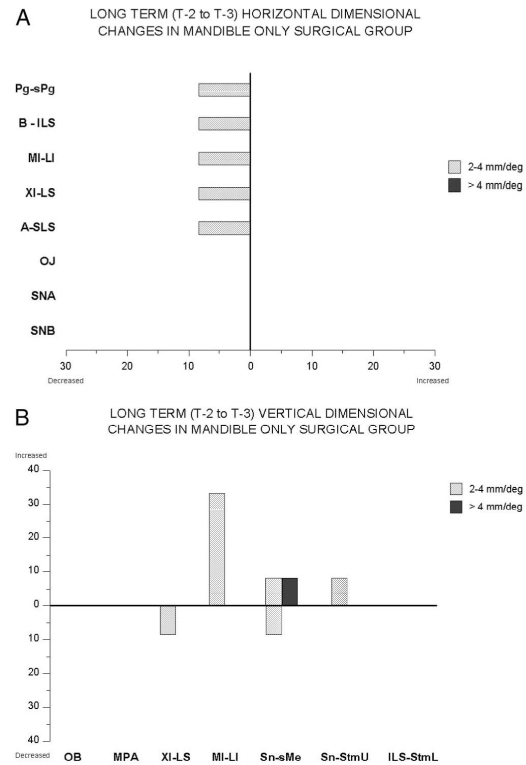

Figure 7.
(A) Long-term change (T2 to T3) horizontal dimensional changes in mandible-only surgical group. (B) Percentage of the mandibular setback patients with horizontal and vertical changes of greater than 2 mm from 1 year postsurgery to longest follow-up.

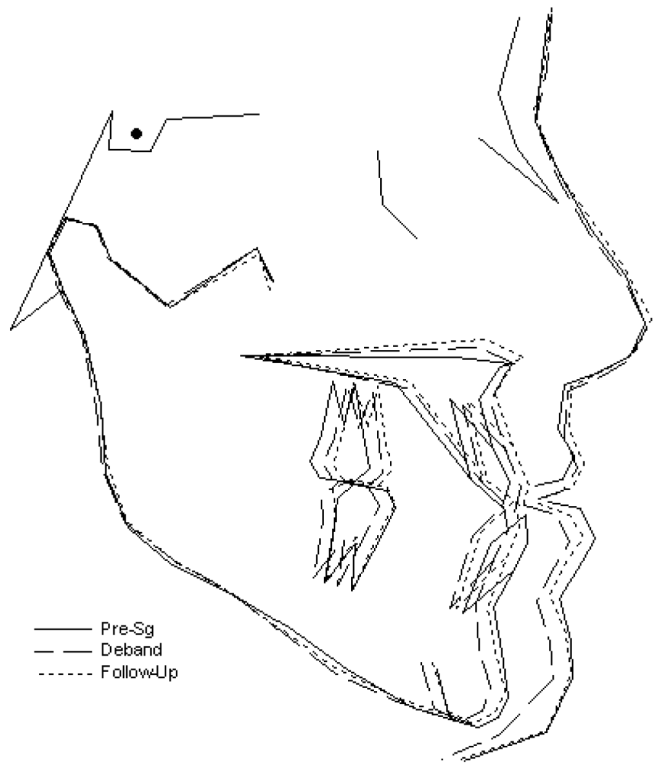

Figure 8.

Composite tracing demonstrating presurgery, postsurgery, and long-term follow-up for the two-jaw patients.

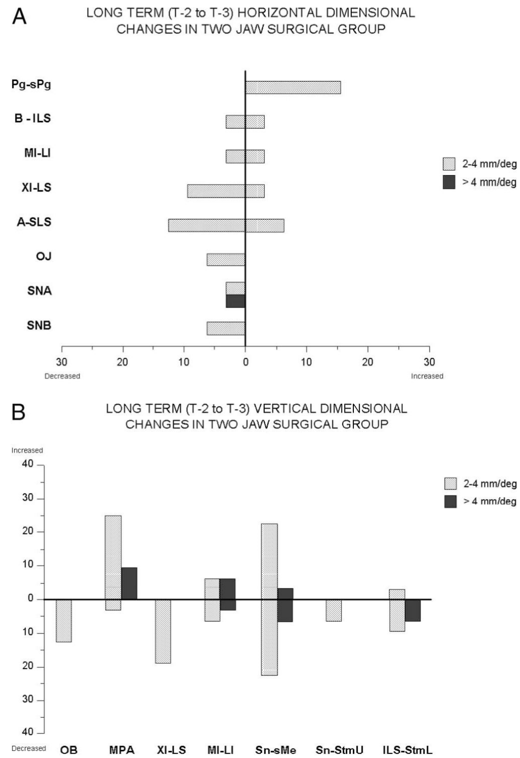

Figure 9.

(A) Long-term change (T2 to T3) horizontal dimensional changes in two-jaw surgical group. (B) Percentage of the two-jaw patients with horizontal and vertical changes of greater than 2 mm from 1 year postsurgery to longest follow-up.

Table 1

Summary of patients

	Orthodontics only (n = 25)		Maxilla only (n = 48)		Mandible only (n = 12)		Both jaws (n = 32)	
Variables	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Age, y	16.3	7.6	26.0	11.2	22.0	9.4	23.3	9.7
Male, %	40.0		52.1		25.0		21.9	
Female, %	60.0		47.9		75.0		78.1	
One segment, %			60.4		100.0		59.4	
More than one segment, %			39.6		0.0		40.6	
Genioplasty, %			12.5		25.0		21.9	
Rigid fixation, %			56.3		58.3		maxilla	62.5
							mandible	71.9
Wire fixation, %			43.7		41.7		maxilla	37.5
							mandible	28.1

	Orthodontics only (n = 25)				All surgery groups (n = 92)			
	Mean	**SD**	**Minimum**	**Maximum**	**Mean**	**SD**	**Minimum**	**Maximum**
Length of follow-up, y	9.88	3.14	5.47	16.17	6.93	2.61	4.56	20.51

Table 2

Posttreatment (T2 to T3) measurement changes[a]

Variables	Orthodontics only (n = 25) Mean	SD	Maxilla only (n = 48) Mean	SD	Mandible only (n = 12) Mean	SD	Both jaws (n = 32) Mean	SD
Anterioposterior measurements, mm								
xA–SLS	−0.56	1.50	−0.13	1.37	−0.36	1.08	−0.47*	1.19
xXI–LS	0.56*	1.25	−0.51*	1.30	−0.79*	1.11	−0.32	1.27
xMI–LI	0.54	1.67	−0.41*	1.22	−0.35	1.17	−0.40	1.11
xB–ILS	−0.64*	1.07	−0.06	1.14	0.02	0.94	0.17	1.04
xPg–sPg	−0.98*	1.49	0.26	1.23	−0.20	1.12	0.66*	1.12
Vertical measurements, mm								
yXI–LS	−1.39*	1.35	−0.75*	1.50	−0.06	0.94	−0.55*	1.31
yMI–LI	−0.67**	2.82	0.40	1.75	1.29**	1.70	0.20	1.99
ySn–sMe	0.91	3.22	−0.73	2.62	0.48	1.82	−0.10	2.55
ySn–StmU	1.08*	1.51	0.05	1.92	0.77	0.95	0.01	1.34
yILS–StmL	−0.29	1.48	0.10	1.52	−0.00	0.71	−0.53	1.81
Other measurements, mm								
SNA	−1.62**	1.85	0.00	1.24	−0.22	0.91	−0.18	1.20
SNB	−0.61**	1.87	0.37***	1.16	−0.08	0.84	−0.19	1.23
OJ	−0.13	1.58	0.00	1.16	−0.06	1.05	−0.26	0.96
OB	0.02	1.43	0.19	1.07	1.04*	0.60	−0.23	1.34
MPA	0.08	2.55	−0.18	1.49	0.10	1.04	1.03*	1.88

[a]Orthodontics-only group: T1 = pretx, T2 = deband; T3 = longest follow-up. Surgery groups: T1 = presurgery, T2 = 1 year postsurgery, T3 = longest follow-up.

[*]Statistically significant with level of significance set at $P < .05$;

[**]statistically significant for females, with level of significance set at $P < .05$;

[***]statistically significant for males, with level of significance set at $P < .05$.