Long-term soft tissue response to LeFort I maxillary superior repositioning

By David M. Sarver, DMD, MS; and Sherri M. Weissman, DMD

Superior repositioning of the maxilla in orthognathic surgery has many indications in the treatment planning of combined surgical orthodontic cases. These indications include closure of open bite, correction of excessive gingival display on smile, reduction of lip incompetence, and reduction of excessive lower facial height. In the last decade, the use of the LeFort I osteotomy has become quite common and its short-term effect on the surrounding soft-tissue has been well documented (Table 1). The most frequent soft-tissue changes associated with maxillary impaction are elevation of the nasal tip with an increase in nasolabial angle, increase in alar base width, shortening of lip length, and changes in maxillary lip position concurrent with horizontal movements of the maxilla.

Many studies[1-8] have investigated soft-tissue change which accompanies surgical movement of the maxilla. Most studies make hard- and soft-tissue comparisons 6 to 12 months after the surgical procedure and, to date, the long-term effects of maxillary osteotomy on soft-tissue are not well documented.

Resolution of edema and soft-tissue adaptation to maxillary osteotomy is generally described as a 12-month process.[9] Evaluation of nose and lip changes at 12 months may not represent the final soft-tissue adaptation to surgery. The purpose of this study is to compare short-term (approximately 12 months postoperatively) and long-term (24 to 81 months postoperatively) records for assessment of hard- and soft-tissue changes and their stability. The parameters of measurement are set up to not only analyze the stability of the bony movements of the maxilla, but also the effects on soft-tissue of superior repositioning, horizontal movements, and rotational movements of the maxilla.

Materials and methods

The patient sample consists of 36 patients who underwent LeFort I maxillary osteotomies for superior repositioning of the maxilla. The sample was comprised of 34 females and 2 males,

Abstract

The purpose of this study was to compare short-term (approximately 12 months postoperatively) and long-term (24 to 81 months postoperatively) records of 36 patients who underwent superior repositioning of the maxilla via LeFort I osteotomies. The parameters of measurement were set up to analyze the net response of the soft tissues of the face to superior repositioning of the maxilla. The results of this study show that soft-tissue changes associated with maxillary impaction are minimal and that no significant differences exist between twelve-month records and five-year records.

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Key Words

LeFort I osteotomy • Maxillary surgery • Surgical orthodontics • Stability • Soft tissue

Table 1
Short-term soft-tissue changes following LeFort I maxillary osteotomy as presented in previous literature.

Authors	Number of patients	Mean follow-up (months)	Range follow-up (months)	Upper lip length	Upper lip thickness	Nasal tip
Schendel et al[1]	30	14	4-29	Ratio of superior movement of upper lip to superior movement to upper incisor 0.38:1	Ratio of posterior movement of upper lip to posterior movement of upper incisor 0.76:1	Elevated slightly
Radney and Jacobs[2]	10	11.1	6-28	Dependent of intrusion and retraction of anterior maxilla and intrusion of posterior maxilla	Ratio of posterior movement of upper lip to posterior movement of upper incisor 0.67:1	Elevates 1 mm for every 6 mm of superior maxillary repositioning
Tomlak et al[3]	10	17.5	10-46	Not significant	Less than 1%	Not stated
Rosen[4]	41	9.8	6 minimum	Lip shortened 20-50% of vertical maxillary reduction	Soft: Hard tissue 0.51:1 at subnasale 0.82:1 at vermilion border	Elevated when anterior vector of maxillary movement
Stella et al[5]	21	Not stated	6 minimum	Not stated	Decreased approximately 2 mm	Not stated
Carlotti et al[6]	25	8.8	4 minimum	No significant change	Incisor: Lip ratio 1:0.9	No significant change but tends to move forward and upward
Schendel et al[7]	10	4	Not stated	No change	No change	2.4 mm average elevation

with the mean age of the patient population being 28.4 years. LeFort I osteotomy procedures were performed by four different surgeons at the University of Alabama School of Dentistry and the impactions were fixated with skeletal suspension and direct wiring with no rigid fixation techniques used. It is important to note that this is a 5-year study, and reflects analysis of LeFort I impactions done prior to the popularity of rigid fixation. In the area of soft tissue closure, no V-Y closures were used in this patient sample. Closure of the vestibular incision was accomplished with continuous suture technique. While the scope of this paper was to study the soft-tissue reaction to LeFort I impaction long-term, 27 patients underwent mandibular surgery in addition to maxillary surgery and 19 patients had genioplasty in addition to the LeFort I impaction. Only two patients in the sample had pure maxillary surgery. In order to evaluate long-term soft-tissue changes, preoperative records were analyzed and compared to 1-year, 3-year, and 5-year posttreatment records.

Thirty-one patients had 1-year posttreatment

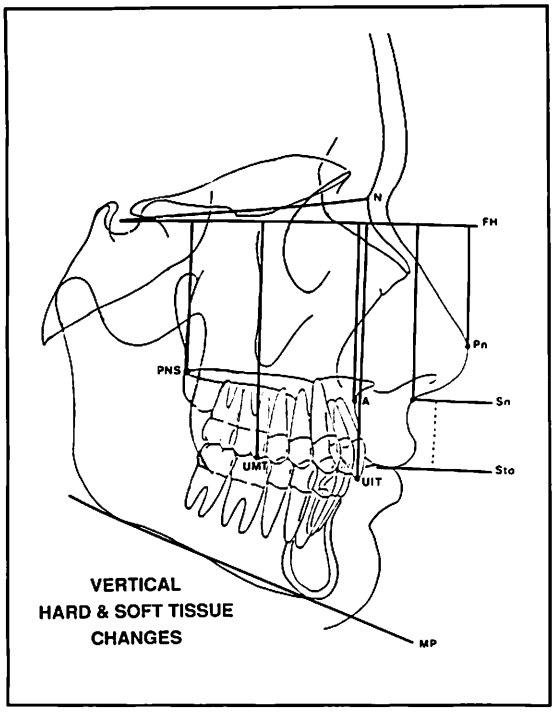

Figure 1

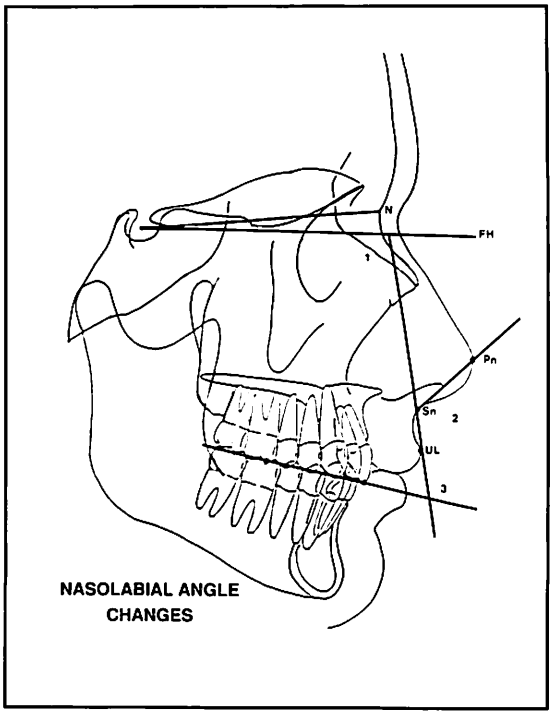

Figure 2

Figure 1
Vertical hard- and soft-tissue changes

Figure 2
Nasolabial angle changes

records, 28 patients had 3-year records, and 5-year or greater records were found for 17 patients in the sample. Five patients did not have 1-year records, but had either 3-year or 5-year records or both. The mean follow-up period was 49.5 months.

A measurement system was devised and categorized to include vertical changes, nasolabial angle changes, and horizontal changes. The following landmarks were used in this study to analyze hard- and soft-tissue changes:

Hard-tissue landmarks:

1. Sella (S): center of the bony contour of sella turcica.
2. Nasion (N): most anterior point on the frontonasal suture on the midsagittal plane.
3. Point A (A): deepest point on midsagittal plane between the anterior nasal spine and the maxillary dental alveolus.
4. Upper Molar Tip (UMT): the tip of the mesiobuccal cusp of the maxillary first permanent molar.
5. Upper Incisor Tip (UIT): the midpoint of the incisal edge of the maxillary incisor.
6. Upper Incisor Anterior (UIA): the most anterior aspect of the maxillary incisor.
7. Lower Incisor Anterior (LIA): the most anterior aspect of the mandibular incisor.
8. Posterior Nasal Spine (PNS): the most posterior point on the contour of the bony palate.

Soft-tissue landmarks:

1. Pronasale (Pn): the most anterior point on the nose in profile.
2. Subnasale (Sn): the most posterior superior point on the nasolabial curvature.
3. Stomion (Sto): the lowest point of the convexity of the upper lip in relation to Fränkfort horizontal.
4. Upper Lip (UL): the most anterior point on the convexity of the upper lip as measured from a perpendicular Fränkfort horizontal.
5. Lower Lip (LL): the most anterior point on the margin of the mandibular membranous lip.

Evaluation of the vertical hard- and soft-tissue response was determined using the following measurement parameters (Figure 1):

1. Sn-Sto: upper lip length perpendicular to Fränkfort horizontal.
2. Pn-FH: vertical changes of the nasal tip related to Fränkfort horizontal.
3. Sn-FH: vertical changes of the base of the nose related to Fränkfort horizontal.
4. UIT—FH: vertical anterior maxillary changes related to Fränkfort horizontal.
5. A-FH: vertical anterior maxillary changes related to Fränkfort horizontal.
6. UMT-FH: vertical posterior maxillary changes related to Fränkfort horizontal.
7. PNS-FH: vertical posterior maxillary changes related to Fränkfort horizontal.

Evaluation of nasal tip changes in its relation to the upper lip secondary to maxillary impaction were made with the following measurement parameters (Figure 2):

1. Angle 1: upper lip inclination to Fränkfort horizontal (angle formed by FH and Sn-UL).
2. Angle 2: nasolabial angle = Pn-Sn-UL.

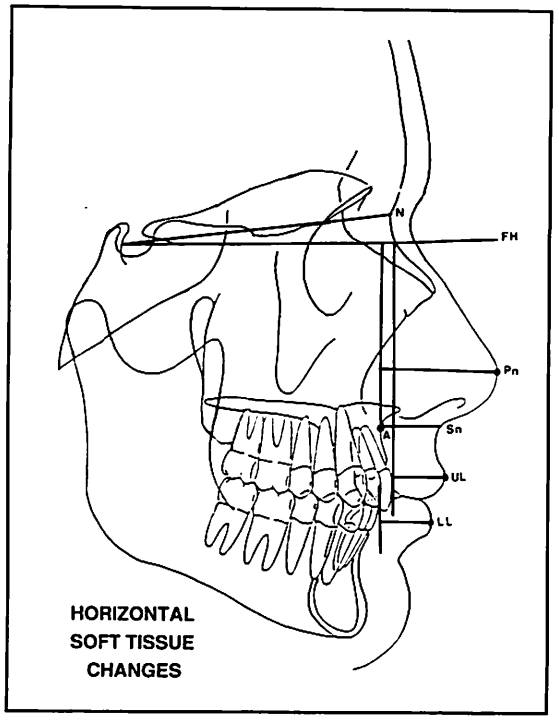

Figure 3

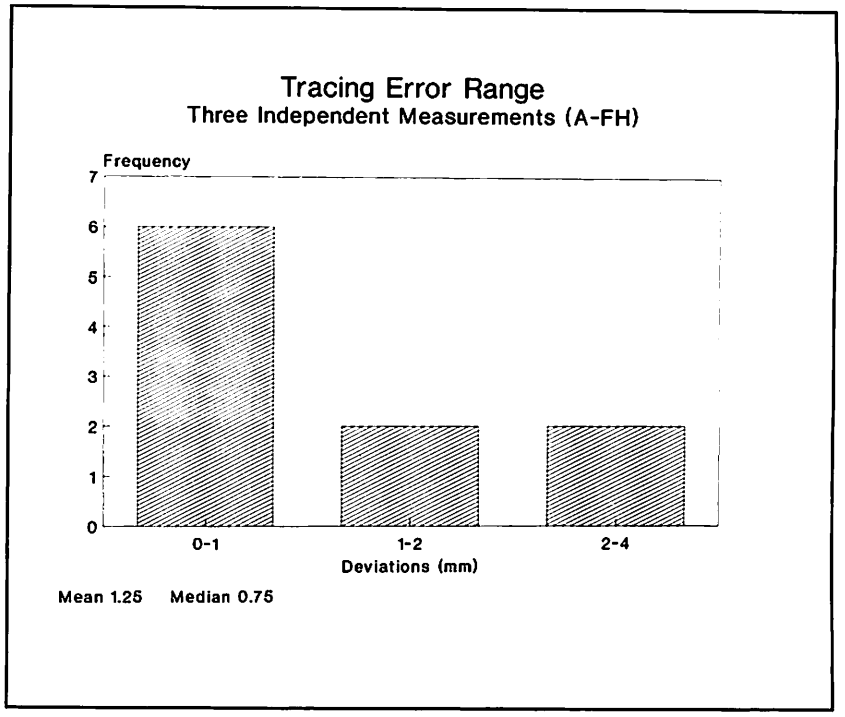

Figure 4

Figure 3
Horizontal soft-tissue changes

Figure 4
Tacing error range

3. Angle 3: occlusal plane to upper lip. (The purpose of this parameter is to measure occlusal plane as it relates to lip and nasal tip changes. For example, posterior maxillary impaction may still affect nasolabial angle or tip by movement of ANS or maxillary incisor.)

Evaluation of the horizontal soft-tissue response to maxillary movement was made using the following measurement parameters (Figure 3):

1. Pn perpendicular to NA: nasal tip projection.
2. A-Sn: upper lip thickness parallel to Fränkfort horizontal.
3. UL-UIA: upper lip thickness at vermilion border parallel to Fränkfort horizontal.
4. LL-LIA: lower lip thickness at vermilion border parallel to Fränkfort horizontal.

In order to investigate the errors in tracing, 10 cephalograms were chosen at random from the set of 36 preoperative films. The locations of Sn-FH and A-FH were traced independently on separate occasions by the same operator. The distribution of the range of the three measurements is given for A-FH in Figure 4. As can be seen, the tracing error is quite low. However, it should be noted that even though significant statistical differences may be found in the range 0 to 1.5 mm, these differences may not represent reproducible results due to the tracing errors which can occur.

Patients for this study were selected from a pool of subjects who had undergone surgical superior maxillary repositioning. Excluded from our sample were patients who were intended to have large anteroposterior movements such as maxillary advancements or segmental osteotomies to retract anterior segments. However, any LeFort I impaction often has some degree of anteroposterior movement incorporated into it, regardless of the skill or intention of the surgeon or the surgical planner. It is possible to assume then, that marked horizontal movements of the maxilla could affect the soft-tissue differently than a pure vertical impaction. To evaluate this potential change each patient was measured along Fränkfort horizontal at A point at three intervals:

1. Preoperative and 1 year.
2. Preoperative and 3 years.
3. Preoperative and 5 years.

Results

Horizontal changes of the maxilla secondary to maxillary superior repositioning

The distribution of horizontal movement of the maxillary osteotomies was found to range from -3.5 mm to +3 mm (Figure 5). Overall analyses consisted of multivariate tests to examine the effect of anterior or posterior movement categories (P = forward, Z = no movement, N = posterior) on other measurements. Due to the number of tests performed, a p level of 0.01 was selected to guard against Type 1 statistical error (claiming there is a difference when in fact no difference exists). None of the variables were significantly related to the variable group (P, N, Z) at the $p = 0.01$ level. The expected soft-tissue changes were not picked up by the measurements made in the study. However, by studying

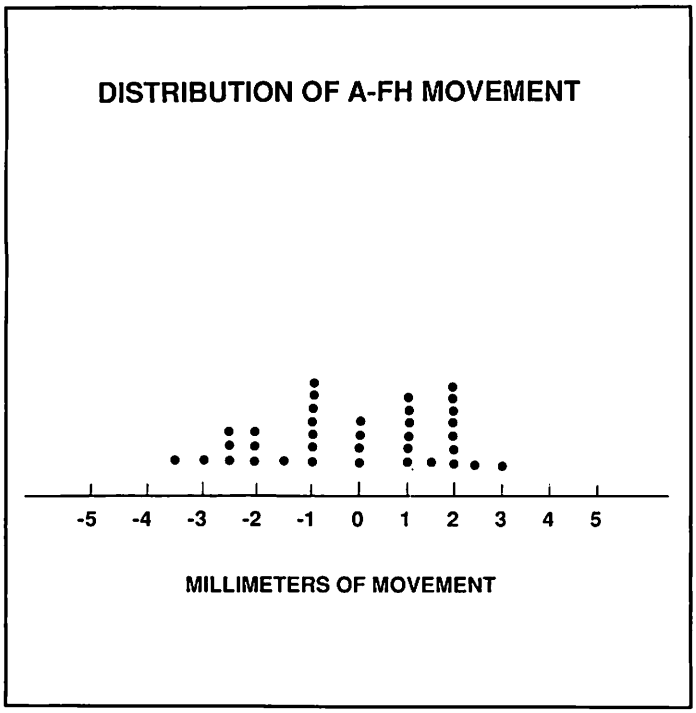

Figure 5

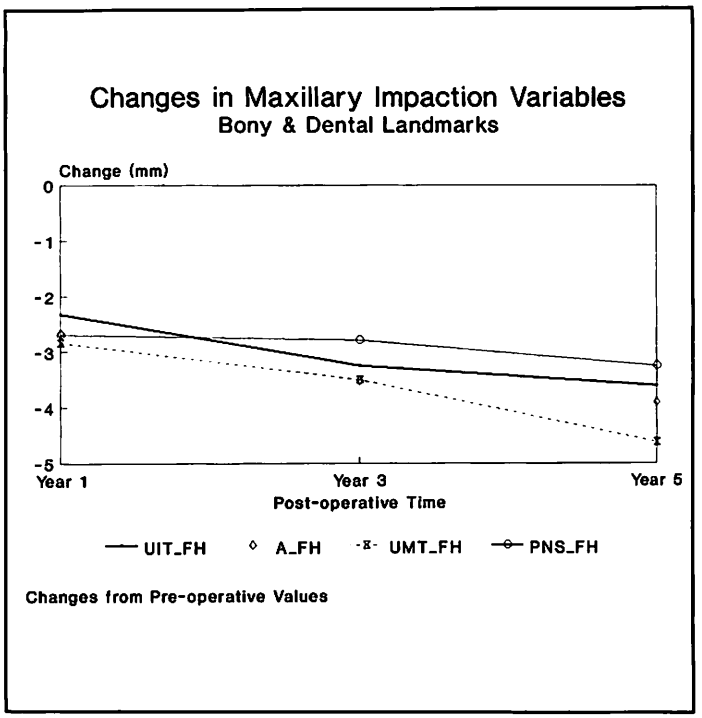

Figure 6

relationships among individuals, changes among variables could be correlated. Further analysis would require conditional tests. (For example, a subset of the 14 variables with values in a given range could be formed, and then one of the other variables or groups of variables tested.) Sample size may also be considered a limiting factor. While powerful statistical tests have been employed, it is possible that in a small sample biological variation prevents detection of subtle changes.

Skeletal changes

In this patient population, the mean superior movement of the maxilla surgically was 2.54 mm. Interestingly, the mean anterior maxillary impaction was identical to the mean posterior maxillary impaction measured at A-FH and PNS-FH. In 22 patients the maxilla moved superiorly at A-FH; in eight patients, the maxilla did not go up at all, and in four patients, the maxilla actually moved downward. The range of anterior impaction was -2.5 mm downward to +8 mm upward. Comparison of the 1-year skeletal measurements with the 3- and 5-year measurements show a continuous, slightly more superior movement of the maxilla between year 1, year 3 and year 5 (Figure 6). For example, the mean A-FH measurement 1 year postoperatively was -2.68 mm; at 3 years, -3.52 mm; and at 5 years, -3.9 mm (Tables 2-4). This would indicate a trend towards some instability in the position of the maxilla, however, in the statistical comparison between years 1 and 3, and years 3 and 5, this trend towards superior movement of the maxilla is statistically insignificant (Tables 5 and 6). Therefore we can conclude that maxillary impaction is very stable or the change is so small that it cannot be measured.

Vertical soft-tissue changes

The mean vertical lip length (Sn-Sto) changes with maxillary impaction at year 1 was -0.15 mm. In year 3, this had increased to -0.25 mm, and by year 5 was 0.26 mm (Tables 3 and 4). Thirty-one of the patients' lip length changes fell within a +2 mm to -2 mm range. The vertical changes in the upper lip were minimal when evaluated at 1 year (Table 2). None of these measurements were found to be significantly different from zero change. The vertical change in position of the nasal tip (Pn-FH) was also very small and not statistically significant at year 1 in comparison to years 3 and 5 (Tables 5 and 7). The vertical changes in the base of the nose (Sn-FH) were also statistically insignificant. The measurement changes not only were statistically insignificant, but were also so small as to be immeasurable, or subject to tracing error.

Changes in the nasolabial angle

Changes in the nasolabial angle (Angle 2) were also found to be insignificant. The mean change was less than 1 mm (0.727 mm) which is quite small. Comparisons between 1, 3, and 5 years were statistically insignificant. Horizontal maxillary movements in our sample were limited, so nasolabial angle changes should have been small. Individuals who did have more than

Figure 5
Distribution of A-FH movement

Figure 6
Changes in maxillary impaction variables

Table 2
Mean changes in variables (year 1 vs. pre-op)

Variable		Number	Mean	Standard error	T	p-value
Sn-Sto		31	-0.15	0.41	-0.35	0.73
Pn-FH		31	-0.05	0.51	-0.10	0.92
Sn-FH		31	-0.56	0.49	-1.16	0.26
UIT-FH	*	31	-2.32	0.70	-3.30	0.00
A-FH	*	31	-2.68	0.64	-4.19	0.00
UMT-FH	*	31	-2.84	0.60	-4.76	0.00
PNS-FH	*	31	-2.69	0.47	-5.72	0.00
Angle 1	*	31	-2.61	1.07	-2.44	0.02
Angle 2		31	0.77	1.48	0.52	0.61
Angle 3		31	-1.23	1.10	-1.12	0.27
Pn perpendicular NA		31	0.53	0.34	1.56	0.13
A-Sn		31	-0.24	0.30	-0.81	0.42
UL-UIA		31	-0.31	0.23	-1.34	0.19
LL-LIA	*	31	-1.37	0.47	-2.94	0.01

"*" Indicates significance of the paired *t*-test (rejection of the null hypothesis of zero mean difference).

Table 3
Mean changes in variable (year 3 vs. pre-op)

Variable		Number	Mean	Standard error	Standard deviation	p-value
Sn-Sto		28	-0.25	0.38	2.02	0.52
Pn-FH		28	-0.43	0.40	2.13	0.30
Sn-FH	*	28	-1.29	0.36	1.89	0.00
UIT-FH	*	28	-3.25	0.73	3.85	0.00
A-FH	*	28	-3.52	0.68	3.61	0.00
UMT-FH	*	28	-3.50	0.72	3.81	0.00
PNS-FH	*	28	-2.79	0.44	2.33	0.00
Angle 1		28	-2.43	1.39	7.33	0.09
Angle 2		28	0.07	1.65	8.71	0.97
Angle 3		28	-1.18	1.37	7.24	0.40
Pn perpendicular NA		28	0.50	0.33	1.77	0.15
A-Sn		28	-0.27	0.26	1.38	0.32
UL-UIA	*	28	-0.46	0.22	1.15	0.04
LL-LIA	*	28	-1.55	0.46	2.44	0.00

"*" Indicates significance of the paired *t*-test (rejection of the null hypothesis of zero mean difference).

+2 mm of horizontal movement had small nasolabial angle changes that were not statistically significant. The same is true for Angle 3, which reflected the potential changes in occlusal plane. As noted previously, however, the anterior and posterior impactions of the maxilla averaged to be equal. Therefore, it is not surprising that Angle 3 did not change. Of some interest is the change in Angle 1 one year postoperatively (an angle constructed by the intersection of the UL-Sn line to the FH line). This change in Angle 1 could be considered edema secondary to the maxillary impaction, however, we would then see changes in the horizontal thickness of the upper lip, or some differential between the thickness of the upper lip to the incisor and subspinale to A point. Angle 1, at 3 years and 5 years, then becomes not statistically different from the preoperative radiograph.

Horizontal soft-tissue changes

Changes in maxillary lip thickness (A-Sn) are insignificant with a mean change of only 0.15

Table 4
Mean changes in variables (year 5 vs. pre-op)

Variable		Number	Mean	Standard error	T	p-value
Sn-Sto		17	0.26	0.43	0.62	0.55
Pn-FH		17	-0.65	0.53	-1.21	0.24
Sn-FH		17	-0.71	0.64	-1.10	0.29
UIT-FH	*	17	-3.62	0.89	-4.05	0.00
A-FH	*	17	-3.91	0.82	-4.78	0.00
UMT-FH	*	17	-4.62	0.69	-6.66	0.00
PNS-FH	*	17	-3.26	0.61	-5.33	0.00
Angle 1		17	-2.71	1.55	-1.75	0.10
Angle 2		17	1.00	1.84	0.54	0.59
Angle 3		17	-1.18	1.17	-1.01	0.33
Pn perpendicular NA		17	0.38	0.55	0.70	0.50
A-Sn		17	-0.41	0.43	-0.96	0.35
UL-UIA	*	17	-0.76	0.35	-2.19	0.04
LL-LIA	*	17	-1.62	0.68	-2.38	0.03

"*" Indicates significance of the paired *t*-test (rejection of the null hypothesis of zero mean difference).

Table 5
Mean changes in variables (year 3 vs. year 1)

Variable	Number	Mean	Standard error	T	p-value
Sn-Sto	26	-0.06	0.32	-0.18	0.86
Pn-FH	26	-0.33	0.50	-0.66	0.52
Sn-FH	26	-0.50	0.38	-1.31	0.20
UIT-FH	26	-0.42	0.38	-1.12	0.27
A-FH	26	-0.27	0.37	-0.37	0.47
UMT-FH	26	-0.40	0.41	-0.98	0.34
PNS-FH	26	-0.10	0.26	-0.37	0.71
Angle 1	26	0.04	0.78	0.05	0.96
Angle 2	26	-0.19	0.97	-0.20	0.84
Angle 3	26	0.15	0.76	0.20	0.84
Pn perpendicular NA	26	-0.08	0.21	-0.37	0.72
A-Sn	26	0.23	0.23	1.00	0.33
UL-UIA	26	-0.23	0.19	-1.20	0.24
LL-LIA	26	-0.10	0.16	-0.61	0.55

"*" Indicates significance of the paired *t*-test (rejection of the null hypothesis of zero mean difference).

mm. Intergroup comparisons between years 1, 3, and 5 also show no long-term significant lip thickness changes. Furthermore, this holds true of nasal tip projection (Pn-NA). Upper lip thickness relative to the maxillary incisor (UL-UIA) was significantly thinner at 5 years than it was at 1 or 3 years (Figure 7). This finding would be important in the evaluation of lip fullness and the surgical plan. Significant changes were also noted in the lower lip (LL-LIA) with reductions in the lower lip thickness consistently observed at all three dates of comparison (Figure 7). This change in lower lip thickness would likely be attributable to overjet changes in correction of severe malocclusion.

Discussion

The original intent of this study was to analyze the most frequent soft-tissue changes associated with maxillary impaction. As was indicated in the reviewed literature,[1-9] the most frequent soft-tissue changes generally associated with

Table 6
Mean changes in variables (year 5 vs. year 3)

Variable	Number	Mean	Standard error	T	p-value
Sn-Sto	9	0.94	0.63	1.50	0.17
Pn-FH	9	0.11	0.73	0.15	0.88
Sn-FH	9	0.28	0.58	0.48	0.65
UIT-FH	9	0.17	0.69	0.24	0.81
A-FH	9	-0.17	0.59	-0.28	0.78
UMT-FH	9	0.33	0.60	0.56	0.59
PNS-FH	9	0.17	0.33	0.50	0.63
Angle 1	9	0.78	1.02	0.76	0.47
Angle 2	9	-1.33	1.35	-0.98	0.35
Angle 3	9	-0.56	1.14	-0.49	0.64
Pn perpendicular NA	9	0.33	0.39	0.85	0.42
A-Sn	9	0.39	0.44	0.89	0.40
UL-UIA	9	0.17	0.22	0.76	0.47
LL-LIA	9	0.06	0.34	0.16	0.87

"*" Indicates significance of the paired *t*-test (rejection of the null hypothesis of zero mean difference).

Table 7
Mean changes in variables (year 5 vs. year 1)

Variable	Number	Mean	Standard error	Standard deviation	p-value
Sn-Sto *	13	0.77	0.33	1.18	0.04
Pn-FH	13	-0.08	0.61	2.21	0.90
Sn-FH	13	0.08	0.49	1.78	0.88
UIT-FH	13	-0.12	0.49	1.76	0.82
A-FH	13	-0.73	0.43	1.56	0.12
UMT-FH	13	-0.35	0.44	1.57	0.44
PNS-FH	13	-0.08	0.30	1.10	0.80
Angle 1	13	-1.15	1.29	4.65	0.39
Angle 2	13	0.77	1.24	4.46	0.55
Angle 3	13	-1.08	1.11	4.01	0.35
Pn perpendicular NA	13	0	0.52	1.88	1.00
A-Sn	13	-0.23	0.42	1.52	0.59
UL-UIA	13	-0.62	0.35	1.26	0.10
LL-LA	13	-0.23	0.29	1.05	0.44

"*" Indicates significance of the paired *t*-test (rejection of the null hypothesis of zero mean difference).

maxillary impaction were changes in the nasal tip, increases in alar base width, shortening of lip length, and changes in maxillary lip position concurrent with horizontal movements of the maxilla. Analysis of 36 long-term patient records however, showed that the soft-tissue changes measurable on cephalograms were minimal. Simply stated, our data does not support the contention that many soft-tissue changes occur with maxillary impaction in the long-term analysis. Certainly, short-term changes do occur, but this data indicates that many of the soft-tissue characteristics return to their preoperative measurements in the long-term analysis. This analysis is concerned with profile analysis and measures structures in the midsagittal plane. It would be inappropriate to say that other soft-tissue changes seen with LeFort I impaction, such as widening of the alar base from the frontal aspect, do not occur since this is not measurable on a cephalometric radiograph. The previous literature studying soft-tissue reaction to LeFort I

osteotomy ranges from as little as 4 months[1,6,7] postoperatively to as many as 17.5 months.[3] Schendel and Eisenfeld[1] had an average mean follow-up of 14 months with a sample of 30 patients. In this study, sample size was 36 patients with a mean follow-up of 49.5 months. Superior movement of the upper lip to the maxillary incisor was only 0.38 mm, which is an extremely small movement. The measured change at 12 months was 0.15 mm, which is even smaller. Tomlak[3] had a longer follow-up period, but only 10 patients were included in his study. He found no upper lip length change and less than 1% upper lip thickness change.

Soft-tissue reaction to surgical impaction can be variable. Most of the studies have shown very little soft-tissue change and this study certainly agrees with the literature. The comparison of the 12-month postoperative groups to the 5-year records show no significant differences. It would therefore be safe to say that soft-tissue changes noted 12 months after LeFort I impaction will probably be stable for at least 5 years.

The clinical application of this data relates to some treatment judgments routinely made in patients undergoing superior repositioning of the maxilla. In the 1970s and early 1980s it was common to plan sufficient impaction of the maxilla so that incisal edges of the teeth were placed at the vermilion border. The concern at that time was that the maxillary lip would shorten with the impaction and this shortening would leave too much of the maxillary incisors showing at rest. Over the decade, however, many clinicians have been disappointed in the long-term esthetic results in some cases, feeling that they were overimpacted.

Based on the sample studied and presented in this paper, the surgeon would be wise to err to the side of underimpaction, since the long-term tendency is for the maxilla to continue to migrate superiorly, and the lip length tends to be unaffected. In a review of stability following superior repositioning of the maxilla by LeFort I osteotomies in 61 patients, Proffit[10] found that the maxilla continued to move slightly upwards in the short-term postsurgical period in about 20% of the patients. However, he also found

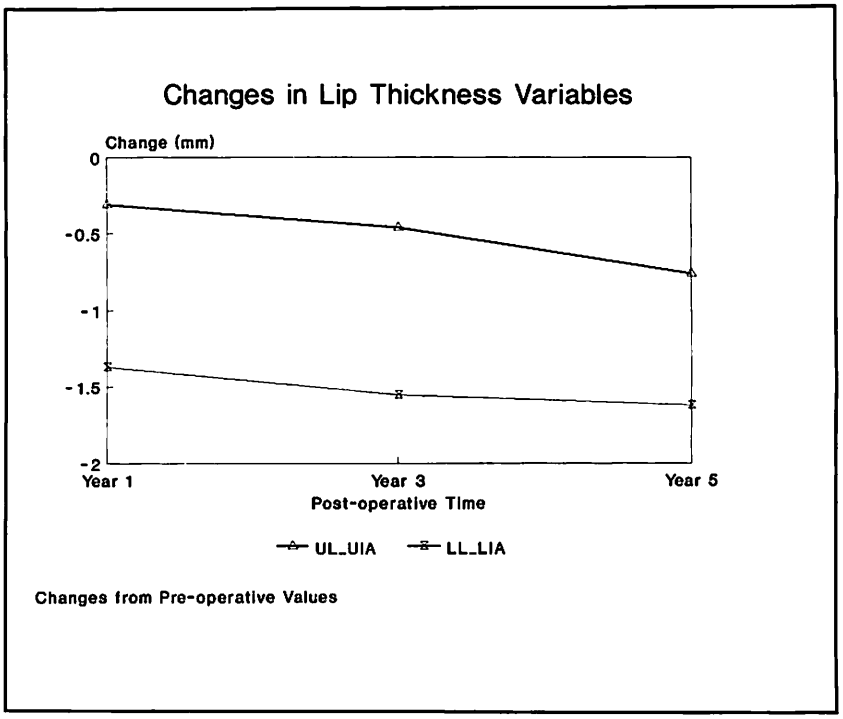

Figure 7

Figure 7
Changes in lip thickness variables

that the maxilla tends to move back down by the end of the first postsurgical year. It is evident from our study that horizontal movements of the maxilla do not change the lip length. The clinical axiom that anterior movement of the maxilla rolls the lip up is not supported by this data. The upper lip 1 year postoperatively is not significantly different from its preoperative measurement, except that at years 3 and 5 it is significantly thinner. Retraction of the maxillary anterior segment or teeth should be carefully evaluated so as to not flatten the upper lip, and accordingly, it would be prudent to inform the patient that thinning of the upper lip may occur.

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