Original Article

Importance of the vertical incisor relationship in the prediction of the soft tissue profile after Class III bimaxillary surgery

Gundega Jakobsone[a]; Arild Stenvik[b]; Lisen Espeland[b]

ABSTRACT

Objective: To quantify the relative soft tissue profile response to the skeletal changes resulting from bimaxillary surgery to correct Class III malocclusion in patients with different vertical incisor relationships presurgery.

Materials and Methods: The sample comprised lateral cephalograms of 80 consecutive patients before and 2 months after surgery. All patients had one-piece Le Fort I and bilateral sagittal split osteotomies. Patients were divided in three subgroups according to their preoperative characteristics, as follows: (1) open-bite patients, (2) patients with positive overbite and the upper lip resting on upper incisors, and (3) patients with positive overbite and the upper lip resting on lower incisors (lip-block). Trimmed means of soft to hard tissue ratios were calculated for the subgroups. Regression analyses were performed to examine factors influencing the soft tissue changes.

Results: There were strong correlations between the horizontal movement of upper incisors and upper lip in patients with open bite ($r = 0.77$) and in patients with positive overbite and upper lip resting on upper incisors ($r = 0.85$). The upper lip followed the maxilla with a ratio of 0.5:1. In patients with lip-block, the association between maxillary repositioning and upper lip changes was weak. In all groups a strong association between horizontal soft and hard tissue changes was observed for the lower lip and chin, but the pattern differed depending on the vertical movement of the mandible.

Conclusions: In the prediction of soft tissue response it is important to take into account the vertical incisor relationship, particularly in patients with lip-block. (*Angle Orthod.* 2012;82:441–447.)

KEY WORDS: Orthognathic surgery; Soft tissue response; Class III malocclusion

INTRODUCTION

A challenge in the planning of orthognathic surgery is to communicate to the patient the impact of treatment on future facial appearance.[1] Visual aids are powerful instruments for providing the patient with an idea of potential facial changes, and since the 1990s computerized prediction programs have become tools with which the clinician can visualize the effect on the soft tissue profile.

Several studies[2–5] have reported ratios close to 1:1 for soft to hard tissue change after mandibular setback surgery. Investigations[6–10] of the soft tissue response after isolated maxillary advancement have reported a wide range of ratios (0.3:1 to 0.9:1) for upper lip change to maxillary movement with weak correlations. Factors that have been suggested to contribute to the unpredictable response of the upper lip are a "dead space" (lip-block) between a retrognathic maxilla and the upper lip[8] and adjunctive soft tissue procedures such as V-Y closure of the upper lip suture[11] and alar base cinch suture.[12]

Bimaxillary surgery for Class III correction is often implemented to correct vertical discrepancies, to avoid large skeletal movements, or to meet esthetic or functional needs. It has been proposed[13,14] that the soft tissue changes after Class III bimaxillary surgery are similar to the changes that occur following single-jaw surgery of the maxilla or mandible. Nevertheless, studies[13,15–20] related to bimaxillary procedures have so far reported great variation in ratios for the soft to hard tissue changes (Table 1).

[a] Associate Professor, Department of Orthodontics, Riga Stradins University, Riga, Latvia.

[b] Professor, Department of Orthodontics, University of Oslo, Oslo, Norway.

Corresponding author: Dr Lisen Espeland, Department of Orthodontics, Institute of Clinical Dentistry, University of Oslo, PO Box 1109, Blindern, N-0317 Oslo, Norway (e-mail: lisene@odont.uio.no)

Accepted: October 2011. Submitted: July 2011.
Published Online: November 30, 2011

Table 1. Studies on Soft Tissue Response Following Bimaxillary Surgery to Correct Class III Malocclusion. Horizontal Soft Tissue Change Related to Skeletal Movement[a]

Study	Sample Size (No.), Follow-Up	Maxillary Advancement at A, mm	Upper Lip to Upper Incisor, % (sign. corr.)	Mandibular Setback at Pg, mm	Soft to Hard Tissue Chin (Pg), % (sign. corr.)	Lower Lip to Lower Incisor, % (sign. corr.)
Marşan et al.,[20] 2009, Turkey	44, 2.6 y	5	36 ($r = 0.52$)	5.8	36 ($r = 0.48$)	28 ($r = 0.47$)
McCollum et al.,[13] 2009, South Africa	26 Mixed sample: bimaxillary and one-jaw, 7 mo	Not specified	55 ($r = 0.51$) Thin (<15 mm) lips: 76 ($r = 0.69$) Thick (>15 mm) lips: 27 (NS)	Not specified	100 ($r = 0.97$)	79 ($r = 0.91$)
Altug-Atac et al.,[19] 2008, Turkey	20, >10 mo	3.5	50	2.4	81	72
Chew,[18] 2005, Singapore	34, >6 mo	3.3	73 ($r = 0.78$) 66 ($r = 0.58$)	4.8	85 ($r = 0.98$)	84 ($r = 0.90$)
Soncul and Bamber,[17] 2004, UK	46, 6 mo	3.0 5.9 9.0	66 57 49	2.9 2.7 2.8	97 98 100	64 65 71
Enacar et al.,[16] 1999, Turkey	12, 1 y	2.5 (at ANS)	–	9.0	113 (NS)	37 ($r = 0.75$)
Lin and Kerr,[15] 1998, UK	17, 3–6 mo	4.3	74 ($r = 0.77$)	4.3	99 ($r = 0.99$)	99 ($r = 0.96$)

[a] A indicates A-point; Pg, pogonion, and NS; not significant.

Bimaxillary surgery for Class III patients often addresses complex anomalies, in particular because the vertical skeletal and dental pattern varies. A study was therefore conducted on a large sample with the purpose of examining the association between soft and hard tissue profile changes in subjects with positive vs negative overbite and different relationships between the upper lip and the incisors.

MATERIALS AND METHODS

The initial sample comprised 84 consecutively operated patients who underwent a combination of one-piece Le Fort I and bilateral sagittal split osteotomies with rigid fixation. None had undergone additional surgery (such as genioplasty). Patients with syndromes, cleft of the lip and/or palate, or dentofacial trauma were excluded from the study. The patients were retrieved from the files at the Department of Orthodontics at the University of Oslo. Surgery had been performed at the Oslo University Hospital, Ullevaal, during the period ranging from 1990 to 2003. Pre- and postsurgical orthodontic treatments were carried out by specialist orthodontists in their practices or by postgraduate students under supervision. The patients were followed on a regular basis over a 3-year period. In the present study the records obtained within 1 week prior to surgery and 2 months after surgery were used, and cephalograms of sufficient quality from 80 patients (52 male and 28 female) were available. The age of the patients at the time of surgery varied from 15.7 to 49.2 years, with a mean of 24.2 years (standard deviation, 7.3 years).

A team of five senior surgeons was involved in performing the surgery. For all patients a standard one-piece Le Fort I osteotomy was performed. Fixation was achieved using four "L"-shaped miniplates (Walter Lorentz Co, Jacksonville, Fla), two on each side of the maxilla. After the maxilla had been stabilized, the mandibular sagittal split osteotomies were performed. The bony segments were stabilized using three 2.0-mm bicortical screws with washers (Krenkel, Normed Medizin-Technik GMBH, Tuttlingen, Germany), which were placed in the gonial area. In cases of instable occlusion an interocclusal splint was used during surgery.

The same cephalostat was used for all radiographs, and the cephalograms were taken with the head in a standardized position with the teeth in occlusion and the lips relaxed. All cephalograms were hand-traced by the same examiner on acetate paper. A postsurgery cephalogram was traced first, and then the tracing was superimposed on sella, nasion, and anterior and posterior cranial base using the "best-fit" method. From the same radiograph a template of the outline of the maxilla was constructed and superimposed on the presurgical radiograph on the outline of the bony palatal structures. The tracings were scanned and digitized with the Dentofacial Planner Plus software (Dentofacial Software, Toronto, Canada) on a computer with a digitizing screen (Numonics Cooperation, Montgomeryville, Pa). The measurements were not corrected for magnification (5.6%). Changes in landmark

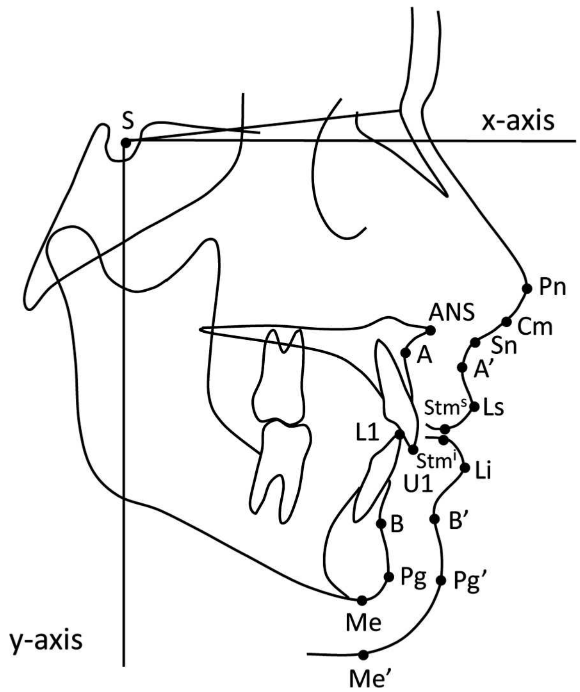

Figure 1. Skeletal, dental, and soft tissue landmarks applied in the cephalometric analysis.

position were recorded using a coordinate system (Figure 1). The definitions of landmarks and measurements have been presented previously.[4]

The sample was divided in subgroups according to the vertical incisor relationship. Patients with an overbite measuring less than 0 mm were assigned to the open-bite group. Patients with positive overbite were allocated to one of two groups depending on the position of the upper lip: upper lip resting on upper incisors (positive overbite group) or upper lip blocked from contact with upper incisors because it rested on the lower incisors (lip-block group) (Figure 2).

For analysis of method error, 20 radiographs, chosen at random, were traced and digitized by the same investigator on two separate occasions at least 2 weeks apart. Statistical analyses were performed with SPSS for Windows software (SPSS, Chicago, Ill). Dahlberg's calculation and the intraclass correlation coefficient (ICC) were used to determine error between duplicate measurements. Systematic error was assessed using paired *t*-tests, with a 10% level of significance. Paired *t*-tests were used to analyze changes between time points. Ratios for the change of soft tissue landmarks relative to the underlying hard tissue surgical repositioning were calculated, and the 5% trimmed mean was used. Analysis of variance was used to compare changes between the subgroups. Multiple linear regression analyses were used to identify factors with a potential influence on the soft tissue response. In addition to horizontal movement of the upper and lower lips and the chin, the upward movements of the tip of the nose were used as dependent variables.

RESULTS

The method error expressed by Dahlberg's calculation ranged from 0.26 mm (the nasal tip to y-axis) to 1.28 mm (Stomion superius to y-axis). ICC coefficients were between 0.989 (Stomion superius to y-axis) and 1.000 (A point to y-axis). The systematic error test reached a 10% level of significance for only two variables: the nasal tip to y-axis and the upper lip to x-axis (paired *t*-test).

The skeletal and dental changes in the subgroups are summarized in Table 2. The mean differences in horizontal repositioning of the maxilla between the groups were not statistically significant, while the mandible was set back significantly more in the patients with lip-block compared with the open-bite patients ($P =$ .009 at B-point, $P =$ .001 at Pg). In the open-bite patients there was significant upward movement of the lower incisors ($P =$ .000) and the chin at Me ($P =$ .002). This was not observed in the other groups.

Soft Tissue Changes

The variation in horizontal soft tissue changes for the total sample is illustrated in Figure 3. For the soft tissue A-point and the upper lip (Ls) the changes were less than 2 mm in half of the patients. The majority of individuals showed posterior movement of 4 mm or more for mandibular soft tissue landmarks. The mean pre- and postoperative characteristics of the soft tissues and mean changes resulting from surgery appear in Table 3. Preoperatively there were statistically significant differences between the groups for the nasolabial angle ($P =$ .005), the mentolabial angle ($P =$ .020), and upper ($P =$ .002) and lower ($P =$ .000) lip thickness, while postoperatively there were no statistically significant differences. Upper lip thickness remained about the same in the open-bite group, whereas a significant decrease took place in the other groups, particularly in the lip-block group (mean, -4.2 mm). Even if the forward movement of the maxilla was the same in both groups with a positive overbite, the majority (62%) of the patients in the lip-block group had less than 2 mm change in the upper lip, whereas most patients (67%) without lip-block had a forward change of more than 2 mm. In the open-bite group the mentolabial angle was on average significantly reduced.

Relationships Between Soft Tissue and Hard Tissue Changes

The correlation coefficients and ratios (in percent) for the soft and hard tissue changes are presented in

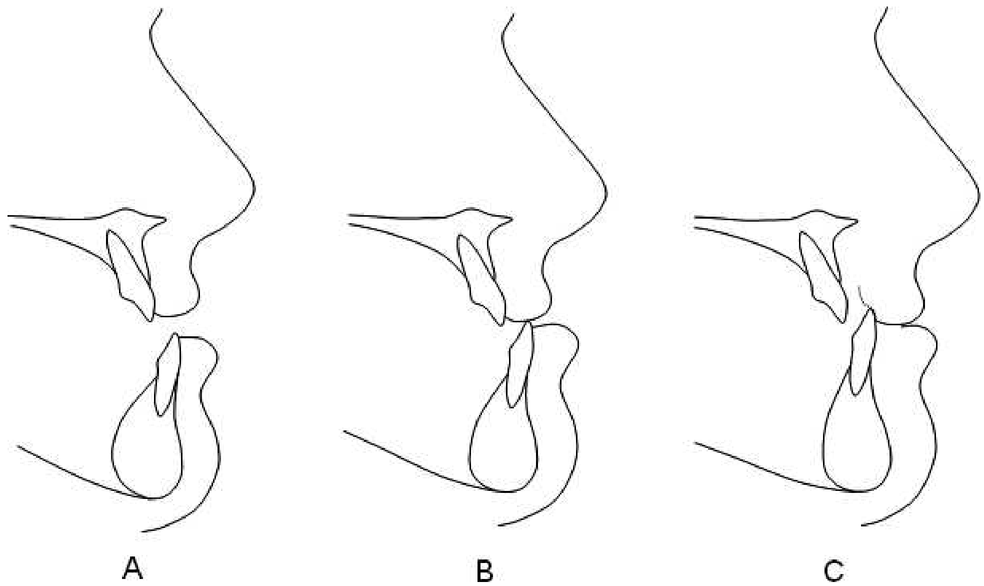

Figure 2. Schematic illustration of incisor and lip relationships in three subgroups. (A) Open-bite group; (B) Positive overbite group, upper lip resting on the upper incisors; (C) Lip-block group having positive overbite and the upper lip resting on the lower incisors.

Table 4. These changes were in general highly correlated, except for the upper lip to upper incisors in the lip-block group (the only correlation coefficient below 0.50).

Soft tissue A-point and upper lip. The landmarks followed the horizontal maxillary changes at a rate of about 50% except for the upper lip in the lip-block group (ratio 12%). From the regression analysis (Table 5) it appeared that the variables included in the final model explained 68% of the horizontal change in the upper lip. A significant negative association was observed between upper lip thickness and upper lip change, indicating that thinner lips tended to move more than did thicker lips.

Lower lip and chin. In the patients in the open-bite and positive overbite groups soft tissue B-point followed the mandibular setback at a higher ratio compared to lower lip and soft tissue Pg, contrary to the corresponding soft tissue changes in the lip-block group. The response of the soft tissue chin relative to Pg differed between the subgroups, and the ratios varied from 77% in the positive overbite group to 146% in the lip-block group. Soft tissue Me followed the upward movement of the mandible at a rate close to 1:1 in all groups. The regression models explained 85% and 97% of the variation in the horizontal change of the lower lip and soft tissue chin, respectively (Table 5).

Tip of the nose. Maxillary advancement was associated with forward and upward movement of the tip of nose in all subgroups (ratios between 20% and 30%). The variables included in the final regression models explained 53% of the variation in vertical change of tip of the nose.

DISCUSSION

While conventional orthodontic treatment is accompanied by gradual and continuous soft tissue adaptations, orthognathic surgery produces sudden and often

Table 2. Horizontal and Vertical Skeletal and Dental Changes (mm) in Subgroups as a Result of Surgery (T1 to T2). Mean Value and 1 Standard Deviation (SD)[a]

	Open-Bite Group (n = 55)		Positive Overbite Group (n = 12)		Lip-Block Group (n = 13)	
	Mean	SD	Mean	SD	Mean	SD
ANS vertically	0.6	3.1	−0.5	2.9	−0.6	2.9
A-point horizontally	3.3***	2.6	4.8***	2.2	4.1***	1.8
Upper incisors horizontally	2.8***	3.6	4.8***	3.1	4.8***	2.2
Upper incisors vertically	1.1*	3.2	−0.3	3.1	−0.5	2.4
Lower incisors horizontally	−5.6***	3.9	−7.0***	4.1	−7.8***	2.9
Lower incisors vertically	−4.4***	4.1	−0.7	5.0	0.6	2.5
B-point horizontally	−5.0***	4.7	−7.3**	5.4	−9.3***	3.8
Pg horizontally	−3.7***	5.8	−7.7**	6.6	−10.6***	5.5
Me vertically	−3.5***	3.9	−0.1	4.9	0.1	2.8

[a] Paired *t*-test for surgical change (T1 to T2): * $P \leq .05$; ** $P \leq .01$; *** $P \leq .001$. Positive value indicates forward and downward movement; negative value indicates backward and upward movement.

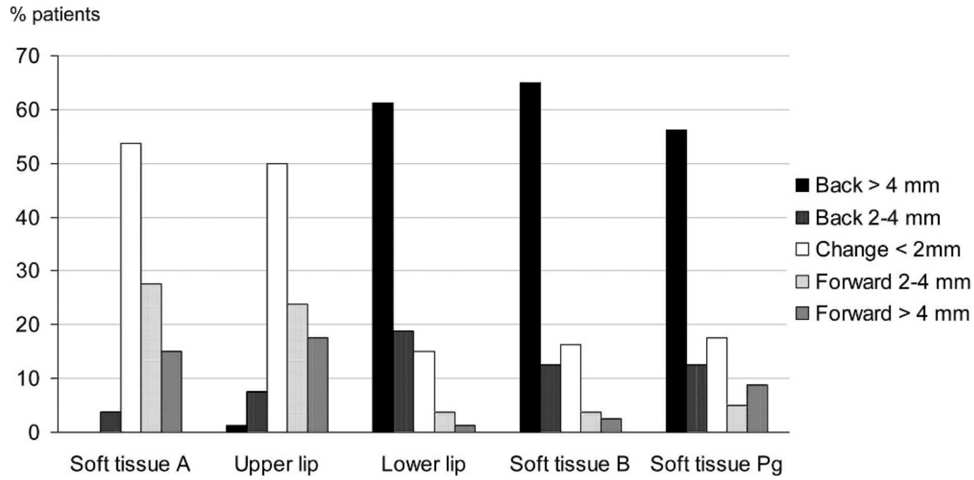

Figure 3. Distribution of individuals (%) according to soft tissue change (n = 80).

dramatic change requiring rapid integration of the new facial features into the patient's body image.[1] Therefore, the present study analyzes the short-term soft tissue changes, and the rationale for recording changes 2 months after surgery was based on the assumption that most of the postoperative swelling had been resolved by then.[4] Kau et al.[21] observed that 1 month after bimaxillary surgery the soft tissues had obtained 82% of the contour they had 6 months after surgery, and during the following 2 months they changed only by 6%. Potential relapse of the surgical correction might still not be fully expressed, but it was assumed to be moderate.[21] The long-term response will be addressed in a future study. The variability in soft tissue changes (Figure 3) likely reflects the difference in the initial skeletal morphology and, accordingly, the skeletal changes as well. This supports the establishment of subgroups based on vertical incisor relationship.

Except for the group with lip-block, the ratio for the forward movement of the upper lip was 0.5:1, which is in line with reports from other studies[13,15,17–19] of Class III bimaxillary surgery. Stella et al.[8] have suggested that in some cases an air pocket could be present between the maxillary dentoalveolar structures and the upper lip mucosa, and they proposed that maxillary advancement into this "dead space" would not result in a change in the soft tissue contours. This is in accordance with the observations in our subsample with lip-block, in which advancement of the maxilla did not affect the upper lip to any extent. Soncul and Bamber[17] found that in a sample with large maxillary advancement, the ratio for the vermillion landmark was small. This finding and previous reports[8,13] on weak correlations between hard and soft tissue changes in patients recorded as having thick upper lips could indirectly indicate the presence of a "dead space." It is noteworthy that upper lip thickness was reduced by 4.2 mm in the lip-block group, in contrast to 0.5 mm in the open-bite group. The validity of the landmarks used to define upper lip thickness (distance from Labrale superius to upper incisor) may be questioned when applied to patients with lip-block or "dead space." Accordingly, patients with lip-block were excluded in the regression analysis with the upper lip as dependent variable.

Previous reports[2–4] have indicated that mandibular setback might have an effect on the upper lip. This effect may have influenced the result in the non–open-bite groups, in particular, having greater setbacks and to some extent disguised the effect of the maxillary advancement. This is one of the factors that may explain low soft to hard tissue ratios for the upper lip reported in

Table 3. Pre- (T1) and Postoperative (T2) Soft Tissue Characteristics and Mean Differences (T1 to T2) in Subgroups. Mean Values and 1 Standard Deviation (SD) in Parentheses[a]

	Open-Bite Group (n = 55)			Positive Overbite Group (n = 12)			Lip-Block Group (n = 13)		
	T1	T2	T1 to T2	T1	T2	T1 to T2	T1	T2	T1 to T2
Nasiolabial angl, °	110.6 (14.4)	110.1 (14.5)	−0.5 (8.9)	96.9 (28.9)	102.6 (19.2)	5.7 (14.7)	96.8 (12.2)	105.8 (10.7)	9.0** (8.8)
Mentolabial angle, °	149.3 (12.8)	130.8 (11.9)	−18.5*** (11.5)	146.9 (12.9)	140.1 (9.8)	−6.8 (10.9)	138.1 (11.9)	135.4 (13.3)	−2.7 (7.4)
Upper lip thickness, mm	19.4 (3.1)	18.9 (2.3)	−0.5 (2.3)	20.5 (2.9)	17.8 (1.9)	−2.7*** (1.9)	23.0 (3.9)	18.8 (2.5)	−4.2*** (2.9)
Lower lip thickness, mm	13.7 (2.3)	17.3 (2.0)	3.6*** (2.2)	16.0 (3.1)	17.9 (2.8)	1.9* (2.2)	17.1 (2.1)	17.6 (1.7)	0.5 (1.5)
Upper lip length, mm	27.4 (3.3)	26.7 (3.6)	−0.7* (2.4)	25.9 (5.2)	27.1 (5.4)	1.2 (3.2)	27.2 (4.0)	26.7 (4.3)	−0.5 (2.3)

[a] Upper lip thickness = distance from Ls to U1; lower lip thickness = distance from Li to L1; Upper lip length = distance from Sn to Stm^s. Significant difference between T1 and T2: * $P \leq .05$; ** $P \leq .01$; *** $P \leq .001$.

Table 4. Correlation Coefficients and Ratios for Soft to Hard Tissue Changes (%) in Subgroups. Ratios Are Calculated from 5% Trimmed Mean[a]

		Open-Bite Group (n = 55)		Positive Overbite Group (n = 12)		Lip-Block Group (n = 13)	
Hard Tissue	Soft Tissue	Pearson Correlation	Ratio, %	Pearson Correlation	Ratio, %	Pearson Correlation	Ratio, %
Horizontal							
A-point	Soft tissue A-point	0.71**	47	0.97**	53	0.50	55
Upper incisors	Upper lip	0.77**	56	0.85**	53	0.36	12
Lower incisors	Lower lip	0.90**	73	0.97**	77	0.90**	102
B-point	Soft tissue B-point	0.97**	111	0.98**	107	0.97**	96
Pg	Soft tissue Pg	0.98**	99	0.99*	77	1.00**	146
Vertical							
Upper incisors	Upper lip	0.58**	38	0.55	130	0.59*	57
Upper incisors	Stomion superius	0.75**	47	0.70*	54	0.77**	33
Lower incisors	Lower lip	0.66**	−7	0.84**	57	0.83**	111
Me	Soft tissue Me	0.95**	103	0.97**	102	0.86**	111

* $P \leq .05$; ** $P \leq .01$.

some bimaxillary studies[13,19,20] compared to ratios for isolated maxillary advancement.[6,10,11] This assumption was supported by the regression analysis, which revealed that the upper lip position was positively correlated with movement of the lower incisors.

Except for the lip-block group, the present results were in agreement with those of previous studies[3,5,13,16,17] reporting higher ratios for B-point than for lower incisors and Pg. The observed effect on the contour of the chin (decrease of mentolabial angle) when the mandible was repositioned upward (open-bite group) is in accordance with the findings of a study of Marşan et al.,[20] who reported a correlation between an increase in the depth of the mentolabial fold and a decrease in the lower facial height.

Most software prediction programs use a ratio of 1:1 for the lower lip, but this was observed only for the lip-block group. In this group the lips were in contact both before and after surgery. In the other groups the lower lip rested on the lower incisors prior to surgery, while after surgery it was supported by the upper incisors. As a consequence, approximately 25% less lip response to lower incisor movement was recorded in those groups, which corresponds to most previous studies of bimaxillary surgery.[13,17,19] Software programs for prediction of soft tissue changes should therefore take into account the impact of varying incisor vertical relationships.[22]

CONCLUSIONS

- The upper lip response was influenced by the amount of movement of the upper incisors in addition to preoperative upper lip thickness. The distance between the upper lip and the upper incisors decreased significantly more in patients with lip-

Table 5. Result from Regression Analyses

Dependent Variable	Independent Variables with Significant Effect (Movement = Surgical Repositioning)	*P* Value	Explanation by the Regression Model of the Variation in the Dependent Variable %
Tip of the nose, vertical change	A-point, horizontal movement	.011	53
	ANS, vertical movement	.000	
Upper lip, horizontal change*	Upper lip thickness	.028	68
	Upper incisor, horizontal movement	.000	
	Lower incisor, horizontal movement	.035	
Lower lip, horizontal change	Lower incisor, horizontal movement	.000	85
	Upper incisor, horizontal movement	.037	
	Presurgical overbite	.000	
Soft tissue chin, horizontal change	Pg, horizontal movement	.000	97
	Me, vertical movement	.005	

* Patients with upper lip-block were excluded because the increased distance between upper incisors and Labrale superius might conceal the effect of surgery.

Variables with non-significant association with the dependent variable and therefore excluded in the final regression model for the various dependent variables:

Tip of the nose, vertical change: age, gender, horizontal and vertical movement of mandible

Upper lip, horizontal change: age, gender, vertical movement of upper and lower incisors, presurgical overjet and overbite

Lower lip, horizontal change: age, gender, vertical movement of upper and lower incisors, presurgical overjet

Soft tissue chin, horizontal change: age, gender, presurgical overjet and overbite.

block compared to the other groups, and in this group the upper lip change was particularly unpredictable.

- In the mandible, the associations between the soft and hard tissue changes were strong in all subgroups. The contour of the soft tissue chin was influenced by the vertical movement of the mandible which varied between the groups.
- Landmarks generally used to describe upper lip thickness should be redefined for patients with lip-block.

REFERENCES

1. Kiyak HA, McNeill RW, West RA, Hohl T, Bucher F, Sherrick P. Predicting psychologic responses to orthognathic surgery. *J Oral Maxillofac Surg*. 1982;40:150–155.
2. Gjorup H, Athanasiou AE. Soft tissue and dentoskeletal profile changes associated with mandibular setback osteotomy. *Am J Orthod Dentofacial Orthop*. 1991;100:312–323.
3. Gaggl A, Schultes G, Karcher H. Changes in soft tissue profile after sagittal split ramus osteotomy and retropositioning of the mandible. *J Oral Maxillofac Surg*. 1999;57:542–546.
4. Mobarak KA, Krogstad O, Espeland L, Lyberg T. Factors influencing the predictability of soft tissue profile changes following mandibular setback surgery. *Angle Orthod*. 2001;71:217–227.
5. Iizuka T, Eggensperger N, Wilke S, Seto I, Thüer U. An alternative soft tissue analysis following mandibular setback by sagittal split ramus osteotomy. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2005;100:1–8.
6. Freihofer H-PM Jr. The lip profile after correction of retromaxillism in cleft and non-cleft patients. *J Maxillofac Surg*. 1976;4:136–141.
7. Rosen HM. Lip-nasal aesthetics following Le Fort I osteotomy. *Plast Reconstr Surg*. 1988;81:171–179.
8. Stella JP, Streater MR, Epker BN, Sinn DP. Predictability of upper lip soft tissue changes with maxillary advancement. *J Oral Maxillofac Surg*. 1989;47:697–703.
9. Hui E, Hägg EU, Tideman H. Soft tissue changes following maxillary osteotomies in cleft lip and palate and non-cleft patients. *J Craniomaxillofac Surg*. 1994;22:182–186.
10. Peled M, Ardekian L, Krausz AA, Aizenbud D. Comparing the effects of V-Y advancement versus simple closure on upper lip aesthetics after Le Fort I advancement. *J Oral Maxillofac Surg*. 2004;62:315–319.
11. Carlotti AE Jr, Aschaffenburg PH, Schendel SA. Facial changes associated with surgical advancement of the lip and maxilla. *J Oral Maxillofac Surg*. 1986;44:593–596.
12. Schendel SA, Williamson LW. Muscle reorientation following superior repositioning of the maxilla. *J Oral Maxillofac Surg*. 1983;41:235–240.
13. McCollum AGH, Dancaster JT, Evans WG, Becker PJ. Sagittal soft-tissue changes related to the surgical corrections of maxillary-deficient Class III malocclusions. *Semin Orthod*. 2009;15:172–184.
14. Jensen AC, Sinclair PM, Wolford LM. Soft tissue changes associated with double jaw surgery. *Am J Orthod Dentofacial Orthop*. 1992;101:266–275.
15. Lin SS, Kerr WJS. Soft and hard tissue changes in Class III patients treated by bimaxillary surgery. *Eur J Orthod*. 1998;20:25–33.
16. Enacar A, Taner T, Toroglu S. Analysis of soft tissue profile changes associated with mandibular setback and double-jaw surgeries. *Int J Adult Orthod Orthognath Surg*. 1999;14:27–35.
17. Soncul M, Bamber MA. Evaluation of soft tissue changes with optical surface scan after surgical correction of Class III deformities. *J Oral Maxillofac Surg*. 2004;62:1331–1340.
18. Chew MT. Soft and hard tissue changes after bimaxillary surgery in Chinese Class III patients. *Angle Orthod*. 2005;75:959–963.
19. Altug-Atac AT, Bolatoglu H, Memikoglu UT. Facial soft tissue profile following bimaxillary orthognathic surgery. *Angle Orthod*. 2008;78:50–57.
20. Marşan G, Cura N, Emekli U. Soft and hard tissue changes after bimaxillary surgery in Turkish female Class III patients. *J Craniomaxillofac Surg*. 2009;37:8–17.
21. Kau CH, Cronin A, Durning P, Zhurov AI, Sandham A, Richmond S. A new method for the 3D measurement of postoperative swelling following orthognathic surgery. *Orthod Craniofac Res*. 2006;9:31–37.
22. Jakobsone G, Stenvik A, Sandvik L, Espeland L. Three-year follow-up of bimaxillary surgery to correct skeletal Class III malocclusion: stability and risk factors for relapse. *Am J Orthod Dentofacial Orthop*. 2011;139:80–89.
23. Chunmaneechote P, Friede H. Mandibular setback osteotomy: facial soft tissue behavior and possibility to improve the accuracy of the soft tissue profile prediction with the use of a computerized cephalometric program: Quick Ceph Image Pro: v. 2.5. *Clin Orthod Res*. 1999;2:85–98.