doi:10.25143/prom-rsu_2010-10_dts

RIGA STRADINS UNIVERSITY

Andris Ābeltiņš

CHANGES OF THE FACIAL SOFT TISSUE FOLLOWING BIMAXILLARY ORTHOGNATHIC SURGERY

(speciality – orthodontics)

Doctoral thesis

Supervisor
Doctor of Medical Science *Gundega Jākobsone*

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ESF
EIROPAS SOCIĀLAIS FONDS

The project was carried with the support of the national ESF programme "Project support for doctoral and post doctoral studies in medical sciences"

Riga, 2010

Doctoral study was performed in the Riga Stradins University Department of Orthodontics

Scientific supervisor:
Dr. med., assistant professor **Gundega Jākobsone**

Approved reviewers:
Dr.med., professor **Rūta Care**
Dr. habil. med., professor **Aleksandrs Zaķis**
Dr. med., professor **Antanas Šidlauskas**

The defense of the Doctoral thesis will take place on the 22nd December, 2010, at 5.00 p.m. in an open session in the Hippocrates lecture-hall of Rīga Stradiņs University, Dzirciema st. 16

The Promotion Paper is available at the library of Rīga Stradiņš University.

Secretary of the Promotion Council:
Dr. hab. med., professor *Ingrīda Čēma*

INTRODUCTION

Skeletal class III is a malocclusion, that may affect speech, eating and cause psychological disorders, and diminish social skills of a person. Skeletal Class III may be characterized by maxillary retrusion, mandibular protrusion or combination of both. Patients with this severe malocclusion where sagittal unconformity and vertical discrepancy of both jaws are the most pronounced are referred to bimaxillary surgery. In Latvia every year approximately 35 orthognathic surgeries are performed, 25 of which are bimaxillary surgeries. Due to frequently changing funding from State budget and changes in funding requirements for these patients, in majority of cases these patients should pay themselves for x-ray examinations during post-surgery period. Some patients are living relatively far away and after the end of active treatment they are losing motivation for follow-up examinations. Pre-surgery, post-surgery (within 1 month post-surgery) and midterm (1 year post-surgery) x-ray images were available for only 51 patients who have undergone bimaxillary orthognathic surgery during the period 1997 -2007. All these patients had undergone maxillary Le Fort I advancement osteotomy and two types of mandibular osteotomies. 30 patients had undergone vertical ramus osteotomy, and 21 patients – bilateral sagittal split osteotomy.

The study was performed to compare hard tissue stability of both surgical techniques, and the same stability was found. Since only midterm data on Latvian population is available, it was important to determine is there any difference between short-term and long-term soft and hard tissue movements. It was done with kind help of the University of Oslo that offered radiological data for common research. Therefore, patient data from the University of Oslo were used in this research, and with methodological adjustment these finding will be compared, adopted and used for needs of patients in Latvia.

Relevance of the doctoral thesis

Even the effect of soft tissue on development of dentofacial anomalies is widely recognized, there is no research results published regarding significant impact of soft tissue on relapse rate after orthognathic surgery. Desired treatment result includes two components – functional and aesthetic, and both are significantly affected by impact of facial and neck soft tissues. The proportion of bimaxillary orthognathic surgery is very high, yet number of studies on soft tissue following this surgery is rather small with small cohort size and heterogenous groups. There is no information about impact of hard tissue relapse on soft tissues, about effect of soft tissue thickness on surgery outcomes. All these factors play an important role as prognostic factors for bimaxillary surgery long-term outcomes, even before treatment onset. Therefore, it may prevent possible misunderstanding after the surgery and allow for a more accurate and thoughtful treatment.

Novelty of the doctoral thesis

Short-term and long-term soft tissue changes were determined following orthognathic bimaxillary surgery and taking into account hard tissue relapse. Differences between soft and hard tissue movement by gender and the effect of soft tissue thickness on improvement of facial aesthetics were assessed.

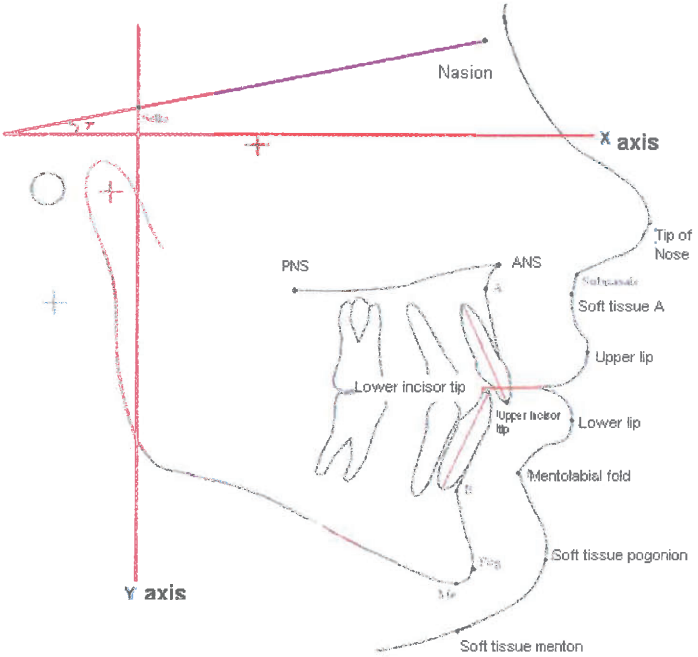
The aims of the doctoral thesis

1) To determine soft tissue movement ratio against hard tissue movement due to orthognathic surgery.
2) To assess post-surgical soft tissue changes in relation to hard tissue relapse.
3) To assess relationship between different direction of surgical maxillary movement and soft tissue changes.
4) To evaluate effect of soft tissue thickness on soft tissue movements.
5) To evaluate difference in soft tissue movement by gender.

MATERIAL AND METHODS

The study population included 83 skeletal Class III patients (29 females and 54 males) who had undergone bimaxillary orthognathic surgery with maxillary Le Fort I advancement osteotomy and mandibular setback and internal rigid fixation at the Ullevaal Hospital (University of Oslo) during the period 1990-2003. Maxillary advancement could be combined with different vertical movements. In all cases bilateral sagittal split osteotomy (BSSO) was performed for mandible. None of these patients had craniofacial syndromes, clefts and facial trauma, and no additional surgical procedures were performed. None of these patients had severe facial asymmetry. The age of patients during the surgery varied from 16.2 up to 52.2 years. Mean age was 25.8 years (SD – 9.5 years). All patients had a lateral cephalogram taken prior surgery (T0), one week post-surgery (T1), 2 months post-surgery (T2), 6 months post-surgery (T3), 1 year (T4) and 3 years post-surgery (T5). Pre-surgery and post-surgery lateral cephalograms were analyzed by the author. X and Y axis were constructed in cephalograms, where X axis was constructed at 7° angle to SN plane, and Y axis was perpendicular to X axis through point S. The analysis of hard and soft tissue movement was performed against horizontal and vertical plane. Generally accepted points were labeled in cephalograms (Figure 1), and Numerical Aquagrid digitazer (Dentofacial Software, Toronto, Canada) was used for input of these points. No adjustment for magnification (5.6%) was done. Orthognathic surgery was performed by 5 surgeons' team. All patients had undergone standard Le Fort I osteotomy. 4 L-type miniplates, two for each side were used for maxillary fixation. Plate system (Leibinger CMF Modular Wurzburg Stryker, Freiburg, Germany). Following maxillary stabilization mandibular sagittal split osteotomy was performed. Osseous segments were fixed using three bicortical screws with 2 mm diameter (Howmedica Leibinger GmbH and Co), which were inserted in the gonial area through a transcutaneous approach.

Figure 1. Cephalometric points and their description.



ANS (anterior nasal spine)- most anterior point of the bony maxilla; PNS (posterior nasal spine)- most posterior point of the bony maxilla; Sella- centre of the sella turcica; Nasion- most anterior point of frontonasal suture; A- innermost point on contour of maxilla between anterior nasal spine and incisor tooth; B- innermost point on contour of mandible between incisor tooth and bony chin; Pog (Pogonion)- most anterior point on osseous contour of chin; Me (menton)- most inferior midline point on mandibular symphesis; Tip of nose- most anterior and prominent point of nose; Subnasale- point at which columella merges with upper lip in midsagital plane; Soft tissue A- point of greatest concavity in middle of upper lip between subnasale and labrale superius; Lower lip- most anterior point of upper lip; Lower lip- most anterior point of lower lip; Mentolabial fold- point of greatest concavity in midline of lower lip between labrale inferius and soft tissue pogonion; Soft tissue pogonion- most prominent point on chin in midsagittal plane; Soft tissue menton- lowest point on contour of soft tissue chin.

Relation between soft and hard tissues by changes of vertical facial dimension

Soft tissue movement in relation to hard tissue movement was calculated as a proportion expressed by a percentage. Short-term relation was calculated for soft tissue movement during period T0T2 (when post-surgery edema was gone) and hard tissue movement during surgery T0T1, long-term relation was calculated for soft and hard tissues during period T0T5. Patients were divided into groups depending on how marked vertical movement against frontal facial height was performed during the surgery. Point Me was used as a reference point. Upward movement of point Me for more than 2mm (Me < 2mm) during the hard tissue surgery was considered as decreased facial vertical dimension. Thereby the first group – facial reduction group – consisting of 41 patients was formed. The second group (31 patient) was characterized by insignificant changes of vertical dimension; the movement of point Me was within range of +2mm up to -2mm. The third smallest group included 11 patients and was characterized by increased vertical facial dimension (Me > 2mm) (see Table 1).

Table 1. Characteristics of the groups according to the vertical changes during surgery

Value	All sample	Decreased facial height group	No vertical change group	Increased facial height group
Number of patients	83	41	31	11
Age (Years)	24,0 ± 7	22,0 ± 4,6	27,1 ± 9,1	26,5 ± 7,1
Gender	54 male 29 female	22 male 19 female	25 male 6 female	7 male 4 female
Overjet (mm)	-6,8 ± 5,0	-6,0 ± 5,5	-7,2 ± 4,3	-9,1 ± 4,3
Overbite (mm)	-1,9 ± 3,7	-3,4 ± 2,7	-1,0 ± 3,9	1,2 ± 3,9
SNA angle (°)	79,6 ± 3,5	79,2 ± 3,8	79,2 ± 3,2	82,1 ± 2,4
SNB angle (°)	84,7 ± 5,4	82,7 ± 5,4	85,1 ± 3,5	91,1 ± 5,1
ANB angle (°)	-5,1 ± 4,1	-3,4 ± 4,1	-6,0 ± 2,9	-9,0 ± 3,9
Mandibular plane angle (°)	35,8 ± 7,5	38, 9 ± 6,8	35,4 ± 5,2	25,6 ± 7,0

Relation between soft and hard tissues by gender

Description of the groups by gender can be found in Table 2.

Table 2. Group description according to gender.

Value	All sample	Male	Female
Number of patients	83	54	29
Age (Years)	24,0 ± 7	26,5 ± 8,0	20,8 ± 3,7
Overjet (mm)	-6,8 ± 5,0	-7,3 ± 4,4	-6,0 ± 5,9
Overbite (mm)	-1,9 ± 3,7	-1,6 ± 4,0	-2,4 ± 3,1
SNA angle (°)	79,6 ± 3,5	79,3 ± 3,7	80,0 ± 3,3
SNB angle (°)	84,7 ± 5,4	85,0 ± 5,4	84,2 ± 5,6
ANB angle (°)	-5,1 ± 4,1	-5,6 ± 4,0	-4,2 ± 4,1
Mandibular plane angle (°)	35,8 ± 7,5	35,7 ± 7,1	36,1 ± 8,5

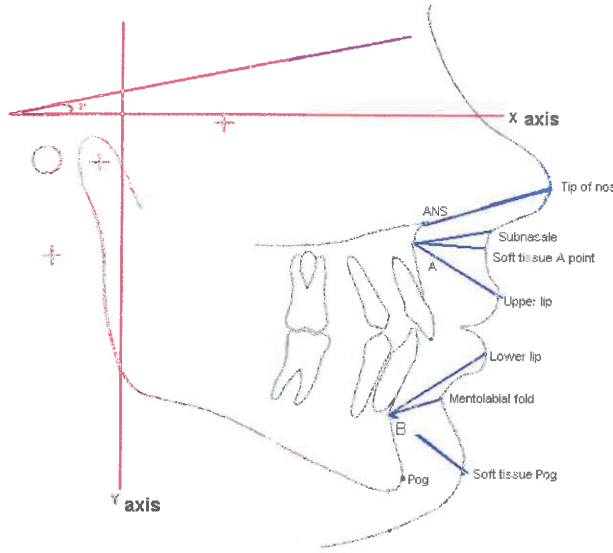
Thickness of the soft tissue

Grouping of cohort by soft tissue thickness was done by dividing cohort into two equal groups according to the mean thickness of upper lip and lower lip, and according to the distance from point ANS to the tip of the nose. Distances and points used in the measurements of soft tissue thickness are shown in Figure 2. For distribution of groups see Table 3.

Table 3. Group description according to soft tissue thicnesses.

Value	Distance from A point to soft tissue A point	Distance from B point to mentolabial fold	Distance from ANS point to tip of nose
Thin upper lip (1A)	16.1mm	12.1mm	31.1mm
Thick upper lip(2A)	20.0mm	12.9mm	33.1mm
Thin lower lip (1B)	17.3mm	11.1mm	31.8mm
Thick lower lip (2B)	18.7mm	13.9mm	32.3mm
Short nose (1C)	17.3mm	12.3mm	28.9mm
Long nose (2C)	18.7mm	12.7mm	34.9mm

Figure 2. Soft tissue thicknesses.



Statistical analysis

Descriptive statistical analysis was used for assessment of mean values and standard deviations in all groups. Difference in indicators between time periods within one group was tested using paired t-test. Independent samples t-test was used to compare two groups. More than two groups were compared by means of ANOVA analysis. Pearson correlation was used to determine correlation between soft and hard tissue movements. The error of the method was within range of 0.35 – 0.63 mm for linear measurements and within range of 0.42° - 1.30° for angular measurements. Data was processed and statistical analysis performed by means of computer software SPSS for Windows 16.0. The error of the method was calculated using Microsoft Excel.

RESULTS

Relation between soft and hard tissues in whole cohort

All short-term (during the surgery) and long-term (T0T5) hard tissue changes were with high level of statistical significance. Movements in maxilla were less than in mandible. However, standard deviation and variability in both jaws were rather high. Post-surgery (T1T5) changes of hard tissue varied. In maxilla only changes related to the changes of teeth position were observed, and these changes were in direction of the surgical movement. However, in mandible statistically significant hard tissue relapse was observed (Table 4).

Table 4. Surgical and postsurgical movements of the hard tissues in horizontal direction.

Value	Hard tissue movements (mm) T0T1 ± SD (Range)	Hard tissue movements (mm) T0T5 ± SD (Range)	Hard tissue movements (mm) T1T5 ± SN (Range)
A point	3.7** ± 2,5 (-1,8 to 9,8)	3,6** ± 2,3 (-2,5 to 8,9)	-0,1 ± 1,0 (-3,0 to2,7)
Upper incisors	2,9** ± 3,6 (-5,8 to 11,7)	3,6** ± 3,2 (-6,8 to 10,1)	0,7** ± 1,9 (-5,0 to5,8)
Lower incisors	-7,1** ± 4,1 (- 15,7 to 1,4)	-5,6** ± 4,0 (-14,8 to 3,9)	1,5** ± 1,8 (-3,1 to 8,3)
B point	-6,9** ± 5,5 (-18,3 to5,1)	-5,2** ± 4,7 (-15,8 to4,3)	1,7** ± 2,2 (-4,3 to 6,6)
Pog point	-6,6** ± 7,0 (-20,6 to 8,6)	-4,3** ± 6,2 (-18,0 to 7,7)	2,2** ± 2,5 (-4,3 to 9,1)

**- p<0,001 „+"- anterior movement
„-" – posterior movement

In case of horizontal movement of soft tissue statistically significant changes in short-term (T0T1) and long-term (T0T5) movements were observed. Yet, standard deviation was high. Soft tissue changes similarly to hard tissue changes were more pronounced in maxillary region than in mandibular region. There were no changes in a post-surgery period (T2T5) in a horizontal plane of the tip of the nose and lower lip. However, there were observed significant changes in other soft tissue points to both, surgery and opposite directions (Table 5).

Table 5. Surgical and postsurgical movements of the soft tissues in horizontal direction.

Lielums	Soft tissue movement (mm) T0T2 ± SN (Range)	Soft tissue movement (mm) T0T5 ± SN (Range)	Soft tissue movement (mm) T2T5 ± SN (Range)
Tip of nose	0,8** ± 1,0 (-1,3 to 4,1)	0,9** ± 1,0 (-1,3 to 4,8)	0,1 ± 1,0 (-2,9 to 2,4)
Subnasale	1,3** ± 1,7 (-2,4 to 5,9)	0,9** ± 1,5 (-2,2 to 5,0)	0,4** ± 1,0 (-3,1 to 1,6)

Soft tissue A point	1,7** ± 2,4 (- 3,9 to 8,6)	1,4** ± 2,2 (-4,1 to 8,2)	0,5** ± 1,0 (-3,1 to 2,8)
Upper lip	1,5** ± 2,8 (-4,8 to 8,7)	1,0** ± 2,7 (-4,3 to 9,0)	-0,6** ± 1,4 (-4,7 to 2,2)
Lower lip	-5,1** ± 4,1 (-14,5 to 5,5)	-5,1** ± 4,0 (-14,1 to 5,2)	-0,2 ± 1,7 (-5,0 to 3,3)
Mentolabial fold	-6,3** ± 4,9 (-16,7 to 4,6)	-5,4** ± 4,7 (-15,9 to 4,1)	0,8** ± 1,5 (-3,0 to 4,6)
Soft tissue pogonion	-5,4** ± 6,4 (-20,0 to 8,8)	-3,6** ± 6,1 (-17,2 to 7,6)	1,7** ± 2,0 (-1,8 to 6,8)
Soft tissue menton	-4,8** ± 7,4 (-22,6 to 10,2)	-3,5** ± 7,2 (-20,3 to 10,2)	1,1** ± 2,5 (-3,6 to 7,5)

**- p<0,001 „+"- anterior movement
„-" – posterior movement

There were small changes in a vertical movement of hard tissues. Hard tissue changes during the surgery and during log-term period were characterized by minor decrease of mandibular frontal facial height, and no such changes were observed in maxilla. Only minor maxillary incisor extrusion was observed. During post-surgery (T1T5) small and statistically significant changes were observed, indicating further facial reduction in a mandibular region and minor vertical relapse in a maxillary region (Table 6).

Table 6. Surgical and postsurgical movements of the hard tissues in vertical direction.

Value	Hard tissue movements (mm) T0T1 ± SD (Range)	Hard tissue movements (mm) T0T5 ± SD (Range)	Hard tissue movements (mm) T1T5 ± SN (Range)
A point	0,7 ± 3,7 (-6,7 to 10,0)	0,0 ± 3,0 (-7,0 to 8,7)	-0,8** ± 1,9 (-6,1 to 4,5)
Upper incisors	1,4** ± 3,7 (-7,3 to 10,2)	0,4 ± 3,0 (-8,9 to 8,0)	-1,1** ± 2,0 (-7,3 to 1,8)
Lower incisors	-1,7** ± 5,4 (-11,9 to 11,8)	-2,8** ± 4,2 (-11,8 to 8,6)	-1,1** ± 2,6 (-12,6 to 4,7)
B point	-1,7** ± 5,0 (-9,6 to 12,5)	-2,2** ± 4,4 (-11,9 to 13,1)	-0,6* ± 2,5 (-9,3 to 5,8)
Pog point	-1,6** ± 5,0 (-11,1 to 12,7)	-2,4** ± 3,5 (-9,5 to 8,5)	-0,8 **± 2,6 (-11,4 to 4,6)

**- p<0,001 * - p<0,05 „+" – Downward movement
„-" – Upward movement

Soft tissue changes had a greater variability than hard tissue changes. During short-term (T0T1) period minor elevation of the tip of the nose with following relapse during post-surgery period and descending upper lip that progressed also during post-surgery period. In a short-term period lower lip showed downward movement with further decrease. Maxillary soft tissue showed persistent upward movement with a minor relapse in sub mental area (Table 7).

Table 7. Surgical and postsurgical movements of the soft tissues in vertical direction.

Lielums	Soft tissue movement (mm) T0T2 ± SN (Range)	Soft tissue movement (mm) T0T5 ± SN (Range)	Soft tissue movement (mm) T2T5 ± SN (Range)
Tip of nose	-0,7** ± 1,7 (-6,3 to 3,8)	-0,3 ± 1,7 (-5,4 to 4,2)	0,4** ± 1,1 (-2,7 to 4,0)
Subnasale	-0,2 ± 1,4 (-5,3 to 3,5)	0,0 ± 1,3 (-4,1 to 3,6)	0,2* ± 1,0 (-2,1 to 3,5)
Soft tissue A point	0,0 ± 1,9 (- 5,8 to 3,7)	0,2 ± 1,9 (-6,0 to 3,9)	0,2 ± 1,2 (-2,4 to 3,2)
Upper lip	0,9** ± 2,6 (-5,6 to 8,9)	1,2** ± 2,4 (-4,4 to 8,4)	0,3* ± 1,4 (-4,4 to 4,8)
Lower lip	1,2* ± 4,7 (-15,1 to 12,5)	0,5 ± 4,5 (-13,5 to 11,2)	-0,6* ± 2,1 (-5,7 to 6,4)
Mentolabial fold	-1,6** ± 4,7 (-11,3 to 10,5)	-1,5** ± 3,9 (-9,2 to 8,9)	0,2 ± 2,5 (-5,8 to 5,8)
Soft tissue pogonion	-1,8** ± 5,3 (-14,1 to 13,4)	-1,9** ± 4,4 (-9,4 to 9,8)	0,0 ± 2,2 (-6,2 to 7,0)
Soft tissue menton	-2,1** ± 4,6 (-10,5 to 12,2)	-1,8** ± 4,0 (-10,5 to 10,8)	0,4** ± 2,0 (-5,3 to 5,1)

**- p<0,001 * - p<0,05 „+" – Downward movement
„-" – Upward movement

Horizontal soft tissue movement against hard tissue movements in a horizontal and vertical direction in a maxillary and nose region is shown in a Table 8. In all cases level of statistical significance was very high (p<0,001). Correlation between soft tissue and hard tissue movements in a horizontal direction was strong or moderate.

Table 8.Soft to hard tissue short and long term ratios in maxillary region. Horizontal movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Tip of nose to A point horizontal movement	17%	0,62	24%	0,54
Tip of nose to A point vertical movement	27%	-0,35	27%	-0,40
Subnasale to A point horizontal movement	27%	0,61	35%	0,54
Soft tissue A point to A point horizontal movement	30%	0,7	35%	0,65
Upper lip to A point horizontal movement	18%	0,57	51%	0,59
Upper lip to upper incisors horizontal movement	11%	0,72	39%	0,65

R- Coefficient of correlation.
All correlations p<0,001

However, correlation between soft tissue vertical movement and hard tissue movements in a vertical and horizontal direction was weaker. Correlation between soft tissue and hard tissue vertical movements was moderate. Rather high difference between tissue movements in a short-term and long-term period was observed (Table 9).

Table 9. Soft to hard tissue short and long term ratios in maxillary region. Vertical movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Tip of nose to A point vertical movement	2%	0,43	7%	0,37
Tip of nose to A point horizontal movement	9%	-0,54	2%	-0,51
Subnasale to A point vertical movement	4%	0,48	59%	0,42
Soft tissue A point to A point vertical movement	29%	0,48	70%	0,47
Upper lip to A point vertical movement	9%	0,52	71%	0,42
Upper lip to upper incisors vertical movement	45%	0,62	77%	0,46

R- Coefficient of correlation.
All correlations $p<0,001$

Very strong correlation was observed between soft tissue horizontal movement and hard tissue horizontal movement in a maxillary area. In some cases these movements were almost directly related. Sometimes there were rather substantial differences between short-term and long-term relations (Table 10).

Table 10. Soft to hard tissue short and long term ratios in mandibular region. Horizontal movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Lower lip to lower incisor horizontal movement	73%	0,88	57%	0.90
Lower lip to B point horizontal movement	105%	0,89	82%	0,92
Mentolabial fold to B point horizontal movement	106%	0,93	67%	0,97
Soft tissue pogonion to Pog point horizontal movement	112%	0,95	88%	0,98
Soft tissue menton to Me point horizontal movement	65%	0,91	102%	0,95

R- Coefficient of correlation.
All correlations $p<0,001$

Soft tissue and hard tissue vertical movement data showed in a Table 11 represented strong correlation in short-term and long-term period, and also in this case there were rather substantial differences between short-term and long-term period for both tissues.

Table 11. Soft to hard tissue short and long term ratios in mandibular region. Vertical movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Lower lip to lower incisor vertical movement	73%	0,74	80%	0.66
Lower lip to B point vertical movement	94%	0,76	27%	0,70
Mentolabial fold to B point vertical movement	109%	0,85	49%	0,80
Soft tissue pogonion to Pog point vertical movement	144%	0,84	135%	0,89
Soft tissue menton to Me point vertical movement	105%	0,92	124%	0,92

R- Coefficient of correlation.
All correlations $p<0,001$

Soft tissue and changes in vertical facial dimension

Relation between soft and hard tissues in a facial reduction group

The facial reduction group included 41 patients; it was biggest group categorized by the changes of vertical facial dimension. All movements during surgery were statistically significant; all long-term movements, except movement of Pog point, also were statistically significant. Mean maxillary movements were higher and mandibular movements smaller than in whole cohort. In a post-surgery period minor statistically significant relapse was observed in A point. However, no changes in relation to maxillary incisors were observed. Rather substantial and statistically significant hard tissue relapse was observed in mandible.

Regarding horizontal soft tissue changes there were statistically significant short-term and long-term movements in area of nose, lips and mentolabial fold. However, there were no statistically significant soft tissue movements during surgery and in a long-term period in a mental and sub mental area. In post-surgery period there were almost no soft tissue changes in a tip of the nose, lower lip and sub mental area. Minor, yet statistically significant relapse was observed for a maxillary, mentolabial fold and mental area.

Vertical hard tissue movement in this group was, as expected, with upward vector. For maxilla these changes were minor and statistically significant in point A during surgery and in long-term period. However, there were no statistically significant changes in vertical plane for mandible. There were no statistically significant hard tissue upward movements for mandible. No vertical relapse was observed in a post-

surgery period in maxillary area. Minor relapse was observed only in point Me for mandible.

In a short-term and long-term period soft tissue changes in both jaws were related to the decrease of facial height. In a short-term and long-term period statistically significant soft tissue changes were observed in the area of the tip of the nose, point Sn and base of upper lip. There were no changes in the upper and lower lip area in a short-term period. However, there were minor changes in lower lip area and no changes in upper lip area in a long-term period. There were substantial and statistically significant soft tissue changes in area of mentolabial sulcus, mental and submental are after short-term and long-term period. Statistically significant relapse was observed in a post-surgery period for point Sn, upper lip, mentolabial sulcus and mental and submental soft tissue area. The relapse observed was minor.

Relationship between maxillary and nasal soft tissue horizontal movement and hard tissue movements are shown in Table 12. All correlations were statistically significant. Correlation between soft tissue movement and hard tissue movements was moderate or strong. There were no statistically significant differences in this group between short-term and long-term results when comparing soft tissue horizontal movement and hard tissue horizontal movement, except for relation between upper lip and incisors.

Table 12. Soft to hard tissue short and long term ratios in maxillary region. Horizontal movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Tip of nose to A point horizontal movement	25%	0,69	33%	0,53
Tip of nose to A point vertical movement	34%	-0,33	22%	-0,35
Subnasale to A point horizontal movement	34%	0,64	52%	0,53
Soft tissue A point to A point horizontal movement	55%	0,77	56%	0,73
Upper lip to A point horizontal movement	55%	0,72	87%	0,74
Upper lip to upper incisors horizontal movement	8%	0,80	63%	,80

R- Coefficient of correlation.
All correlations $p<0,001$

Relationship between maxillary and nasal soft tissue vertical movement and hard tissue movements are shown in Table 13. Correlation between soft tissue vertical movements was weak and sometimes even not statistically significant. Relation between soft tissue and hard tissue movements in majority of cases was small or none.

Table 13. Soft to hard tissue short and long term ratios in maxillary region. Vertical movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Tip of nose to A point vertical movement	0%	0,47	11%	0,31*
Tip of nose to A point horizontal movement	31%	-0,46	28%	-0,40
Subnasale to A point vertical movement	0%	0,36*	30%	NS
Soft tissue A point to A point vertical movement	64%	0,41*	36%	0,44
Upper lip to A point vertical movement	22%	0,45	44%	0,35*
Upper lip to upper incisors vertical movement	40%	0,50	94%	0,40*

R- Coefficient of correlation.
P< 0,001; *- p<0,05; NS- not significant.

Soft tissue horizontal movement in relation to hard tissue movement for mandibular area is shown in Table 14. There were strong correlations and in some cases almost direct relationship in all relations where soft and hard tissue horizontal movements were compared. Relationship between soft tissue and hard tissue in a horizontal plane was different with decreasing trend in a short-term period, except for a soft tissue in a sub mental area.

Table 14. Soft to hard tissue short and long term ratios in mandibular region. Horizontal movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Lower lip to lower incisor horizontal movement	62%	0,86	36%	0.87
Lower lip to B point horizontal movement	144%	0,88	103%	0,90
Mentolabial fold to B point horizontal movement	134%	0,93	83%	0,97
Soft tissue pogonion to Pog point horizontal movement	112%	0,94	78%	0,98
Soft tissue menton to Me point horizontal movement	81%	0,84	109%	0,92

R- Coefficient of correlation.
All correlations p<0,001

Summary of the relation between soft tissue vertical movement and hard tissue movement is described in Table 15. In this group strong, moderate and sometimes weak correlation was observed between soft tissue and hard tissue vertical

proportions. No substantial variation between soft and hard tissue vertical relation was observed when comparing short-term and long-term data.

Table 15. Soft to hard tissue short and long term ratios in mandibular region. Vertical movements of the soft tissues

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Lower lip to lower incisor vertical movement	9%	0,42*	25%	0.49
Lower lip to B point vertical movement	25%	0,38*	14%	0,61
Mentolabial fold to B point vertical movement	79%	0,46	67%	0,62
Soft tissue pogonion to Pog point vertical movement	146%	0,45	76%	0,78
Soft tissue menton to Me point vertical movement	110%	0,71	124%	0,78

R- Coefficient of correlation.
P< 0,001; *- p<0,05.

Relation between soft and hard tissues in group without changes of vertical facial dimension

Group without changes of vertical facial dimension was second biggest group and comprised of 31 patients. Hard tissue horizontal plane movements during post-surgery and long-term period were statistically significant. Maxillary movements were similar to movements in a whole cohort. However, mandibular movement was more pronounced. In a post-surgery period no maxillary relapse was observed, and only minor, statistically significant proinclination of the incisors occurred. There was no statistically significant relapse in mandible.

All short-term and long-term soft tissue movements were statistically significant; even they did not exceed 2 mm in a maxillary and nose area. Short-term and long-term mandibular soft tissue changes were substantial with mean values reaching almost 8 mm. The soft and hard tissue movement direction completely matched. There were no changes in post-surgery period for tip of the nose and lower lip area; and statistically significant relapse less than 1 mm was observed in point Sn, soft tissue A point and upper lip area. Greater and statistically significant relapse was observed in mentolabial fold, mental and sub mental soft tissues.

Hard tissue changes in this group were, as expected, with a small movement. During the surgery minor maxillary movement downward in a point A and maxillary incisor movement downward was observed. No statistically significant mandibular vertical changes were observed during this period. During long-term period maxillary incisor movement downward and minor mandibular incisor and point Me movement upward was observed. During post-surgery period statistically significant upward movement of all hard tissues, except point A (where movement was not statistically significant), was observed.

Similarly to hard tissue movements, soft tissue movement in a vertical plane did not show great values. In short-term period substantial changes occurred only regarding tip of the nose, upper lip and lower lip. In a long-term period vertical changes related to downward movement occurred in a base of upper lip, in upper lip and lower lip. In a post-surgery period minor and statistically significant relapse for the tip of the nose was observed.

Relationship between soft tissue horizontal movement and hard tissue maxillary and nasal movements are shown in Table 16. Correlation between soft tissue and hard tissue horizontal movement was weak or moderate. In all cases, except upper lip movement in relation to horizontal movement of upper incisors, relation between soft and hard tissue was similar during short-term and long-term period.

Table 16. Soft to hard tissue short and long term ratios in maxillary region. Horizontal movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Tip of nose to A point horizontal movement	12%	0,56	19%	0,61
Tip of nose to A point vertical movement	19%	NS	111%	NS
Subnasale to A point horizontal movement	30%	0,60	28%	0,57
Soft tissue A point to A point horizontal movement	24%	0,60	29%	0,54
Upper lip to A point horizontal movement	5%	0,38*	16%	0,36*
Upper lip to upper incisors horizontal movement	100%	0,60	18%	0,50

R- Coefficient of correlation.
P< 0,001; *- p<0,05; NS- not significant.

For soft tissue vertical movement in a nose and maxillary area, the only indicator with a statistically significant and strong correlation during short-term and long-term period was vertical movement of the tip of the nose in relation to horizontal movement of point A. There was minor movement of point Sn with a moderate correlation in a short-term period, but not during long-term period. No statistical significance was found for other proportions.

In mandibular area relation between soft tissue horizontal movement and hard tissue movements was better than in maxillary area. Strong correlation close to direct proportion between all soft tissue relations and hard tissue horizontal movement was observed. In majority of cases, except mental and sub mental soft tissue movements, minor changes were observed between short-term and long-term data (Table 17).

Table 17. Soft to hard tissue short and long term ratios in mandibular region. Horizontal movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Lower lip to lower incisor horizontal movement	85%	0,86	75%	0.88
Lower lip to B point horizontal movement	71%	0,83	82%	0,90
Mentolabial fold to B point horizontal movement	82%	0,88	78%	0,97
Soft tissue pogonion to Pog point horizontal movement	125%	0,91	99%	0,96
Soft tissue menton to Me point horizontal movement	39%	0,90	90%	0,91

R- Coefficient of correlation.
All correlations $p<0,001$

Mandibular soft tissue vertical movements in relation to hard tissue movements in majority of cases were with statistically significant correlation coefficients. In almost all cases soft tissue movements were more pronounced than hard tissue vertical movements, and correlations between these relations were moderate or strong (Table 18).

Table 18. Soft to hard tissue short and long term ratios in mandibular region. Vertical movements of the soft tissues

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Lower lip to lower incisor vertical movement	146%	0,44*	207%	NS
Lower lip to B point vertical movement	167%	0,69	161%	0,43*
Mentolabial fold to B point vertical movement	150%	0,58	15%	0,59
Soft tissue pogonion to Pog point vertical movement	155%	0,59	196%	0,77
Soft tissue menton to Me point vertical movement	112%	0,52	104%	0,73

R- Coefficient of correlation.
$P< 0,001$; *- $p<0,05$.

Relation between soft and hard tissues in facial elongation group

The facial elongation group included 11 patients, and it was a smallest group. During surgery rather minor horizontal maxillary movements were observed, and no incisor movements were observed. Among all groups in this group the biggest horizontal movement in mandibular area was observed. In a long-term period statistically significant upward maxillary incisor and point A movements were observed. Overall movement (T0T5) in mandibular area was substantially smaller than during the surgery. Mainly it was related to rather high relapse in mandibular area. No horizontal relapse in point A of maxilla was observed, and incisors during post-surgery period moved forward.

No significant changes were observed in this group regarding horizontal movement in upper lip and nose area in any of time periods, except small forward movement of the tip of the nose during short-term period. In mandible soft tissue changes were substantial during short-term and long-term periods, also small, insignificant relapse was observed, except mental soft tissue where relapse was more pronounced.

Substantial hard tissue vertical movement was observed and it was related to the facial elongation during surgery. Overall movements in this group were smaller, and it was related to high relapse in both jaws. Facial elongation group was group with a highest hard tissue vertical relapse rate.

Soft tissue vertical movements in nose and upper lip area during short-term period were rather small, and for nose area even non-significant. Short-term vertical movements were substantially greater in mandible than in maxilla. In long-term period no statistically significant changes of the tip of the nose and point Sn were observed. However, the base of the upper lip and upper lip moved downward. In a long-term mandibular soft tissue vertical changes were smaller than these changes in a short-term, because soft tissues unlike hard tissue had a statistically significant relapse only in lower lip area.

Almost all relations between soft tissue horizontal movement and hard tissue movements were non-significant; and only exception with a moderate correlation were movement of point Sn in relation to vertical movement of point A in a long-term period.

Relationship between soft tissue vertical movement and hard tissue movement in different directions is described in Table 19. Strong correlation was observed in short-term changes, except area of the tip of the nose, where relation between soft tissue and hard tissue vertical movement was compared. For long-term data strong and statistically significant correlation was observed only in nose and upper lip area. These correlations were not significant for mandible in a long-term period.

Table 19. Soft to hard tissue short and long term ratios in maxillary region. Vertical movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Tip of nose to A point vertical movement	41%	NS	104%	0,75
Tip of nose to A point horizontal movement	74%	NS	57%	NS
Subnasale to A point vertical movement	47%	0,71*	51%	0,86

Soft tissue A point to A point vertical movement	59%	0,68*	24%	0,64*
Upper lip to A point vertical movement	124%	0,70*	230%	NS
Upper lip to upper incisors vertical movement	70%	0,69*	141%	NS

R- Coefficient of correlation.
P< 0,001; *- p<0,05; NS- not significant.

Very strong correlation or sometimes even direct relation was observed between mandibular soft tissue horizontal movement and hard tissue horizontal movement in a maxillary area. Substantial variation between soft and hard tissue vertical relation was observed when comparing short-term and long-term data (Table 20).

Table 20. Soft to hard tissue short and long term ratios in mandibular region. Horizontal movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Lower lip to lower incisor horizontal movement	78%	0,85	87%	0.93
Lower lip to B point horizontal movement	64%	0,78	6%	0,93
Mentolabial fold to B point horizontal movement	77%	0,94	19%	0,99
Soft tissue pogonion to Pog point horizontal movement	78%	0,87	97%	0,97
Soft tissue menton to Me point horizontal movement	80%	0,82	110%	0,95

R- Coefficient of correlation.
P< 0,001

Soft tissue mandibular vertical movement in relation to hard tissue movements showed substantial variability in proportions. In a short-term period moderate and strong correlation between all soft tissue and hard tissue vertical movements was observed. In a long-term period statistically significant strong correlation between soft tissue and hard tissue vertical movement was observed for lower lip in relation to incisors, mentolabial fold and sub mental area. Differences in proportions of mentolabial fold, mental and sub mental area data between short-term and long-term period was rather substantial (Table 21).

Table 21. Soft to hard tissue short and long term ratios in mandibular region. Vertical movements of the soft tissues

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Lower lip to lower incisor vertical movement	105%	0,62*	133%	0,82

Lower lip to B point vertical movement	122%	0,77	197%	NS
Mentolabial fold to B point vertical movement	95%	0,84	161%	NS
Soft tissue pogonion to Pog point vertical movement	104%	0,68*	189%	0,75
Soft tissue menton to Me point vertical movement	74%	0,84	179%	0,90

R- Coefficient of correlation.
P< 0,001; *- p<0,05; NS- not significant

ANOVA analysis of all three groups (facial reduction, facial elongation group and group without changes of vertical facial dimension) showed statistically significant changes for all hard tissue movements during surgery (p<0.001). The only indicator without statistically significant difference between groups was horizontal movement of point A during surgery (p=0.089).

Soft tissue and gender difference

The relationship between soft and hard tissues among males

Male group of this study included 54 patients, i.e. 65% of the study cohort. Since male group was almost 2/3 of the cohort, findings were quite similar to those of whole study cohort. For maxillary area movement forward during surgery and in a long-term period was pronounced than in whole cohort, and post-surgery changes were similar. For mandibular area all hard tissue changes were almost identical to hard tissue changes in whole cohort.

All short-term and long-term soft tissue horizontal changes were statistically significant. Changes in a nose and upper lip area were rather small, except in relation to point Sn, where they exceeded 2 mm. Soft tissue relapse also was small, not exceeding 1 mm, even for upper lip it was 47% of short-term movements. For mandible short-term and long-term changes were greater than for maxilla, and for mentolabial fold movement was 6.7 mm. Soft tissue relapse in mandibular area was small, not exceeding 2 mm, and no relapse was observed for lower lip.

In a male group there was no substantial mean vertical maxillary movement during surgery and in a long-term, because small statistically significant downward movement was observed for maxillary incisors during surgery. For maxilla small statistically significant relapse was observed. In a mandibular area small hard tissue movement upward during surgery was observed, and total movement (T0T5) almost reached 3 mm (p<0.001). In mandibular area statistically significant changes in relation to decreased facial vertical dimension were observed for incisors.

For soft tissue in a vertical direction there was statistically significant upward movement of the tip of the nose and downward movement of upper lip in a short-term and long-term period. These changes were followed by a small relapse in a tip of the nose area. In a short-term period statistically significant changes for mandibular area was observed only in relation to mental and sub mental area leading to the facial reduction. In a long-term period small upward movement for mentolabial fold was

also observed. For a mandibular area no statistically significant soft tissue changes in a post-surgery period were observed.
Relation between soft and hard tissue horizontal movements in nose and maxillary area are shown in Table 22. All measurements had a statistically significant moderate correlation in a short-term and long-term period. There was a small difference between short-term and long-term data for all proportions, except movement of upper lip in relation to maxillary incisors.

Table 22. Soft to hard tissue short and long term ratios in maxillary region. Horizontal movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Tip of nose to A point horizontal movement	22%	0,62	24%	0,63
Tip of nose to A point vertical movement	34%	0,60	42%	0,56
Subnasale to A point horizontal movement	37%	0,71	42%	0,62
Soft tissue A point to A point horizontal movement	27%	0,61	44%	0,56
Upper lip to A point horizontal movement	51%	0,72	20%	0,66

R- Coefficient of correlation.
All correlations $p<0,001$

Relation between soft and hard tissue vertical movements in maxillary and nose area was weaker than horizontal relations in the same area. Correlation between vertical movement of the tip of the nose and vertical movement of point Sn in relation to vertical movement of point A was not statistically significant, and in all other cases it was weak or moderate. Relation between soft tissue and hard tissue movements was small (Table 23).

Table 23. Soft to hard tissue short and long term ratios in maxillary region. Vertical movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Tip of nose to A point vertical movement	28%	0,30*	14%	NS
Tip of nose to A point horizontal movement	15%	-0,58	7%	-0,50
Subnasale to A point vertical movement	13%	0,35*	58%	NS
Soft tissue A point to A point vertical movement	62%	0,42	64%	0,34*

Upper lip to A point vertical movement	11%	0,47	66%	0,31*
Upper lip to upper incisors vertical movement	36%	0,60	93%	0,39

R- Coefficient of correlation.
P< 0,001; *- p<0,05; NS- not significant

Soft tissue movements in relation to hard tissue horizontal movements in mandibular area had a strong correlation, close to direct relation, for all indicators in a short-term and long-term period. Rather great difference between short-term and long-term data was observed for lower lip movement in relation to mandibular incisors and sub mental movement in relation to point Me. For the rest of the data this difference was minor (Table 24).

Table 24. Soft to hard tissue short and long term ratios in mandibular region. Horizontal movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Lower lip to lower incisor horizontal movement	83%	0,89	34%	0.88
Lower lip to B point horizontal movement	89%	0,89	92%	0,92
Mentolabial fold to B point horizontal movement	78%	0,93	75%	0,97
Soft tissue pogonion to Pog point horizontal movement	77%	0,95	96%	0,98
Soft tissue menton to Me point horizontal movement	29%	0,90	81%	0,95

R- Coefficient of correlation.
All correlations p<0,001

In majority of cases soft tissue vertical changes in relation to hard tissue changes in mandibular area had a strong correlation. The difference between short-term and long-term data was rather substantial. In a mental and sub mental area soft tissue movements were more pronounced than hard tissue movements (Table 25).

Table 25. Soft to hard tissue short and long term ratios in mandibular region. Vertical movements of the soft tissues

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Lower lip to lower incisor vertical movement	71%	0,71	115%	0.56
Lower lip to B point vertical movement	58%	0,73	61%	0,61
Mentolabial fold to B point vertical movement	93%	0,83	44%	0,75

Soft tissue pogonion to Pog point vertical movement	175%	0,83	135%	0,93
Soft tissue menton to Me point vertical movement	110%	0,89	165%	0,91

R- Coefficient of correlation.
All correlations $p<0,001$

The relationship between soft and hard tissues among females

Female group consisted of 29 patients, i.e. 35% of the study cohort. For a several measurements findings in a female group differed from findings in male group and in whole study cohort. Hard tissue horizontal movements during surgery and in a long-term period were statistically significant for both jaws. Maxillary movement was small not exceeding 3 mm, and maxillary relapse was also small not exceeding 1 mm in the area for maxillary incisors. In mandible movements during surgery and in a long-term period were greater and reached 6.7 mm. Mandibular relapse was statistically significant and reached 2 mm in the area of the point Pog.
In a short-term period soft tissue horizontal movement in the area of nose and upper lip was small, yet statistically significant not exceeding 1.5 mm. In mandibular area movement was much greater and reached 5.7 mm. In long-term period movement of all indicators was smaller than in a short-term period, except the area of the tip of the nose and lower lip, where this movement was greater than in a short-term period. In this group relapse was observed in mentolabial fold, mental and sub mental area, and in area of the tip of the nose forward movement continued in a post-surgery period.
None of vertical movements during the surgery was statistically significant in a female group. In a long-term period statistically significant vertical changes were observed only for mandibular point, and these changes were related to decrease of facial vertical height. In a post-surgery period all changes, except B point area, were statistically significant and related to the decreased facial vertical dimension.
In a short-term period statistically significant soft tissue vertical changes were observed in upper lip, mentolabial fold, mental and sub mental area. Upper lip downward movement and upward movement of all other listed points were observed. Long-term changes were very similar to the short-term changes with the same points involved. None of vertical movements in a post-surgery period was statistically significant.
In the majority of cases moderate or weak correlation was observed between soft tissue horizontal changes in relation to hard tissue horizontal movements in the nose and upper lip area. The level of statistical significance varied. There were rather substantial differences between short-term and long-term data (Table 26).

Table 26. Soft to hard tissue short and long term ratios in maxillary region. Horizontal movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Tip of nose to A point horizontal movement	7%	0,53	25%	0,44*
Tip of nose to A point vertical movement	13%	0,56	21%	0,47*
Subnasale to A point horizontal movement	17%	0,64	23%	0,67
Soft tissue A point to A point horizontal movement	1%	0,52	47%	0,68
Upper lip to A point horizontal movement	63%	0,74	76%	0,68

R- Coefficient of correlation.
P< 0,001; *- p<0,05.

Correlation between soft and hard tissue vertical movements in the nose and maxillary area was weak or moderate. There were substantial differences in a vertical movement of the base of upper lip in relation to vertical movement of point A between short-term and long-term data. Other indicators were similar in different periods of time (Table 27).

Table 27. Soft to hard tissue short and long term ratios in maxillary region. Vertical movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Tip of nose to A point vertical movement	62%	0,60	55%	0,54
Tip of nose to A point horizontal movement	7%	-0,39*	9%	-0,50
Subnasale to A point vertical movement	39%	0,67	62%	0,64
Soft tissue A point to A point vertical movement	36%	0,55	81%	0,66
Upper lip to A point vertical movement	5%	0,60	81%	0,57
Upper lip to upper incisors vertical movement	62%	0,67	48%	0,55

R- Coefficient of correlation.
P< 0,001; *- p<0,05.

Strong correlation close to direct relationship between soft and hard tissue horizontal movements in mandibular area was observed. Soft tissue sub mental area was the only area without substantial differences between short-term and long-term data; differences in other points were rather big (Table 28).

Table 28. Soft to hard tissue short and long term ratios in mandibular region. Horizontal movements of the soft tissues.

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Lower lip to lower incisor horizontal movement	55%	0,89	100%	0.92
Lower lip to B point horizontal movement	134%	0,88	63%	0,92
Mentolabial fold to B point horizontal movement	159%	0,93	53%	0,98
Soft tissue pogonion to Pog point horizontal movement	180%	0,94	74%	0,98
Soft tissue menton to Me point horizontal movement	134%	0,95	140%	0,94

R- Coefficient of correlation.
All correlations $p<0,001$

Correlation between soft tissue vertical movements in relation to hard tissue vertical movement in mandibular area was strong, in some cases very strong. There were substantial differences between short-term and long-term data. In all cases, except soft tissue of chin area, trend toward decreased proportion was observed (Table 29).

Table 29. Soft to hard tissue short and long term ratios in mandibular region. Vertical movements of the soft tissues

Value	T0T2 soft tissue/T0T1 hard tissue(%)	R	T0T5 soft tissue/T0T5 hard tissue(%)	R
Lower lip to lower incisor vertical movement	86%	0,82	10%	0.81
Lower lip to B point vertical movement	160%	0,82	36%	0,84
Mentolabial fold to B point vertical movement	139%	0,87	57%	0,87
Soft tissue pogonion to Pog point vertical movement	83%	0,88	136%	0,87
Soft tissue menton to Me point vertical movement	97%	0,97	46%	0,95

R- Coefficient of correlation.
All correlations $p<0,001$

There was statistically significant differences between male and female group regarding hard tissue movement during surgery, particularly regarding horizontal movement of point A ($p=0.018$) and horizontal movement of maxillary incisors ($p=0.025$). There was no statistically significant difference between groups for other movements.
There was a trend indicating gender differences in one indicator of relationship between soft tissue movement and hard tissue movement in maxillary and nose area, i.e. relation between horizontal movement of the tip of the nose during time period T0T2 and horizontal movement of point A during time period T0T1 ($p=0.051$). In

mandibular area some statistically significant differences and trends indicating gender differences were observed. Statistically significant gender differences were observed: in relation between soft tissue vertical movement of the mental area during time period T0T2 and vertical movement of point Pog during the time period T0T1 (p=0.032); in relation between soft tissue vertical movement in sub mental area during time period T0T2 and horizontal movement of hard tissue point Me during the time period T0T1 (p=0.019); in relation between soft tissue vertical movement in sub mental area during time period T0T5 and horizontal movement of hard tissue point Me during the time period T0T5 (p=0.011). Trend for a gender difference was observed: in relation between lower lip horizontal movement T0T2 and horizontal movement of mandibular incisors T0T1 (p=0.074); in relation between horizontal movement of the mentolabial fold during time period T0T2 and horizontal movement of hard tissue point B during the time period T0T1 (p=0.067); in relation between soft tissue vertical movement in sub mental area during time period T0T5 and vertical movement of hard tissue point Me during the time period T0T5 (p=0.075).

Thickness of the soft tissues

The surgical movement between groups of thin and thick upper lip was compared and no statistically significant differences between groups in relation to vertical and horizontal movements were found. The same comparison was performed for the length of the nose between vertical and horizontal movements of the frontal part of maxilla. For mandible vertical and horizontal surgical movements between groups of thin and thick lower lip was compared. No statistically significant differences between groups were observed and therefore, these groups are comparable, because there were no substantial differences in surgical movements. Thus, factors related to surgical movement and relapse can be excluded.

Changes of the soft tissue thickness in upper lip and nose area in a long-term period (T0T5) were statistically significant. Decrease of the soft tissue thickness between different anatomical points in the groups of thin and thick upper lip was observed. Statistically significant decrease of soft tissue thickness was observed in a short and long nose groups (p<0.01) (Table 30).

Table 30.Changes in soft tissue thicknesses in upper lip and nasal region.

Value changes from T0 to T5	Thin upper lip (1A)	Thick upper lip (2A)	Short nose (1C)	Long nose (2C)
ANS point- tip of nose	-1.6± 3.0**	-2.3± 2.3**	-1.4± 3.1** (5%)	-2.5± 2.0** (7%)
A point- soft tissue A point	-1.4± 1.8** (9%)	-2.8± 1.7** (14%)		
A point –subnasale	-1.9± 2.1**	-3.1± 1.4**		
A point- upper lip	-0.9± 2.6**	-2.9± 2.7**		

**-P<0.01

„+"- increase in thickness of soft tissues

„-"-decrease in thickness of soft tissues

In the area of lower lip these changes were more complicated. Soft tissue thickness decreased in both groups in a distance between point B and lower lip and between point B and soft tissue in a mental area. Small and statistically significant increase of thickness in a thin lower lip group and in a thick lower lip group was observed in distance between point B and mentolabial fold (Table 31).

Table 31. Changes in soft tissue thicknesses in lower lip region.

Value changes from T0 to T5	Thin lower lip (1B)	Thick lower lip (2B)
B point- lower lip	-1.1± 2.6**	-1.8± 2.2**
B point – mentolabial fold	0.4± 0.7** (4%)	-0.5± 1.4** (4%)
B point – soft tissue pogonion	-1.2± 1.8**	-1.1± 1.9**

**-P<0.01
„+"- increase in thickness of soft tissues
„-"-decrease in thickness of soft tissues

When comparing changes of soft tissue thickness in a thin (1A) and thick (2A) upper lip group, statistically significant differences were observed in distances: point A – base of the upper lip; point A- point Sn, point A- upper lip. Comparing groups of thin (1B) and thick (2) lower lip difference was observed only in distance point B – mentolabial fold. Comparing groups of short (1C) and long (2C) nose group, statistically significant differences were found for distances point A – base of the upper lip and point A – upper lip (Table 32).

Table 32. Comparison of the groups.

Value changes from T0 to T5	1A with 2A (mm)	1B with 2B (mm)	1C with 2C (mm)
ANS point- tip of nose	-0.8		-1.1
A point- soft tissue A point	-1.3**		-0.9*
A point –subnasale	-1.2**		-0.7
A point- upper lip	-2.0**		-1.3*
B point- lower lip		-0.7	
B point – mentolabial fold		-0.9**	
B point – soft tissue pogonion		-0.1	

**-P<0.01; *- p<0.05

CONCLUSIONS

- Relationship between maxillary soft tissue and hard tissue horizontal movements is less pronounced than relation between soft tissue and hard tissue horizontal movements in mandibula.
- Forward and upward movements of the tip of the nose are strongly related to the vertical and horizontal movements of skeletal part of maxilla.
- Changes of vertical facial dimension during surgery affects nature of the soft tissue movements.
- Hard and soft tissue relapse is affected by the changes of vertical facial dimension.
- Soft and hard tissue changes during 3-year period varied.
- Soft tissue movements in relation to hard tissue movements differed among males and females.
- Soft tissue thickness plays an important role in the soft tissue reaction to minor hard tissue movements.
- Gender, soft tissue thickness, changes of vertical facial dimension – are factors to be taken into account and integrated in a surgery planning software in addition to standard soft/hard tissue ratio.
- These data based on clinical experience can be successfully used in a population of Latvia.

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