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University of Szeged, Faculty of Medicine, Department of Oral & Maxillofacial Surgery, Craniofacial Unit, Hungary*
University of Szeged, Faculty of Medicine, Department of Oral & Maxillofacial Surgery, Hungary**

Three-dimensional changes of the facial soft tissue after bimaxillary surgery of skeletal class III patients: a prospective study

DR. ALKHAYER ALI* DR. PIFFKÓ JÓZSEF** DR. SEGATTO EMIL*

Soft tissue adaptation and contours are of paramount importance in the design of orthognathic surgeries. The aim of our study was to investigate the use of three-dimensional handheld structured-light scanners for an extensive evaluation of the post-operative soft tissue changes in various morphological regions of the face following the bimaxillary surgery of skeletal class III patients. Our study sample consisted of 12 patients (6 males and 6 females) with mean age of (22 ± 2.17 years), with skeletal class III malocclusion, all which required bimaxillary osteotomy as the second step of their comprehensive treatment. The three-dimensional facial images were acquired one week before surgery (T_0), and thereafter, 6 months after surgery (T_1), using a 3D-handheld structured light scanner. Linear and angular measurements were recorded and compared. Three-dimensional deviation analyses were done for the 7 morphological regions of the face. Based on obtained results, we found statistically significant increases in the nasal and the nasal base widths, the nasal tip angle, the upper lip height, and the lower lip angle; significant decreases in the lower lip height and the inter-labial angle were also found. The three-dimensional soft tissue changes after the bimaxillary surgery of skeletal class III patients were observed in majority of the facial regions, with the most significant ones found in the middle third of the face, the nose, and the upper lip areas. These findings must be taken into account during treatment planning.

Keywords: Orthognathic Surgery, class III malocclusion, Facial Soft tissue, Three-Dimensional Imaging

Introduction

It is widely known that deficiencies associated with malocclusion and craniofacial deformities are usually comorbid with cognitive difficulties and psychiatric disorders. Therefore, it is important to consider the adaptation of soft tissue and its contours during treatment planning whilst accommodating the limitations presented by the patients' disabilities [1, 34].

As bimaxillary surgery provides more favourable results for the aesthetic facial proportion, it has been increasingly used, especially in patients with mandibular prognathism [8, 21].

Previous post-operative studies on the soft tissue changes after the bimaxillary surgery were mainly based on the use of two-dimensional (2D) methods as an inspection tool, e.g. cephalometric images, anteroposterior graphs, and photogrammetric analyses [17, 31], in which superimposition and magnification were considered limitations affecting the final results.

In the new era of three-dimensional (3D) imaging techniques, we can overcome these disadvantages and utilise more reliable diagnostic tools. Cone-beam computed tomography (CBCT) is highly utilized for soft tissue inspection, although, the high radiation dose should always be taken into consideration [6, 32]. New 3D imaging methods for soft tissue visualization, such as laser surface scanning and stereophotogrammetry, have recently been introduced [10]. These friendly, non-invasive procedures require a short scanning time; however they are large footprint and are not easy to operate.

Using a structured-light scanning device, facial texture and colour details can be easily collected with high resolution without exposure to the external radiation hazards [3], and is benefited by fast scanning time, portability, and flexible operability [30]. To our knowledge, there were only a few studies that used a 3D-facial scanner to evaluate the soft tissue changes after the orthognathic surgery of skeletal class III patients. Nevertheless, only some examined deviations at specific points or calculated linear and angular measurements [7, 29]. Such finding may be improved by evaluating facial regions on a 3D-basis assessment. Therefore, the purpose of our prospective study is to perform an extensive evaluation of the short-term soft tissue changes in various morphological regions of the face after the bimaxillary surgery of skeletal class III patients using a 3D handheld structured-light scanner.

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Materials and Methods

Study Sample

This prospective study was approved by the Human Investigation Review Board, the University of Szeged, Albert Szent-Györgyi Clinical Centre (No. 151/2019-SZTE). Informed consent was obtained from all patients who agreed to participate in this study.

Patients with skeletal class III malocclusion requiring bimaxillary surgery as the second step of their full comprehensive orthodontic-orthognathic treatment were recruited from the Craniofacial Unit, Department of Oral and Maxillofacial Surgery, Albert Szent-Györgyi Clinical Centre, University of Szeged, Hungary. Exclusion criteria were cleft lip and palate, craniofacial syndromes, major medical diseases, a history of facial trauma, and a previous orthognathic surgery. All of patients were of Caucasian ethnic backgrounds, had no further growth anticipated, and had had the pre-and post-surgical orthodontic treatments successfully completed *(Figure 1)*.

Our study consisted of 12 patients (6 males and 6 females) with a mean age of 22 ± 2.17 years, range 19.6–24.5 and without severe facial asymmetry (less than 4 mm of chin deviation from the mid-sagittal plane or facial midline). [13, 42]. The sample size was determined based on the findings of a previous study by Koerich and colleagues [26]. All patients were treated by the same surgeon (J. P.), who performed maxillary advancement and a mandibular setback to achieving a normal dento-skeletal relationship. Following implementation of the treatment plan, the level of achieved skeletal movement was 3.87 ± 1.6 mm for the maxillary advancement, and 3.46 ± 1.34 mm for the mandibular setback. No additional surgical procedures such as genioplasty, rhinoplasty, or infraorbital augmentations were performed either, in conjunction with the osteotomies or postoperatively.

Surgical Protocol

The surgical procedure consisted of the conventional Le Fort I osteotomy and the Bilateral sagittal split setback osteotomy (BSSO). As per Obwegeser, the Le Fort I osteotomy cut was made above the apices of the maxillary teeth and underneath the infraorbital nerve [35], and then extended to achieve a full mobilization of the maxilla. The mobilized maxilla was moved and fixed in a previously planned position using a surgical splint.

During the (BSSO), the subperiosteal incision was made. The osteotomy was performed according to Obwegeser/Dal Pont [15]: splitting of the mandible was carried out, and a segment of bone was removed to retract the body of the mandible guided by the fabricated surgical splint. All patients underwent internal fixation of the maxilla and the mandible with functional mini-plates and mini-screws, and a surgical wafer was placed for approximately 5-6 weeks after surgery. Following removal of the surgical wafers, intermaxillary elastic fixations were performed to stabilize the occlusion.

Data processing and measurements

3D facial images using the 3D handheld structured-light scanner (Artec Eva^{TM}; Artec Group, Luxembourg) were obtained one week prior to the surgery (T_0), and thereafter, 6 months post-surgery (T_1). This scanner uses structured light scanning technique for precise capture of up to 16 frames per second in a point-and-shoot mode with every frame captured as a 3D image. The frames are adjusted automatically, real-time and deliver high resolution (up to 0.5 mm) and high accuracy (up to 0.1 mm).

All images were taken with the head in a natural position, teeth within centric occlusion, lips in rest, and slightly closed eyes [39]. To accomplish the natural head balance, the subjects were seated in a back-supported and a vertically adjustable chair. They were instructed to turn their heads forward and backward with decreasing amplitude until a relaxed position is achieved [43]; then, they were requested to look straight ahead to the point on the wall in front of them at the eye level. During scanning, a hairband was used to prevent the concealment of the facial regions by the subjects' hair.

19 landmarks, 5 bilateral and 9 unilateral *(Table 1, Figure 2)*, were located according to the literature [27, 40]; 13 linear and 6 angular measurements were taken directly with the 3D-facial images using Artec Studio V.12 software *(Figure 3, 4)*.

To perform the 3D deviation analysis, the images were transferred into reverse engineering software (GOM Inspect Evaluation Software, Capture 3D, Inc., Santa Ana, CA); then, polygon meshes were created in stereolithography (STL) format. The hair, the ears, and the below-neck region were removed. The images obtained at the T_0 time point were aligned with the images taken at T_1 by using the overall best-fit method as per Dindaroglu and colleagues [16] *(Figure 5)*.

Negative values indicate that T_1 images are located behind the T_0 images (blue shades), whereas positive values indicate that T_1 images are located in front of the T_0 images (red shades). To create morphological regions, reference lines passing through different points specified on the face were determined and a 3D deviation analysis was performed in seven morphological regions of the face [16] *(Table 2, Figure 6)*. In addition, we calculated the deviation magnitude for the facial soft tissue landmarks directly on the 3D inspected meshes *(Figure 7)*.

Statistical Analysis

Normal distribution of the data was set up through the Shapiro–Wilk and Kolmogorov-Smirnov tests. To determine the method's reliability, T_0 and T_1 images of the

Figure 1: Intraoral photographs of one patient included in our study.
(a) The initial phase. (b) T0 phase, during the pre-surgical orthodontic treatment.
(c) T1 phase, during the post-surgical orthodontic treatment. (d) The final phase after removal of the appliance

Table 1

Definition of facial landmarks used in our study.

Landmark		Definition
Exocanthion	(Ex)*	The point at the outer commissure of the eye fissure
Endocanthion	(End)*	The point at the inner commissure of the eye fissure
Soft tissue nasion	(N)	Midpoint on the soft tissue contour of the nasal root's base
Alare	(Al)*	The most lateral point on each alar contour (on the base view).
Pronasale	(Prn)	The most anterior midpoint of the nasal tip (on the right and left profile view). If a bifid nose is present, the more protruding tip is chosen to determine Pronasale.
Alar curvature point	(Ac)*	The point located at the facial insertion of each alar base. (on the submental view)
Subnasale	(Sn)	The midpoint on the nasolabial soft tissue contour between the Columella crest and the upper lip
Columella	(Cm)	The midpoint of the Columella crest at the level of the nostril top points
Labiale superius	(Ls)	The midpoint of the vermilion line of the upper lip (on the submental view).
Stomion	(Stm)	The midpoint of the horizontal labial fissure.
Chelion	(Ch)*	The point located at each labial commissure (on the frontal view).
Labiale inferius	(Li)	The midpoint of the vermilion line of the lower lip (on the right profile view).
Sublabiale	(Sl)	The most posterior midpoint on the Labiomental soft tissue contour that defines the border between the lower lip and the chin.
Soft tissue pogonion	(Pog´)	The most anterior midpoint of the chin
Menton	(Me´)	The most inferior midpoint on the soft tissue contour of the chin located at the level of the 3-D cephalometric hard tissue Menton landmark

* Indicates bilateral landmarks (right and left).

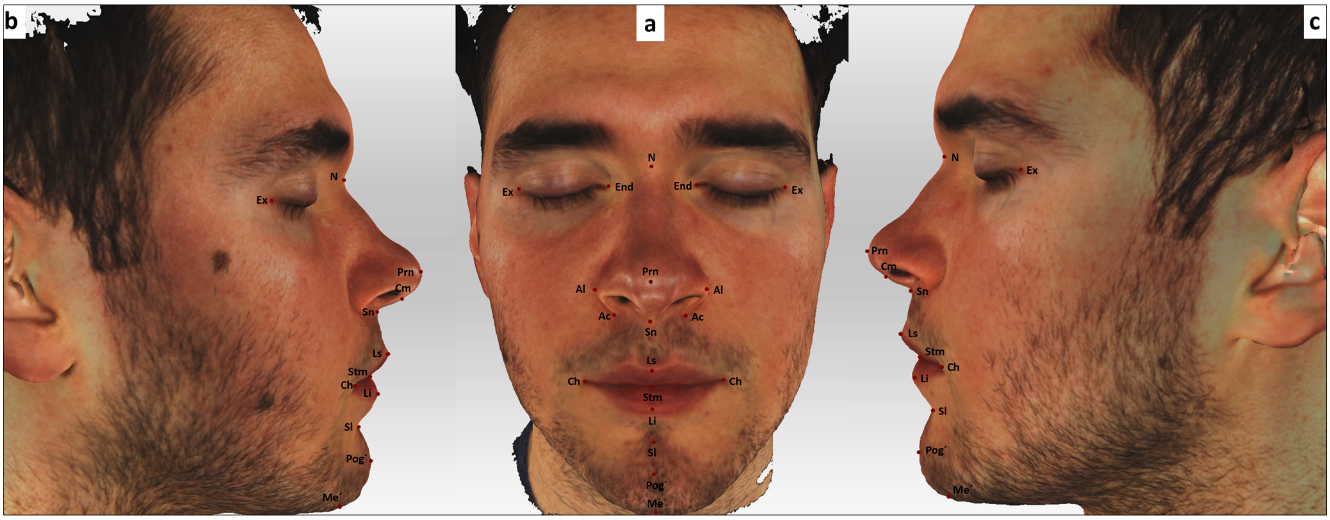

Figure 2: Landmarks used in our study located directly on the 3D-facial images
(a) Frontal view. (b) and (c) Lateral views.

Figure 3: Linear measurements used in our study
(a) Frontal view. (b) and (c) Lateral views.

patients were re-aligned; then, the measurements were recalculated a month later by the same investigator. Intra-examiner reliability was evaluated utilizing the intraclass correlation coefficient (ICC). The random errors were calculated according to Dahlberg's formula (D = √ ∑ d2/2N) [19], where D is the error variance, d is the difference between the first and second measure, and N is the sample size which was re-measured. The systematic errors were also assessed by the dependent t-test. The (T_0) and (T_1) linear and angular measurements were compared. Significant differences at the level of 5% significance were tested utilizing the Wilcoxon signed-rank test. Likewise, for every patient, a 3D deviation analysis was performed to calculate not only maximum positive and negative deviations, but also mean deviation amounts for the facial meshes. Additionally, the deviation magnitude for specific facial landmarks was calculated directly on the 3D-assessed meshes. All statistical analyses were performed using the Statistical Package for Social Sciences software (SPSS Inc. v 24; Chicago, IL, USA).

Results

Based on Shapiro–Wilk test and Kolmogorov-Smirnov test, all parameters were normally distributed. The ICC values between the two sets of measurements were high (range 0.816–0.924). The amount of random error was small enough (less than 0.5 mm/°), and no systematic errors were found in the measurements obtained on the two different occasions ($p \geq 0.05$).

We found statistically significant increases in the nasal and nasal base width, the upper lip height, and

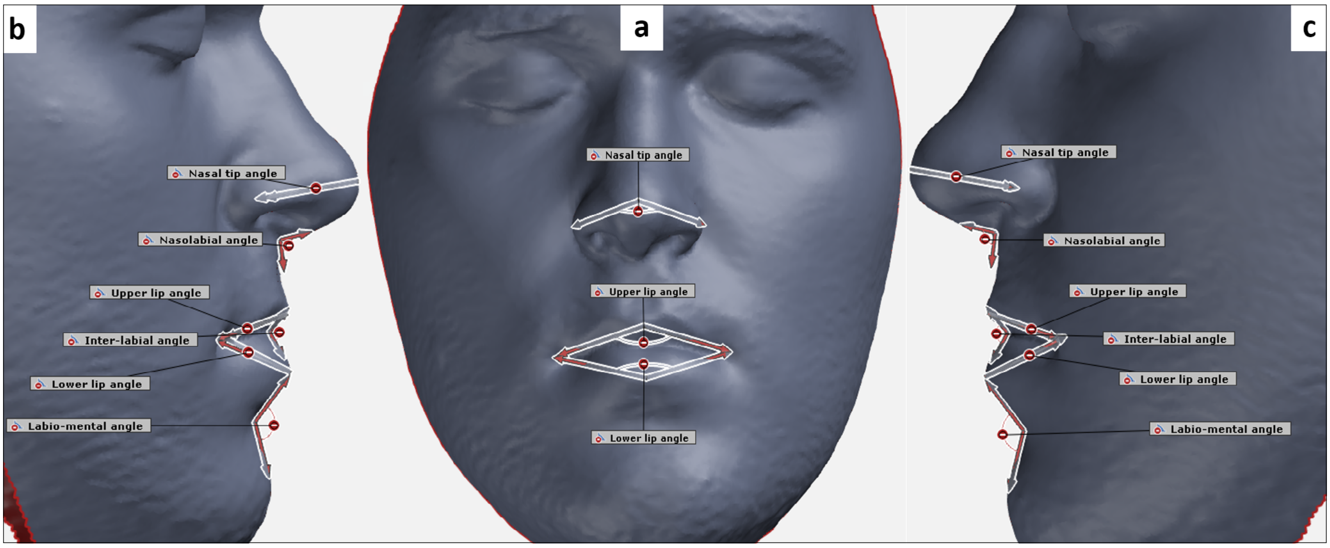

Figure 4: Angular measurements used in our study,
(a) Frontal view. (b) and (c) Lateral views.

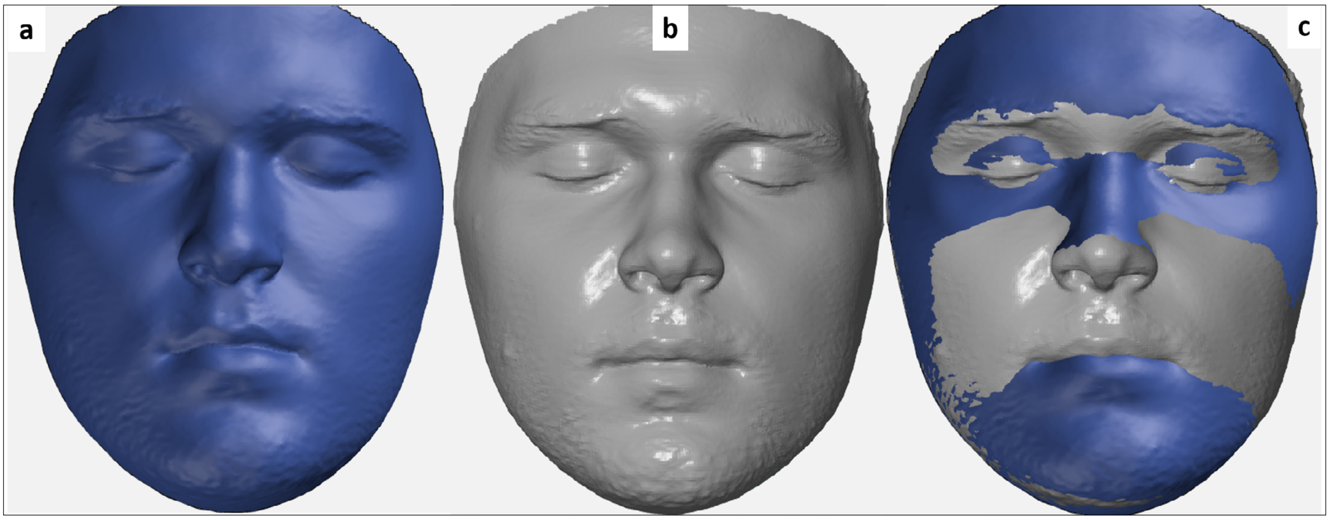

Figure 5: The best fit method used,
(a) T_0 mesh. (b) T_1 mesh. (c) The final mesh aligned.

a decrease in the lower lip height after bimaxillary surgery *(Table 3),* which is also demonstratable in descriptive statistics of the pre-treatment (T_0) and post-treatment (T_1) variables.

Statistically significant increases in the nasal tip angle, the lower lip angle, and a decrease in the Inter-labial angle were noticed after the bimaxillary surgery, as seen in *Table 4*.

We found facial soft tissue changes in both the upper and the lower face regions with a mean of (0.77, 0.67 mm) respectively; the mean deviation at the nasal region was (1.03 mm), with the highest magnitude of the soft tissue changes found in the upper lip region with a mean deviation (3.25 mm). Descriptive statistics of the maximum positive and negative deviation limits and also of the mean limits of the meshes are seen in *Table 5, 6*.

After calculating the deviation in the soft tissue, changes were observed in several further facial landmarks *(Table 7)*.

Discussion

Facial soft tissue is dynamic and elastic, and is easily affected by other factors; such as swelling, weight, head position changes, or even by the treatment itself and the underlying hard tissue changes [11]. That's why 2D-facial images and cephalometric examination were found to be inadequate methods for soft tissue evaluation after surgical procedures. With advances in 3D technology,

Table 2

Definition of the morphological regions used for the 3D deviation analyses

Region	Definition
Total face	The facial region designated while creating masks before alignment
Upper face	The region between the line passing through the right and left Exocanthion points and the line passing through the Subnasale point parallel to that line.
Lower face	The region between the line passing through the Subnasale point and the line passing through the Menton point parallel to that line.
Upper lip	The region between the lines passing through the right and left Endocanthion points and the right and left Cheilion points, and the line passing through the Subnasale point
Lower lip	The region between the lines passing through the right and left Endocanthion points and the right and left Cheilion points, and the line passing through the supramental point parallel to other lines.
Nose	The region between the lines passing through the right and left Endocanthion points that are tangent to the nasal wings and the line passing through the Subnasale point
Chin	The region formed between four reference lines: the two lines passing through the right and left Endocanthion points, the right and left cheilion points respectively, and the horizontal lines passing through Sublabiale and Menton points respectively.

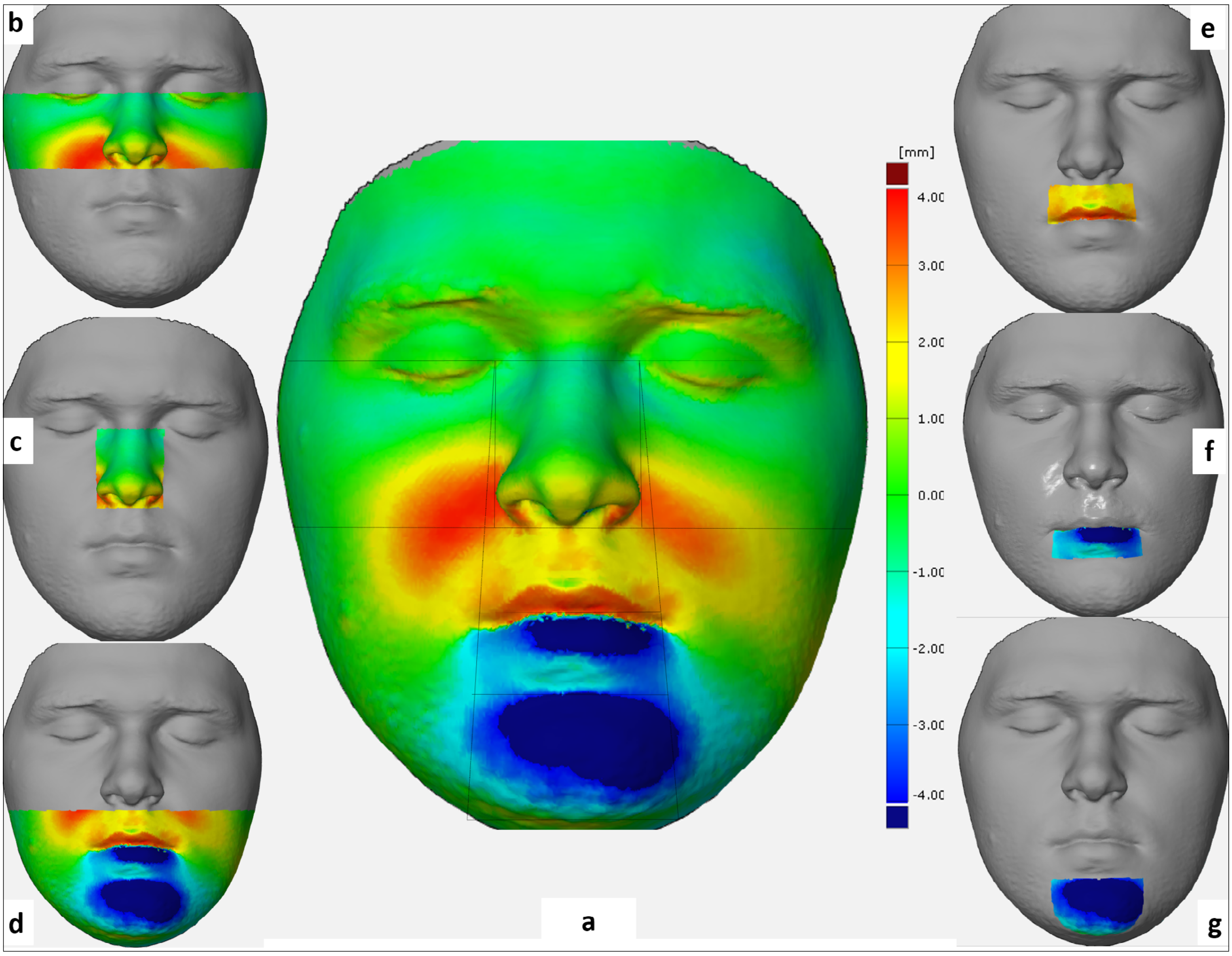

Figure 6: The morphological regions used for the deviation analysis.
(a) Total face region with the reference lines used. (b) Upper face region. (c) Nose region. (d) Lower face region.
(e) Upper lip region. (f) Lower lip region. (g) Chin region.

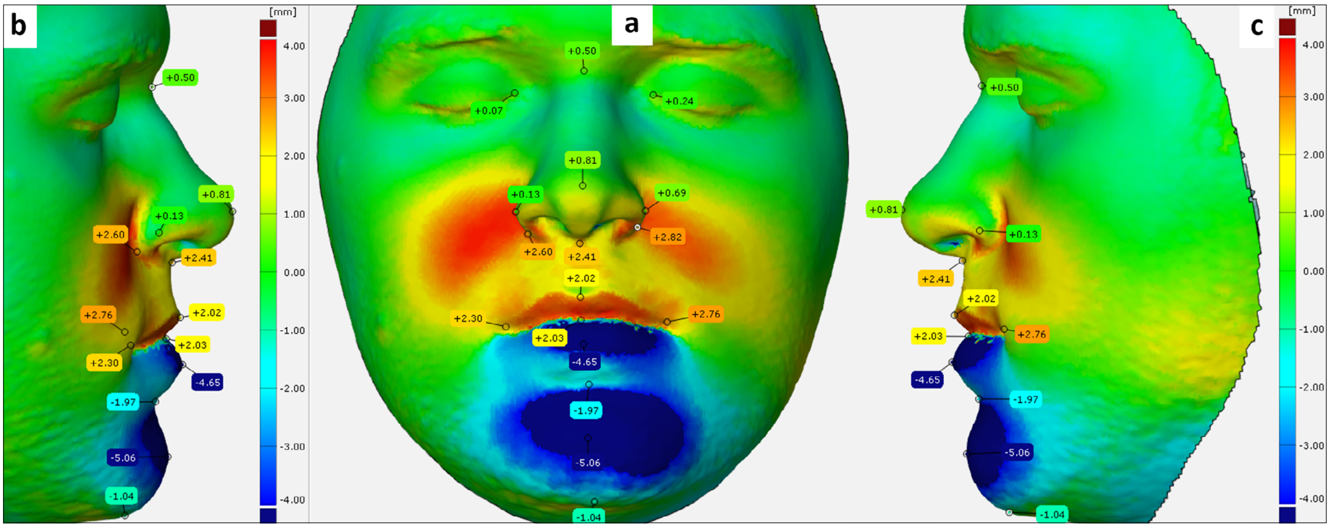

Figure 7: Deviation analysis used for specific landmarks in our study.
(a) Frontal view. (b) and (c) Lateral views.

Table 3

Descriptive statistics of the pretreatment (T_0) and posttreatment (T_1) linear measurements

Measurement		T_0		T_1		$\Delta = T_1 - T_0$ (mm)
		Mean (mm)	SD	Mean (mm)	SD	
Intercanthal width	En_R-En_L	33.87	1.05	33.92	2.02	0.05
Nasal width	$Alar._R$-$Alar._L$	36.44	3.38	38.75	3.32	2.31*
Nasal base width	Ac_R-Ac_L	32.92	3.2	34.94	1.49	2.02*
Mouth width	Ch_R-Ch_L	48.88	4.14	50.47	3.46	1.59
Nasal high	N-Sn	50.13	4.46	50.2	4.9	0.07
Upper lip height	Sn-Ls	12.3	2.97	13.77	2.8	1.47*
Upper lip vermilion height	Ls-Stm	6.71	1.2	9.02	4.4	2.31*
Total upper lip height	Sn-Stm	18.89	2.88	22.7	3.18	3.8*
Lower lip vermilion height	Stm-Li	9.66	0.46	8.36	1.26	–1.3
Lower lip height	Li-Sl	15.56	3.7	13.66	3.18	–1.9*
Lips vermilion height	Ls-Li	16.37	1.47	17.38	1.62	1.01
Chin height	Stm-Me´	53.24	5.61	48.49	4.28	–4.75
Lower anterior facial height	Sn-Me´	72.14	4.7	73.54	4.18	1.4

* Significant changes at the level of 5% of significance (α = 0.05)

Table 4

Descriptive statistics of the pretreatment (T_0) and posttreatment (T_1) angular measurements

Measurement		T_0		T_1		$\Delta = T_1 - T_0$
		Mean (°)	SD	Mean (°)	SD	Mean (°)
Nasal tip angle	$Alar_R$-Prn-$Alar_L$	81.26	7.5	88.62	8.5	7.36*
Upper lip angle	Ch_R-ls-Ch_L	119.7	6.2	115.38	6.9	–4.32
Lower lip angle	Ch_R-li-Ch_L	116	4.8	126.46	4.56	10.46*
Inter-labial angle	Ls–Stm–Li	134.33	8.5	125.52	8.67	–8.81*
Nasolabial angle	Cm-Sn-Ls	82.68	9.14	94.25	6.22	11.57
Labio-mental angle	Li-Sm- Pog´	145.91	10.8	140.59	8.19	–5.32

* Significant changes at the level of 5% of significance (α = 0.05)
based on the Wilcoxon signed-rank test

Table 5

Descriptive statistics of the maximum positive and negative deviation limits of the meshes

Morphological region	Maximum positive deviation limits (mm)				Maximum negative deviation limits (mm)			
	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD
Total face	5.84	5.96	5.9	0.08	–5.04	–4.74	–4.89	0.21
Upper face	5.68	5.98	5.87	0.16	–4.74	–3.04	–3.98	0.86
Lower face	5.62	5.84	5.7	0.15	–5.04	–2.53	–3.83	1.25
Nose	5.6	5.98	5.84	0.21	–4.74	–3.94	–4.49	0.7
Upper lip	5.62	5.84	5.71	0.11	–2.94	–2.4	–2.67	0.27
Lower lip	2.31	2.44	2.37	0.09	–5.04	–3.47	–4.25	1.11
Chin	0.46	1.48	0.97	0.72	–3.94	–3.38	–3.66	0.39

Table 6

Descriptive statistics of the mean limits of the meshes

Morphological regions	Minimum	Maximum	Mean	SD
Total face	0.34	0.7	0.52	0.25
Upper face	0.29	1.31	0.77	0.51
Lower face	0.4	0.95	0.67	0.38
Nose	0.89	1.17	1.03	0.14
Upper lip	3.03	3.38	3.25	0.19
Lower lip	–1.48	–0.95	–1.21	0.37
Chin	–1.73	–1.59	–1.66	0.09

Table 7

Deviation magnitude of the facial soft tissue landmarks

Landmark		Deviation mean (mm)	SD
Endocanthion (right)	End_r	–0.4	1.09
Endocanthion (left)	End_l	–0.1	1.03
Soft tissue nasin	N	–0.23	0.78
Alar point (right)	$Alar_r$	1.26	0.92
Alar point (left)	$Alar_l$	0.85	0.99
Alar curvature (right)	Ac_r	1.36	0.69
Alar curvature (left)	Ac_l	1.14	0.83
Pronasale	prn	1.93	0.12
Subnasale	Sn	3.03	1.32
Chelion (right)	Ch_r	0.63	0.78
Chelion (left)	Ch_l	0.57	0.44
Labiale superius	Ls	3.12	1.23
Labiale inferius	Li	–3	1.77
Stomion	Sto	2.58	1.28
Sublabiale	Sl	–2	1.22
Soft tissue pogonion	Pog´	–2.5	1.94
Soft tissue menton	Me´	–1.3	1.76

it has become possible to standardize image registration and to reduce errors in head orientation [11, 4]. Some studies suggested that the flaws associated with reference landmarks on 3D-facial images were in sub-millimetre dimension. The facial soft-tissue landmarks were reported as having moderate to high reliability and reproducibility, and the 3D-facial scanning systems could be useful in providing accurate images [9, 37]. Furthermore, Jung *et al.* concluded that a structured light scanning system proved to be a useful tool to evaluate the nasolabial soft tissue changes after orthognathic surgery [22], while Modabber and colleagues concluded that the Artec Eva scanner leads to more accurate 3D models as compared to scanning with FaceScan3D, and it is comparable to the other commercially available scanners [33].

To minimize the effects of different types of malocclusion and surgeon-related factors, the subjects' selection was limited to those with skeletal class III defects, and all operations were performed by one surgeon (J. P.).

Unfortunately, considering gender-related effects within the small sample size in our study further analyses were not feasible. Notwithstanding that, Chen and colleagues found no sex-related differences in soft tissue changes in patients with mandibular prognathism after orthognathic surgery [12]. Further studies with larger sample size to inspect the sex-related effects of bimaxillary surgery on the soft tissue are essential.

The timing of the soft tissue analysis is very critical. A period up to 6 months after bimaxillary surgery was chosen as the T_1 stage due to the fact that a sufficient facial soft tissue stabilization is required to avoid any subsequent modifications, such as post-operative swelling, soft tissue remodelling, due to which the relocation should be minor enough to be insignificant [23]. Proffit and colleagues explained that postoperative changes do not show a normal distribution and that only a few patients exhibit considerable changes [38]. Similarly, Oh *et al.* found that 6 months post-surgery will be the ideal time for a proper assessment [36].

Soft tissue changes

We found a statistically significant increase in the nasal width and widening of the alar bases after bimaxillary osteotomies (2.31 mm and 2.02 mm $p < 0.05$ respectively). We can explain these increases by the remodelling and relocating of the surrounding muscles in the alar region [36]. Our results confirmed the results of Baik and colleagues who found a 2.0 mm nasal width increase after maxillary advancement and mandibular setback [7]. Similarly, an increase was also reported in the alar width after bimaxillary surgery in class III patients using a 3D laser scanner and 3D facial morphometry [18]. Liebregts and colleagues found an increase of 0.24 mm in the alar width for every 1 mm of maxillary advancement [28]. Altman and Oeltjen noted that all Le Fort I osteotomies caused widening of the alar bases due to retraction of perioral muscles around the maxilla, which results in their detachment from insertions during maxillary surgery [5].

In the study by Worasakwutiphong and colleagues, which evaluated the nasal changes in class III patients who underwent two-jaw surgery, it was found that, after the surgery, the alar width was increased by 0.74 mm and the nasolabial angle had increased significantly, while the width of the alar base and the nasal height and length remained similar [44].

No significant changes neither in the intercanthal width, nor in the mouth width, were found in our study. This corresponds to results in previous studies following bimaxillary surgeries, and it was reported that changes in the lips were produced by the stretching of soft tissues [7, 41].

With regards to the vertical plane, we found substantial increases in both the upper lip height and the upper lip vermilion height (1.47 and 2.31 mm, $p < 0.05$ respectively); thus, the total upper lip height was significantly increased by (3.8 mm). We can explain these increases by the relocation of the orbicularis oris muscle and a soft tissue tension in the upper lip region.

Marsan *et al.* found elongation in the upper lip (1.2 ± 1.6 mm) after bimaxillary surgery in Turkish female Class III patients [31, which supports our findings.

In our study, we found a statistically significant decrease in the lower lip height (Li-Sl; 1.9 mm, $p < 0.05$). In these changes, the upward and backward movement of the mandible may have played a role. A 4 mm decrease was reported by Marsan *et al.* in their study [31], whilst the findings of Kim *et al.* suggest that the lower lip decrease could be rather due to influence of the muscle rather than the bone [24].

Regarding the angular measurements, we found a statistically significant increase in the Nasal tip angle (7.36 º, $p < 0.05$), which could be affected by the lateral movements of the alar landmarks, and the increase in the nasal and nasal base width due to the relocation of the nasalis muscle after the surgery.

Usually, in addition to the nasal tip projection, the nasolabial angle is used to record the maxillary protrusion in the upper lip. We found an insignificant increase in this angle (11.57 º), which could be produced by stretching the soft tissues in this area. We also noticed a decrease in the Inter-labial angle (–8.81°, $p < 0.05$), which could be explained by the relocation of the orbicularis oris muscle and the upper and lower lips after the bimaxillary osteotomies. Following a bimaxillary surgery, a significant increase found in the lower lip angle (10.46 º) which could refer to the backward movement of the (Li) landmark, a decrease (–5.32 º) was also found in the Labiomental angle, but without reaching a significant level.

In their study on skeletal class III patients after a bimaxillary surgery Al-Gunaid *et al.,* evaluating the hard and soft tissue changes, found an increase in the nasolabial angle, a decrease in the labio-mental angle, and an improvement of dentofacial aesthetics. They also reported that the soft tissue facial profiles and the posture of the lips were improved [2].

A gradual advancement at the nasal tip, a significant increase in the nasolabial angle, and a decrease in the labio-mental angle were reported in the study by Marsan *et al* [31]. In our post-operative study, to improve the analysis of the facial changes, we conducted the deviation analysis of the facial meshes in seven morphological regions across the whole face rather than focusing only on certain linear and angular measurements.

Although the high positive and negative deviation limits were observed in the total face region in our study, the mean deviation of all landmarks forming the region didn't exceed 0.52 ± 0.25 mm. This small magnitude can be explained by the multidirectional soft tissue changes in the facial parts forming the overall facial envelope.

We found facial soft tissue changes in both the upper face and lower face regions with a mean of 0.77 ± 0.51 and 0.67 ± 0.38 mm respectively, while the mean deviation at the nasal region was 1.03 ± 0.14 mm. Previous studies of maxillary advancement and mandibular setback reported more soft-tissue movement in the central parts than in the lateral parts [25]. While Gjorup *et al* found that no changes occurred in the cheeks, they took into consideration that the influence of the muscles and soft tissue tension decreased as the distance from the area where the hard tissue changes increased [20].

The highest magnitude of the soft tissue changes was found in the upper lip region with a mean deviation of 3.25 ± 0.19 mm and high positive and negative deviation peaks of 5.71 ± 0.11 mm and –2.67 ± 0.27 mm respectively.

In regard to the lower lip and chin regions, we noticed soft tissue decrease of –1.21 ± 0.37 mm and –1.66 ± 0.09 mm respectively. Baik *et al.* suggested that the semi-circular shapes of the maxilla and the mandible correspond to fewer changes in the sub-commissural region (a lateral part) than in the labio-mental or chin regions (a central part) [7].

To provide a better overview of the facial changes, we calculated the deviation using designated landmarks of the face. The magnitude of deviation at the level of bilateral Alar points (1.26mm and 0.85 mm for the right and the left respectively) emphasizes lateral and anterior movements mentioned above. A similar movement can be anticipated at the level of bilateral Alar curvature landmarks (1.36, 1.14 mm), indicating soft tissue changes in the nasal region along with the deviation noticed at the level of pronasal and subnasal (1.93mm and 3.03 mm) regions respectively.

Similar results were found in the study of Çoban *et al*, which reported lateral movement of bilateral alar and alar curvature landmarks in addition to the upward and forward movements of alar and alar curvature, subnasale, labiale superior, sublabiale, and pogonion, which concurs with our findings [14].

In the upper lip area, a positive deviation of 3.12 mm was found at the level of Labiale superius point, which is indicative of anterior moment following a bimaxillary surgery. Furthermore, following bimaxillary osteotomies, deviations of –3, –2.5, –1.3 mm at the level of Labiale inferius, Soft tissue pogonion, and Soft tissue menton respectively were reported in our study, which may indicate a posterior movement of the soft tissue in both the lower lip and the chin regions and confirm our previous results in the linear and angular measurements.

Even though small sample size being is one of the limitations of our study, it has delivered relevant and valuable information regarding three-dimensional soft tissue changes of the face. In order to further advance the clinical research and the analysis, it may be beneficial to be repeat the study with a larger sample size and to consider the gender-related effects.

Conclusion

In our present comprehensive 3D evaluation, we succeeded to quantify and visualize the post-operative soft tissue changes in the 6th month of post bimaxillary surgery. Even in the presence of limitations of a small sample size, we concluded that, compared to the other facial structures, the middle third of the face, especially the nose and the upper lip, will be affected by the bimaxillary surgery. These expected changed should be taken into account when planning the treatment, and the patients must be informed accordingly. Further investigations with a larger sample size and appropriate controls will be necessary for a more precise evaluation of the soft tissue responses following a bimaxillary surgery.

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Eredeti cikk

Dr. Alkhayer Ali* Dr. Piffkó József** Dr. Segatto Emil*

Az arc lágyrészeinek háromdimenziós változásai skeletalis III. osztályú páciensek bimaxilláris műtétje után: prospektív vizsgálat

Az ortognath műtétek tervezésénél a lágyrészek adaptációjának és kontúrjainak figyelembe vétele kiemelt fontosságú. Prospektív tanulmányunk célja a skeletalis III. osztályú páciensek bimaxilláris műtétje után, az arc különböző morfológiai régióiban bekövetkezett lágyrész-változások átfogó értékelésének elvégzése kézi háromdimenziós strukturált fényszkennerrel. Vizsgálati mintánk 12 olyan páciensből állt (6 férfi és 6 nő, átlagéletkoruk 22 ± 2,17 év), akiknek a skeletalis III. osztályú eltérése átfogó kezelésük második lépéseként bimaxilláris osteotomiát igényelt. Háromdimenziós arcképeket készítettünk egy héttel a műtét előtt (T0) és 6 hónappal a műtét után (T1) kézi 3D strukturált fényszkennerrel. A képeken lineáris és szögméréseket végeztünk és hasonlítottunk össze, illetve elkészítettük az arc 7 morfológiai régiójának háromdimenziós deviációs elemzését. Statisztikailag szignifikáns növekedést találtunk az orr- és az orralap szélességében, az orrcsúcs szögében, a felső ajak magasságában és az alsó ajak szögében. Ezzel szemben az alsó ajak magassága és az inter-labialis szög értéke szignifikánsan csökkent. A skleletalis III. osztályú betegek bimaxilláris műtétje után különböző mértékű háromdimenziós lágyrész változásokat figyeltünk meg a faciális régiók többségében, melyek közül jelentősebbek voltak a középarc, az orr és a felső ajak változásai. Ezekkel a várható változásokkal a kezelések megtervezésénél számolni kell.

Kulcsszavak: Ortognath sebészet, III. osztályú rendellenesség, arc lágyrész, háromdimenziós képalkotás