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Morphologic outcome of bimaxillary surgery–An anthropometric appraisal

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Abstract

Objectives: To adequately perform orthognathic surgery procedures, it is from basic interest to understand the morphologic changes caused by orthognathic surgery. Anthropometric analyses of standardized frontal view and profile photographs could help to investigate and understand such changes.

Study Design: We present a pre- to postoperative evaluation of orthognathic surgery results based on anthropometric indices described by Farkas and cephalometric measurements. 30 Class III patients undergoing maxillary advancement by Le Fort I Osteotomy and mandibular setback by bilateral sagittal split osteotomy were evaluated. Preoperative as well as three and nine months postoperative lateral cephalograms as well as standardized frontal view and profile photographs were taken. On the photographs 21 anthropometric indices given by Farkas were evaluated. In cephalograms SNA and SNB angle as well as Wits appraisal were investigated.

Results: The investigated anthropometric indices showed a significant increase of the vertical height of the upper lip without changing the relation of the upper vermilion to the cutaneous upper lip. The lower vermilion height increased relatively to the cutaneous lower lip without vertical changes in the lower lip. Due to maxillary advancement the upper face height increased meanwhile the lower face height decreased due to mandibular setback. SNA and SNB angle and Wits appraisal showed typical changes related to surgery.
Conclusions: The investigated photo-assisted anthropometric measurements presented reproducible results related to bimaxillary surgery.

Key words: Orthognathic surgery, bimaxillary surgery, anthropometry, Class III.
taken the day before surgery. Postoperative photographs were taken three and nine months later with a Nikon D80 camera (objective: Nikon AF Micro Nikkor 105 mm 1:2.8 D; aperture: f13; Nikon Corp, Tokyo, Japan) in a standardized manner as described elsewhere (16). All photographs were taken by a professional photographer. Analysis was performed using the Adobe Photoshop CS2 (Adobe Inc, San Jose, CA) software tool.

Based on anthropometric values described by Farkas (17-19) predefined anatomic landmarks (Table 1) and distances (Table 2) were used to calculate the following indices (Table 3) in the frontal view photographs (Fig. 2): (1) Upper lip height-mouth width index, representing the vertical distance between the subnasale and the stomion (ULH, sn-sto) as percentage of the mouth width (MW, ch-ch). (2) Philtrum mouth width index, the philtrum width between the two crista philtri (PW, cph-cph), as percentage of the mouth width between the two cheilions (MW, ch-ch) (3). Medial-lateral cutaneous upper lip height index representing the cutaneous upper lip height, the vertical distance between the labiale superius and the subnasale (CULH, sn-ls), as percentage of the lateral upper lip height, the vertical distance between the subalare and the lateral labiale superius beyond the subalare (LULH, sbal-ls’) (4). Upper vermilion contour index, the mouth width (MW) as percentage of the upper vermilion arc (UVA, ch-ls-ch) (5). Lower vermilion contour index, the mouth width (MW) as percentage of the lower vermilion arc (LVA, ch-li-ch) (6). Vermilion arc index, the lower vermilion arc (LVA) as percentage of the upper vermilion arc (UVA).

In the profile photographs the following data were recorded (Fig. 3): (1) Vermilion total upper lip height index represented by the upper vermilion height, the vertical distance between labiale superius and stomion (UVH, ls-sto) (2). Cutaneous total upper lip height index, the vertical distance between labiale superius and stomion (UVH, ls-sto) as percentage of the upper lip height (ULH, sn-sto) (2). Cutaneous total upper lip height index, the vertical distance between cutaneous upper lip height (CULH, sn-ls) as percentage of the upper lip height, the vertical distance between cutaneous upper lip height (CULH, sn-ls) as percentage of the upper lip height, the vertical distance between labiale superius and stomion (UVH, ls-sto).
distance between subnasale and stomion (ULH, sn-sto) (3). Vermillion height index, represented by the upper ver- 
million height (UVH, ls-sto), as percentage of the lower 
vermillion height (LVH, sto-li) (4). Vermillion total lower 
lip height index, the lower vermilion height, the vertical 
distance between stomion and labiale inferius (LVH, sto-
li) as percentage of the lower lip height (LLH, sto-sl) (5). 
Cutaneous total lower lip height index represented by the 
cutaneous lower lip height, the vertical distance be- 
tween the labiale inferius and the sublabiale (CLLH, li-sl), as 
percentage of the lower lip height, the vertical distance 
between the stomion and the sublabiale (LLH, sto-sl) (6). 
Nasal tip protrusion-nose height index, the nasal tip pro-
trusion (NTP, sn-prn), as percentage of the nose height 
(NH, n-sn) (7). Ala length-nose height index, representing 
the ala length (AL, ac-prn), as percentage of the nose height 
(NH, n-sn) (8) Nasal bridge index, the nasal bridge 
length (n-prn) as percentage of the nose height (n-sn) (9). Nose- upper face height index, the nose height (NH, 
(n-sn), as percentage of the upper face height (UFH, n-sto) 
(10). Nose- lower face height index, the nose height (NH, 
n-sn), as percentage of the lower face height (LFH, sn-gn) 
(11). Nose- face height index, the nose height (NH, n-sn), 
as percentage of the face height (FH, n-gn) (12). Upper 
lip nose height index, the upper lip height (ULH, sn-sto), 
as percentage of the nose height (NH, n-sn) (13). Upper face- 
face height index, the upper face height (UFH, n-sto), 
as percentage of the face height (FH, n-gn) (14). Upper lip- 
mandible height index, representing the upper lip height (ULH, sn-sto), as percentage of the mandible 
height (MH, sto-gn) (15). Chin- mandible height index, 
the chin height (CH, sl-gn), as percentage of the mandible 
height (MH, sto-gn).

Lateral cephalograms were taken preoperatively as well 
as three and nine months postoperatively. SNA and SNB 
angle as well as Wits appraisal as established cephalo-
metric measurements in the appraisal of orthognathic 
surgery were raised.

| Dimension                  | Name of index                                      | Description                                                                 |
|----------------------------|---------------------------------------------------|----------------------------------------------------------------------------|
| En face indices            | Upper lip height-mouth width index                | Subnasale-stomion/Cheilion(I)-Cheilion(r)                                  |
|                            | Philtrum-mouth width index                        | Crista philter®-christa pholtre(I)/Cheilion(I)-Cheilion(r)                 |
|                            | Medial-lateral cutaneous upper lip height index   | Subsanale-labiale superius-Subalare-labiale superius lateralis             |
|                            | Upper vermilion contour index                     | Cheilion(r)-cheilion(I)/Cheilion(r)-labiale superius-cheilion(I)           |
|                            | Lower vermilion contour index                     | Cheilion(r)-cheilion(I)/Cheilion(r)-labiale inferius-cheilion(I)           |
|                            | Vermilion arc index                               | Cheilion(r)-labiale inferius-cheilion(I)/Cheilion(r)-labiale superius-cheilion(I) |
|                            | Vermilion-total upper lip height index           | Labiale superius-stomion/ Stomion- labiale inferius                        |
|                            | Cutaneous-total upper lip height index           | Subnasale-labiale superius/Subnasale-stomion                              |
|                            | Vermillion height index                           | Labiale superius-stomion/ Stomion- labiale inferius                        |
|                            | Vermillion-total lower lip height index          | Stomion-labiale inferius/Stomion-sublabiale                               |
|                            | Cutaneous-total lower lip height index           | Labiale inferius-sublabiale/Stomion-sublabiale                             |
|                            | Nasal lip protrusion-nose height index           | Subnasale-pronasale/Nasion-subnasale                                       |
|                            | Ala length- nose height index                     | Alar curvature point-pronasale/Nasion-subnasale                            |
|                            | Nasal bridge index                                | Nasion-pronasale/Nasion-subnasale                                         |
|                            | Nose-upper face height index                      | Nasion-subnasale/Nasion-stomion                                           |
|                            | Nose-lower face height index                      | Nasion-subnasale/Subnasale-gnathion                                       |
|                            | Nose-face height index                            | Nasion-subnasale/Nasion-gnathion                                          |
|                            | Upper lip-nose height index                       | Subnasale-stomion/ Nasion-stomion                                         |
|                            | Upper face-face height index                      | Nasion-stomion/Nasion-gnathion                                            |
|                            | Upper lip-mandible height index                   | Subnasale-stomion/ Nasion-gnathion                                         |
|                            | Chin-mandible height index                        | Sublabiale-gnathion// Stomion-gnathion                                    |
The desire to improve facial aesthetic and appearance is an important factor in seeking orthognathic treatment (20,21). A number of increasingly sophisticated techniques are available for orthognathic treatment and surgery planning (1). Currently, the most used method to analyse pre- to postoperative changes of hard and soft tissue is two dimensional analysis by cephalograms (22,23). Three dimensional models based on various techniques (2,11,22,24) are also in use, but because of high costs and difficult application not clinical routine.

In an earlier study we showed the value of photo-assisted anthropometric measurements to get a deeper understanding of facial morphologic changes related to mandibular advancement in Class II patients (3). In the presented study we investigated bimaxillary surgery related changes on the facial morphology of Class III patients.

The 21 anthropometric indices (Table 3) presented here were selected because of the reliable exact identification of their corresponding anthropometric landmarks (Tables 1,2) and their potential impact by bimaxillary surgery (19,20). To adequately evaluate facial pre- to postoperative changes, indices in profile as well as frontal view were investigated (12). In the following we describe the meaning of different facial aesthetic units and the investigated anthropometric landmarks and indices in bimaxillary orthognathic surgery:

Positioned in the center of the face, considerations about the morphology of the nose and its relation to upper lip and lower face are of major interest for aesthetic considerations in bimaxillary surgery. Nasion and subnasale are fundamental reference points in orthodontics and aesthetic surgery (5).

Located in the center of the face and dividing the upper lip in two lateral and one medial aesthetic subunits, the philtrum is of great importance for the facial appearance. Philtrum-mouth width index reflects the relation
of philtrum and mouth width. Upper lip height-mouth width index describes the vertical extension of the upper lip to the horizontal extension of the mouth width. Together with the medial lateral cutaneous upper lip height index it reflects the relation of mouth width, upper lip, and nose to each other. Upper and lower vermilion, their relation to each other and the upper and lower lips are from major importance.

Table 4. Comparison of pre- to postoperative cephalometric and anthropometric measurements.

|                        | Preoperative | 3 months postoperative | 9 months postoperative | Sign. Pre-to 3 months postoperative | Sign. Pre-to 9 months postoperative |
|------------------------|--------------|------------------------|------------------------|--------------------------------------|--------------------------------------|
| SNA (º)                | 83.1±4.83    | 85.08±4.46             | 85.12±4.15             | 0.046                                | 0.15                                 | 0.14                                 |
| SNB (º)                | 87.36±6.13   | 83.24±4.89             | 83.62±4.75             | <0.001                               | <0.001                               | <0.001                               |
| Wits appraisal (mm)    | -14.21±9.44  | 0.80±5.73              | 0.47±5.22              | <0.001                               | <0.001                               | <0.001                               |
| Upper lip height-mouth width index (%) | 37.23±6.80 | 42.6±8.42             | 40.67±6.37             | <0.001                               | <0.001                               | <0.001                               |
| Philtrum-mouth width index (%) | 21.67±3.32 | 22.63±2.46             | 22.40±2.63             | 0.176                                |                                      |                                      |
| Medial. Lateral cutaneous upper lip height index (%) | 84.37±10.82 | 86.77±12.44             | 84.83±11.34             | 0.180                                |                                      |                                      |
| Upper vermilion contour index (%) | 94.87±3.30 | 94.00±3.61             | 94.13±3.29             | 0.088                                |                                      |                                      |
| Lower vermilion contour index (%) | 95.70±2.56 | 94.40±3.76             | 95.30±2.94             | 0.018                                | 0.036                                | 1                                     |
| Vermilion arc index (%) | 98.77±5.09   | 99.00±5.74             | 98.10±4.80             | 0.396                                |                                      |                                      |
| Vermilion-total upper lip height index (%) | 34.07±9.14 | 34.20±8.18             | 34.33±8.44             | 0.963                                |                                      |                                      |
| Cutaneous-total upper lip height index (%) | 64.93±9.14 | 64.80±8.18             | 64.67±8.43             | 0.960                                |                                      |                                      |
| Vermilion height index (%) | 91.63±30.90 | 97.8±20.43             | 97.07±23.67             | 0.335                                |                                      |                                      |
| Vermilion-total lower lip height index (%) | 38.07±12.12 | 41.07±10.08             | 41.93±10.23             | 0.028                                | 0.264                                | 0.036                                |
| Cutaneous-total lower lip height index (%) | 61.00±12.14 | 57.93±10.08             | 57.13±10.22             | 0.028                                | 0.256                                | 0.038                                |
| Nasal lip protrusion-nose height index (%) | 38.67±4.48 | 38.63±4.43             | 38.67±4.11             | 0.982                                |                                      |                                      |
| Ala length-nose height index (%) | 56.87±6.96 | 55.17±7.22             | 54.73±6.19             | 0.102                                |                                      |                                      |
| Nasal bridge index (%) | 33.53±7.30   | 36.17±16.10             | 32.73±6.96             | 0.260                                |                                      |                                      |
| Nose-upper face height index (%) | 71.57±4.06 | 69.67±3012             | 69.63±3.02             | <0.001                               | <0.001                               | <0.001                               |
| Nose-lower face height index (%) | 70.07±6.10 | 70.53±6.50             | 70.37±6.01             | 0.586                                |                                      |                                      |
| Nose-face height index (%) | 40.70±2.15 | 41.03±2.30             | 40.87±2.08             | 0.139                                |                                      |                                      |
| Upper lip-nose height index (%) | 38.70±7.62 | 42.30±6.60             | 42.47±6.27             | <0.001                               | <0.001                               | <0.001                               |
| Upper face-face height index (%) | 56.90±2.54 | 58.57±2.43             | 58.53±2.27             | <0.001                               | <0.001                               | <0.001                               |
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for facial aesthetics. Their composition is directly influenceable by bimaxillary surgery. The vermilion-total upper and lower lip height indices describe the relation of the vermilion to the overall vertical height of their belonging lips. The vertical relation of the cutaneous fraction of the lips to the overall height of the lips describe the cutaneous-total upper and lower-lip height indices. Maxillary advancement and mandibular setback may have bigger impact on the vertical relations of upper and lower face, nose, mandible and chin. Considerations about the vertical relations of upper and lower face are not only beneficial in the planning and evaluation of bimaxillary surgery. In order to adequately rate the results of the anthropometric measurements, SNA and SNB angle as well as Wits appraisal as established cephalometric measurements in the estimation of orthognathic surgery were investigated as well (25,26).

Concerning the individual specifics of each patient, data of our patients were not differentiated between males and females as we did not aim at inter-individual changes or correlations. Instead pre- to postoperative changes were analyzed.

-Discussion of the Results

In the anthropometric measurements the significant increases of upper lip-mouth width index and upper lip nose height index pre- to postoperatively indicate an increased visible vertical length of the upper lip due to maxillary advancement and mandibular setback. Vermillion- and cutaneous-total upper lip height index did not show significant changes pre- to postoperatively. This finding is an indicator, that the vertical relation of vermilion and cutaneous fraction of the upper lip was not influenced, meanwhile the total vertical upper lip length increased, which is a typical result after bimaxillary correction of Class III deformities (27). The anthropometric measurements presented by Farkas may help to precisely detect these dimensions regarding vermilion and cutaneous part of the upper lip.

In contrast to the upper lips, the significant increase of the vermilion-total lower lip height index and decrease of the cutaneous-total lower lip height index indicate a changed vertical relation between cutaneous fraction and vermilion of the lower lips in favor of the lower vermilion pre- to postoperatively.

Mouth and philtrum width were reported earlier to present constant pre- and postoperative values after bimaxillary surgery in Class III patients (2). The constant pre- and postoperative values of the philtrum-mouth width index confirm this finding. The significant increase of upper face-face height index, upper lip-mandible height index and chin-mandible height index as well as decrease of nose-upper face height index reflect the vertical shortening of the lower face due to mandibular setback and vertical lengthening of the upper face due to maxillary advancement (28).

Although the postoperatively increased chin mandible height index indicates an increased vertical chin to mandible height, often a weak chin with little prominence may result after bimaxillary surgery or isolated mandibular setback in Class III patients. In this case genioplasty increasing the submental length and chin prominence may be performed (29).

In the cephalometric measurements the preoperative means of SNA and SNB angle were similar to those reported in class III patients (30). The significant increase of SNA and decrease of SNB angle are typical results of bimaxillary correction of Class III malocclusion (31).

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Conflict of interest
All authors state that there are no conflicts of interest. There were no financial or personal relationships that could inappropriately influence their work.