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MISCELLANEOUS

Analysis of select esthetic nasal parameters in virtually planned orthognathic patients

A. Özel[1] · B. Elbir[1,2] · Z. Çukurova Yilmaz[1] · S. Uçkan[1]

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Abstract

Purpose Bony changes after orthognathic surgery are always followed by changes of the overlying soft tissues. Therefore, morphologic changes of the nose may be expected after procedures involving the maxilla. The purpose of this study was to evaluate the changes in the nasal region due to orthognathic surgery using computed tomography (CT) images of virtually planned patients.

Methods 35 patients who underwent Le Fort I osteotomy, with or without bilateral sagittal split osteotomy, were included. 3D measurements on preoperative and postoperative images were performed and analyzed.

Results The results revealed that aesthetically acceptable results can be achieved by orthognathic surgery alone.

Conclusions According to the results of this study, it can be concluded that it is best to reserve decisions on rhinoplasty to the post-orthognathic period.

Keywords Nasal morphology · Orthognathic surgery · Rhinoplasty · Virtual surgical planning

Introduction

Orthognathic surgery is performed to treat dento-facial anomalies, which improves the patient's appearance and occlusal function. The aims of treatment are often to improve both aesthetic and masticatory functions by achieving the ideal position of the jaws in relation to each other and to the patient's face. After orthognathic surgery, soft tissues overlying the maxillomandibular complex adapt their shape to the new position of the bone segments. These bony changes also have an inevitable effect on the soft tissues of the naso-labial complex.

As the most prominent and centrally located feature of the face, the nose plays an important role in facial aesthetics. With the increasing importance of beauty in the twenty-first century, patients are now more concerned about the aesthetic outcomes of their surgery than the functional outcomes. In particular, undesirable alterations to the nose's appearance are the main causes of patient dissatisfaction in maxillary orthognathic surgery [1]. Therefore, it is crucial to predict nasal morphologic changes and inform patients about these changes before orthognathic surgery.

Changes in nasal morphology occur mostly by manipulation of the maxilla, such as maxillary impaction, down grafting, advancement, or in rare circumstances, maxillary setback. Maxillary setback is a very challenging procedure because of the presence of bilateral pterygoid plates. In rare cases when maxillary setback is performed, the naso-labial angle (NLA) increases [2]. Contrarily, advancement of the maxilla causes a decrease in NLA as well as widening of the alar base and upturning of the nasal tip. Inferior positioning of the maxilla is also reported to cause upturning of the nasal tip with an increase in the NLA, whereas superior positioning decreases the NLA [3].

So far, many studies have evaluated nasal morphologic changes and aesthetic outcomes after orthognathic surgery using current developments in 3D technology [4–6]. However, the aesthetic parameters used in these studies were limited. The purpose of this study was to evaluate nasal soft tissue changes after orthognathic surgery using select nasal aesthetic references.

✉ B. Elbir
elbirbegum@gmail.com

[1] Department of Oral and Maxillofacial Surgery, Istanbul Medipol University, School of Dentistry, Istanbul, Turkey

[2] Istanbul Medipol University, Institute of Health Sciences, Istanbul, Turkey

Materials and methods

This study complies with the principles stated in the Declaration of Helsinki "Ethical Principles for Medical Research Involving 'Human Subjects". Ethical approval #201 was taken from Istanbul Medipol University Ethical Committee for Clinical Studies on 18.02.2021.

Patient selection

A total of 35 patients (16 males, and 19 females) who underwent bimaxillary or only the Le Fort I osteotomy between September 2020 and September 2021 in Istanbul Medipol Mega University Hospital were included in this retrospective study. Informed consent was obtained from the patients. Preoperative and 6-month postoperative photographs were taken with corrected natural head position (NHP), which is defined by Lundström et al. [7] using a digital single-lens reflex camera (Nikon D90). Bimaxillary surgery (Le Fort I for the maxilla, and sagittal split osteotomy for the mandible) was performed taking either the maxilla or mandible first according to the patient's treatment plan. All surgeries were carried out by the same surgeon, and soft and hard tissue management was standardized. After incision and osteotomising the segments jaws were set to their new position by rigid internal fixation using mini plates and screws (KLS Martin, Baden, Germany). To perform classic alar base cinch technique, a 2.0 nonresorbable suture was used to pierce the lesser alar cartilage of each nostril and was then tightened until the presurgical alar base width was achieved. The V–Y closure, suturing of the muscles and mucosa was performed using a 4.0 polyglactin suture.

Preoperative and postoperative 3D documentation

Preoperative and 6-month postoperative CT scans were taken with Philips Brilliance ICT 256 Slice (Royal Philips, Netherlands). Images were taken with the patients in a supine position and their Frankfort horizontal plane parallel to the floor. Patients' maxillofacial regions were scanned (0.8 thickness, 120 kV, 200 mAs/slice, 10 s scan time, and 26 × 20 field of view), and the obtained Digital Imaging and Communication in Medicine data were reconstructed into 3D images using the NemoFAB (Nemotec S.L., Madrid, Spain) software. Hounsfield unit values for hard and soft tissues were 186 and -700, respectively.

3D measurements

Reconstructed 3D models of each patient were oriented according to the corrected NHP. The same measurements were separately performed by the same researcher for preoperative and postoperative reconstructions (Fig. 1). Measurements calculated with the NemoFAB software are defined in Table 1. Some measurements, stated with (A), were calculated automatically by the software.

Statistical analysis

All measurements were statistically analyzed using statistical software (SPSS Version 25; Chicago, IL, USA). The differences in the nasal soft tissue changes and skeletal movement after orthognathic surgery were analyzed using Student's paired *t* test, Wilcoxon signed ranks test, and Chi-squared test. The results were assessed at a significance level of $p < 0.05$.

Results

Table 2 shows the mean and standard deviation (SD) of the measurements for the preoperative and postoperative changes for both sexes.

No statistically significant difference was observed between the lobule/nostril ratio, nasal deviation, and nasal index before and after treatment ($p > 0.05$). The postoperative intercanthal distance to alar base ratio (ICD/AW) was found to be statistically significantly lower than the preoperative ICD/AW, and the postoperative columella–lobular angle was statistically significantly higher than the pretreatment columella–lobular angle ($p < 0.001$).

Table 3 shows the mean and SD of the measurements for preoperative and postoperative changes specific to genders.

No statistically significant difference was observed between the mean of the nasal-tip projection (A), columella–labial angle, or NLA before and after treatment in male patients ($p > 0.05$). Postoperative naso-frontal angle (NFA) values in male patients were statistically significantly lower than preoperative NFA averages ($p < 0.05$). No statistically significant difference was observed between the mean columella–labial and NLAs before and after treatment in female patients ($p > 0.05$). Postoperative nasal projection (A) in female patients was statistically significantly lower than preoperative nasal projection (A) ($p < 0.001$), and postoperative NFA in female patients was statistically significantly lower than preoperative NFA ($p < 0.05$).

Discussion

The present study evaluated nasal aesthetic changes after orthognathic surgery with aesthetic norms that are used in rhinoplasty. Our results showed that most of the features of the nose improved or stayed within the aesthetic range

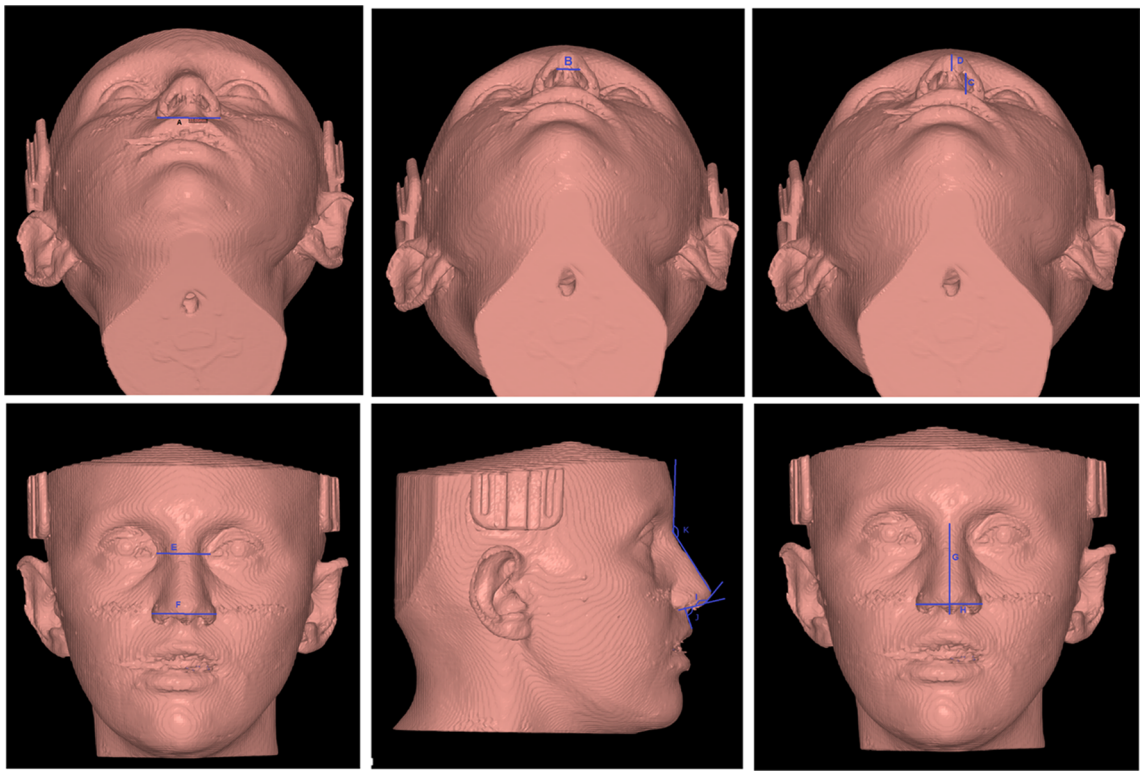


Fig. 1 Performed measurements

Table 1 Definitions of the 3D measurements

Measurement	Definition
Alar base width (AW)	Distance between the ending points of the two ala
Internostril width	Distance between the most superior points of the nostrils
Lobule/nostril ratio	Ratio between the distances from the nasal tip to the most superior point of the nostrils and from the most superior point of the nostrils to the most inferior point (ideally ½)
Intercanthal	Distance/alar Ratio between the distances between the two medial canthi base width ratio (ICD/AW) and the alar base width (ideally equal)
Amount of nasal deviation	Distance between the midline of the face and the nose
Nasal length	Distance between nasion and subnasale
Nasal width	Distance between the most lateral points of the two ala
Nasal index	(Nasal width/nasal length) × 100

after orthognathic surgery. Procedures used during the surgery, such as alar cinch suture, wound closure techniques, anterior nasal spine reduction, contouring of the pyriform aperture, and nasal septum reduction, also have an important role in postoperative nasal aesthetics. However, in our study, maxillary movements were independently assessed from these determinants because of the standardized approach employed for all surgeries, which includes the conventional Le Fort I osteotomy with dissection and suturing of nasal muscles, and alar cinch suturing. However, there are also some variables that cannot be controlled by the surgeon, such as adaptive potency of peripheral soft tissues, fat and muscle ratio and quantity, and postoperative edema formation. Le Fort I surgery generally affects the lower region of nose [8].

NLA is useful for assessing the relationship between the nose and upper lip for rhinoplasty. The ideal NLA for men and women is 90°–95° and 95°–115°, respectively [9]. Although NLA changes associated with Le Fort I have been reported in the literature, these changes were statistically

Table 2 Mean and SD of the measurements for preoperative and postoperative changes for both genders

	Preoperative	Postoperative	*p*
Lobule/nostril ratio	0.64 ± 0.17	0.63 ± 0.15	0.766[a]
Intercanthal distance/alar base ratio (ICD/AW)	1.04 ± 0.12	0.94 ± 0.11	**0.001**[a]
Nasal deviation	0.15 ± 1.94	− 0.23 ± 1.82	0.096[b]
Columella–lobular angle	27.07 ± 10.79	39.8 ± 12.1	**0.0001**[a]
nasal index	71.36 ± 12.97	74.62 ± 8.95	0.085[a]

[a]Paired *t* test

[b]Wilcoxon test

Bold means that p value is smaller than 0,001. (p < 0.001)

insignificant. In the present study, we found a decrease in NLA for female patients and an increase in NLA for male patients. However, these results were statistically insignificant. According to the literature and our results, we can conclude that NLA is a stable variable that cannot be changed significantly through orthognathic surgery. To modify this angle for nasal aesthetics, rhinoplastic procedures involving the vertical position or rotation of the nasal tip should be considered. In addition, the angle of the anterior teeth can be modified through orthodontic or restorative therapy to adjust the NLA for an ideal aesthetic.

A 1:2 lobule/nostril ratio is ideal in the basal view of the nose. With this ratio, oval and teardrop-shaped nostrils seem pleasant. Our results showed a statistically insignificant change in lobule/nostril ratio from 0.64 ± 0.17 to 0.63 ± 0.15 postoperatively ($p = 0.766$) which stayed in the ideal range. However, if there is a deviation from the ideal preoperatively, orthognathic surgery alone cannot correct this, so additional surgical procedures, such as modification of alar base, alar cinch suture, medialization of lateral crura, approximation of the footplates, alar rim graft, suspension of the entire lower lateral cartilage, and partial excision of redundant soft triangle lining may be needed [10].

Aesthetically, ICD/AW should be 1:1 [11]. In their study comparing healthy Caucasian noses to the aesthetic ideal, Leong et al. [12] found that the average AW of 3.6 cm was significantly wider than the average ICD of 3.0 cm. Our preoperative and postoperative proportions were 1.04 ± 0.12 and 0.94 ± 0.11, respectively, which was statistically different ($p = 0.001$). Even after alar cinch suture orthognathic surgery increases AW, decreasing ICD/AW [13–15]. Most studies have examined AW changes, but none have examined ICD/AW. Focusing on AW without ICD will not help assess the nose in frontal view for facial harmony. If AW increases to a point that disrupts ICD/AW, alar wedge excision, sill reduction, a combination of wedge and sill reduction, repositioning the alar insertion with a V–Y advancement flap, alar flap advancement, and multiple suturing techniques may help idealize ICD/AW [16].

NFA can be used in profile view to assess glabellar–nasal dorsum harmony. According to Lehocky [17], the ideal values for NFA are 130° for men and 134° for women. We found a statistically significant decrease in NFA from 142.8 ± 5.85 to 139.25 ± 7.56 for women and 137.77 ± 7.34 to 134.46 ± 8.6 for men. This decrease made the NFA approach ideal for women and men in our study group. The current study's findings support those of Atakan and Ozcirpici [18] and Worasakwutiphong et al. [19], who found a decrease in NFA postoperatively. These findings suggest that NFA may approach the ideal with orthognathic surgery alone; therefore, additional surgeries to modify NFA, including autologous and/or synthetic grafting, diced cartilage surgical technique, and crushed cartilage grafting, should be postponed to observe the outcome of orthognathic surgery.

The tip of the nose is an important factor for the columella–lobular angle, which is ideally 30°–45° [20]. Downward rotation of the lobule, creating an acute columella–lobular angle and a shortening of the vertical dimension of the lower third of the face, results in a relatively longer nose and a droopy tip that gives an older appearance [21]. Ustun et al. [22] and Suzen et al. [23] observed no statistically significant

Table 3 Mean and SD of the measurements for preoperative and postoperative changes specific to genders

	Preoperative	Postoperative	*p*
Nasal tip projection (A)	16.92 ± 3.11	16.36 ± 2.67	0.502[a]
Columella–labial Angle	97.78 ± 15.37	91.92 ± 9.98	0.194[a]
Naso-labial angle (NLA)	101.19 ± 13.12	104.47 ± 15.52	0.386[a]
Male Naso-frontal angle (NFA)	137.77 ± 7.34	134.46 ± 8.6	**0.025**[a]
Nasal tip projection (A)	15.32 ± 1.9	13.81 ± 2.43	**0.0001**[a]
Columella–labial angle	102.48 ± 14.34	98.69 ± 10.5	0.250[a]
Naso-labial angle (NLA)	100.62 ± 16.58	100.54 ± 12.54	0.968[a]
Female Naso-frontal angle (NFA)	142.8 ± 5.85	139.25 ± 7.56	**0.043**[a]

[a]Paired *t* test

Bold means that p value is smaller than 0,001. (p < 0.001)

change in columella–lobular angles. In contrast, our results show a statistically significant increase in columella–lobular angles from 27.07 ± 10.79 to 39.8 ± 12.1, confirming that our results were close to the ideal range.

Based on the nasal index, five morphological categories of the human nose have been described: hyperleptorrhine (40–54.9, very narrow), leptorrhine (55–69.9, long, and narrow), mesorrhine (70–84.9, moderate shape), platyrrhine (85–99.9, broad, and short) and hyperplatyrrhine (≥100, very broad/wide) [24].

Silva et al. [25] found no significant change in nasal index with Le Fort I. A change from 71.36 ± 12.97 to 74.62 ± 8.95 was found in our study group, which was not statistically significant ($p = 0.085$). Although linear measurements of height and width were drastically altered following maxillary advancement, the nasal index did not change. In addition, the leptorrhine type is generally associated with Caucasians, while the mesorrhine is associated with Asians. Our results show that nasal index tends to alter from the Caucasian to the Asian range.

An abnormally projected nose attracts all the attention on the face and frequently throws the other facial structures out of proportion due to its relatively increased volume. The difference between the nasal-tip projection before and after treatment for female patients in our study was found to be 15.32 ± 1.9 and 13.81 ± 2.43, respectively, which was statistically significant ($p = 0.0001$). We found that female patients' nose accentuation decreased, which was pleasing. Male patients' pre- and post-treatment nasal-tip projections were 16.92 ± 3.11 and 16.36 ± 2.67, respectively, and these values did not statistically differ significantly and remained within the aesthetic range ($p = 0.502$).

In profile view, the desired columella–labial angle is 95°–100° for men and 100°–110° for women [26]. The columellar base appears fuller, and the alar–columellar proportion is improved if the columella–labial angle is within these limits. In our study, columella–labial angle decreased from 102.48 ± 14.34 to 98.69 ± 10.5 in women and from 97.78 ± 15.37 to 91.92 ± 9.98 in men, which was not statistically significant ($p = 0.25$ and $p = 0.194$, respectively). Columella–labial angle in men and women were within the aesthetic range pre- and postoperatively, but they became more acute postoperatively. Most literature states that maxilla advancement and impaction only cause minor columella–labial changes that reduce the angle. However, several authors have observed a columella–labial angle increase [27]. Gassmann et al. [28] found a slight correlation between maxilla horizontal movement and columellar angle. The anterior nasal spine can affect the columella–labial angle [8]. Keeping the nasal spine may increase nasal-tip movement. Some researchers have found no correlation between nasal morphology and anterior nasal spine removal or retention. Our surgical protocol did not include ANS removal, which does not appear to have had a significant impact on the columella–labial angle.

Given that maxillary surgery seems to affect the nose, it may be advantageous to undertake rhinoplasty separately after assessing the outcome of orthognathic treatment on the nose. The function of rhinoplasty during maxillomandibular surgery has previously been addressed by Altman and Oeltjen [29]. They concluded that it is challenging, if not impossible, to foresee changes in nasal morphology following orthognathic surgery. It is still controversial whether it is desirable to combine orthognathic surgery with rhinoplastic techniques in a single surgical operation, because the current study also showed nasal alterations when conducting orthognathic surgery, and these alterations were in the nasal aesthetic range. This is the first study, to our knowledge, that examines post-orthognathic nasal modifications while taking aesthetic nasal values into account.

Conclusions

The findings suggest that without simultaneous rhinoplasty, aesthetically acceptable results can be achieved, and it is best to reserve decisions on rhinoplasty to the post-orthognathic period. Understanding these postsurgical changes may prevent the need for additional surgeries and improve the patient's and the surgeon's postoperative preparation.

Data availability The data that support the findings of this paper are available on request from the corresponding author, B. Elbir.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

References

1. Naini FB, Gill DS (2017) Orthognathic surgery: principles, planning and practice. John Wiley Sons
2. Seon S, Lee H-W, Jeong B-J, Lee B-S, Kwon Y-D, Ohe J-Y (2020) Study of soft tissue changes in the upper lip and nose after backward movement of the maxilla in orthognathic surgery. J Korean Assoc Oral Maxillofac Surg 46(6):385–392. https://doi.org/10.5125/jkaoms.2020.46.6.385
3. de Sousa P, Gil A, Guijarro-Martínez R, Haas OL, Hernández-Alfaro F (2019) Threedimensional analysis of nasolabial soft tissue changes after Le Fort I osteotomy: a systematic review of the literature. Int J Oral Maxillofac Surg 48(9):1185–1200. https://doi.org/10.1016/j.ijom.2019.01.028
4. Park S-B, Yoon J-K, Kim Y-I, Hwang D-S, Cho B-H, Son W-S (2012) The evaluation of the nasal morphologic changes after bimaxillary surgery in skeletal class III maloccusion by using the superimposition of cone-beam computed tomography (CBCT)

volumes. J Cranio-Maxillofac Surg 40(4):e87–e92. https://doi.org/10.1016/j.jcms.2011.05.008
5. Jeong H-I, Lee H-S, Jung Y-S, Park H-S, Jung H-D (2017) Nasal soft tissue change following bimaxillary orthognathic surgery. J Craniofac Surg 28(7):e605–e608. https://doi.org/10.1097/SCS.0000000000003736
6. Jung J, Lee C-H, Lee J-W, Choi B-J (2018) Three-dimensional evaluation of soft tissue after orthognathic surgery. Head Face Med 14(1):21. https://doi.org/10.1186/s13005-018-0179-z
7. Lundstrom A, Lundstrom F, Lebret LML, Moorrees CFA (1995) Natural head position and natural head orientation: basic considerations in cephalometric analysis and research. Eur J Orthod 17(2):111–120. https://doi.org/10.1093/ejo/17.2.111
8. Betts NJ (2000) Techniques to control nasal features. Atlas Oral Maxillofac Surg Clin 8(2):53–69. https://doi.org/10.1016/S1061-3315(18)30032-5
9. Orten SS, Hilger P (2016) Facial plastic and reconstructive surgery. Thieme
10. Suh MK (2018) Atlas of Asian rhinoplasty. Springer
11. Leong SCL, White PS (2006) A comparison of aesthetic proportions between the healthy Caucasian nose and the aesthetic ideal. J Plastic Reconstr Aesthet Surg 59(3):248–252. https://doi.org/10.1016/j.bjps.2005.08.008
12. Leong SCL, White PS (2004) A comparison of aesthetic proportions between the oriental and Caucasian nose. Clin Otolaryngol Allied Sci 29(6):672–676. https://doi.org/10.1111/j.1365-2273.2004.00891.x
13. van Loon B, van Heerbeek N, Bierenbroodspot F, Verhamme L, Xi T, de Koning MJJ, Ingels KJAO, Bergé SJ, Maal TJJ (2015) Three-dimensional changes in nose and upper lip volume after orthognathic surgery. Int J Oral Maxillofac Surg 44(1):83–89. https://doi.org/10.1016/j.ijom.2014.08.001
14. Howley C, Ali N, Lee R, Cox S (2011) Use of the alar base cinch suture in Le Fort I osteotomy:is it effective? Br J Oral Maxillofac Surg 49(2):127–130. https://doi.org/10.1016/j.bjoms.2010.02.009
15. Ubaya T, Sherriff A, Ayoub A, Khambay B (2012) Soft tissue morphology of the naso-maxillary complex following surgical correction of maxillary hypoplasia. Int J Oral Maxillofac Surg 41(6):727–732. https://doi.org/10.1016/j.ijom.2012.01.019
16. al Arfaj AM, Obeid AA, Subhan Y (2017) Excessive alar base resection in rhinoplasty. Plastic Surg Case Stud 3:251. https://doi.org/10.1177/2513826X17716453
17. Lehocky BE (2006) Plastic surgery. Elsevier Saunders
18. Atakan A, Özçırpıcı AA (2021) Correlation between cephalometric nasal changes and patients' perception after orthognathic surgery. Am J Orthod Dentofac Orthop 159(6):e449–e460. https://doi.org/10.1016/j.ajodo.2020.11.034
19. Worasakwutiphong S, Chuang Y-F, Chang H-W, Lin H-H, Lin P-J, Lo L-J (2015) Nasal changes after orthognathic surgery for patients with prognathism and Class III malocclusion: analysis using three-dimensional photogrammetry. J Formos Med Assoc 114(2):112–123. https://doi.org/10.1016/j.jfma.2014.10.003
20. Pessa JE, Rohrich RJ (2013) Plastic surgery. Elsevier Saunders
21. Rohrich RJ, Hollier LH, Janis JE, Kim J (2004) Rhinoplasty with advancing age. Plast Reconstr Surg 114(7):1936–1944. https://doi.org/10.1097/01.PRS.0000143308.48146.0A
22. Üstün GG, Konaş E, El H, Akarsu Güven B, Dağ O, Kamburoğlu H, Mavili ME (2020) The effects of maxillary movements on nasal aesthetics following orthognathic surgery. J Craniofac Surg 31(3):796–800. https://doi.org/10.1097/SCS.0000000000006167
23. Suzen M, Dilaver E, Uckan S (2021) Analysis of gull in flight appearance and related parameters following Le Fort I osteotomy. J Craniofac Surg 32(6):2008–2011. https://doi.org/10.1097/SCS.0000000000007484
24. Porter JP, Olson KL (2003) Analysis of the African American female nose. Plast Reconstr Surg 111(2):620–626. https://doi.org/10.1097/01.PRS.0000042176.18118.99
25. da Silva AMBR, Magri LV, Osborne PR, Trivelatto AE, Sverzut CE, da Silva MAMR (2019) Three-dimensional nasal alterations in Le Fort I advancement. J Craniofac Surg 30(4):1125–1130. https://doi.org/10.1097/SCS.0000000000005103
26. Sherris DA, Kern EB (1998) Otolaryngology head neck surgery. Mosby-Year Book Inc
27. Mommaerts MY, Lippens F, Abeloos JVS, Neyt LF (2000) Nasal profile changes after maxillary impaction and advancement surgery. J Oral Maxillofac Surg 58(5):470–475. https://doi.org/10.1016/S0278-2391(00)90002-8
28. Gassmann CJ, Nishioka GJ, van Sickels JE, Thrash WJ (1989) A lateral cephalometric analysis of nasal morphology following Le Fort I osteotomy applying photometric analysis techniques. J Oral Maxillofac Surg 47(9):926–930. https://doi.org/10.1016/0278-2391(89)90375-3
29. Altman JI, Oeltjen JC (2007) Nasal deformities associated with orthognathic surgery. J Craniofac Surg 18(4):734–739. https://doi.org/10.1097/SCS.0b013e3180684328

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