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Postoperative volume increase of facial soft tissue after percutaneous versus endonasal osteotomy technique in rhinoplasty using 3D stereophotogrammetry*

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SUMMARY

Background: *When lateral osteotomies are performed as part of a rhinoplasty, the nose and paranasal region invariably change in three dimensions.*
The purpose of this study is to compare the effect of the percutaneous perforating and endonasal continuous osteotomy techniques concerning the degree of postoperative swelling using three dimensional (3D) stereophotogrammetry.
Methodology: *A prospective follow-up study was conducted. Patients requiring bilateral osteotomies were included and randomly underwent a percutaneous osteotomy on one side and an endonasal osteotomy on the other side. Pre- and postoperative 3D photos were acquired using 3D stereophotogrammetry. Volumetric measurement data were acquired from the paranasal region using 3D software. Measurements were compared using Student's t-test and Wilcoxon signed rank test statistics.*
Results: *Twenty patients were included. A percutaneous osteotomy was performed on the right side in nine patients and on the left side in 11 patients. The total volume, the volume of the right paranasal and left paranasal region were significantly larger postoperative. No difference was found between the sides.*
Conclusions: *No difference concerning swelling is found between the percutaneous and endonasal osteotomy technique sides. With 3D stereophotogrammetry volumetric data can be acquired and compared to evaluate soft-tissue changes.*

Key words: osteotomy, percutaneous perforating, endonasal continuous, 3D sterophotogrammetry, volume, swelling

INTRODUCTION

Lateral osteotomies are frequently performed as part of a rhinoplasty for various purposes: to close an open roof after hump removal, to narrow a broad nasal pyramid or to correct an asymmetric lateral nasal wall contour. Although several techniques using different kinds of osteotomes and chisels have been described [(1)], the lateral osteotomy can be divided into two basic techniques: the percutaneous/perforating/ external osteotomy on one hand and the endonasal/continuous/internal osteotomy on the other hand. Both osteotomy techniques can be used in combination with an open approach as well as with a closed rhinoplasty technique.

The ideal lateral osteotomy should be precise, reproducible and safe with minimal postoperative sequelae such as edema, ecchymosis or scar formation. Critics of the percutaneous technique suggest that visible scars will be a result of using this technique, while advocates of the percutaneous technique suggest that the endonasal technique causes much more mucosal and periosteal disruption including subsequent bleeding and edema. Since few studies address this discussion using only clinical assessment as outcome measure, a randomized study to

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objectively assess both techniques was designed.

With the advent of three dimensional (3D) imaging techniques, such as 3D stereophotogrammetry, it is possible to capture and acquire measurements from the nose rapidly and non-invasively [2]. Specifically precise volumetric measurements concerning changes of the nose can now be calculated from 3D data [3,4].

The aim of this study is to compare the effect of the percutaneous perforating and endonasal continuous osteotomy techniques with regard to the degree of postoperative swelling using 3D stereophotogrammetry.

MATERIALS AND METHODS

Patients

The study sample comprised of patients from the department of Otorhinolaryngology of the Radboud University Nijmegen Medical Centre, the Netherlands. Inclusion criteria were the need for a bilateral osteotomy as well as a signed informed consent. Exclusion criteria were patients who required a dorsal augmentation as well as patients with associated craniofacial deformities or syndromes and earlier rhinoplastic surgery. Permission for the study was obtained from the ethical committees. After written informed consent was obtained, all participating patients were randomly assigned into two groups. In group one, a percutaneous perforating osteotomy was performed on the right side and an endonasal continuous osteotomy was performed on the left side. In group two, the endonasal continuous technique was performed on the right side and the percutaneous perforating technique on the left. The author (BvL) performing the measurements was blinded concerning the technique used on each side.

Operative procedure

All procedures were performed by the same surgeons (KI or NvH). A primary open rhinoplasty was performed in all patients. The right sided osteotomy was always performed before the left sided osteotomy and when paramedian osteotomies, a hump reduction, oblique or transversal osteotomies were necessary, these were performed before the lateral osteotomies. To delineate the lateral osteotomy, lines were drawn on the skin of the patient. The percutaneous osteotomy was performed through a three millimeter (mm) skin incision halfway the osteotomy to be made, without applying a local anesthetic. A three mm osteotome was used to scratch away the supraperiosteal tissue containing the angular artery. Then, 5 to 6 separate perforations through the nasal bone were made just a few millimeters apart using a 2 mm osteotome. The first perforation was made halfway the nasal bone, followed by perforations towards the piriform aperture. Furthermore, the superior part of the nasal bone was perforated. Finally, the nasal bone was infractured.
The endonasal osteotomy was performed with a 4 mm, guided osteotome. First, a local anesthetic was injected at the entry site just above the inferior turbinate followed by an incision just above the inferior turbinate so visualizing the edge of the piriform aperture. Second, a submucosal tunnel was created on the medial side of the nasal bone, the osteotome was inserted and the osteotomy was performed while the tip of the osteotome was palpated continuously through the skin. Finally, the nasal bone was infractured to complete the osteotomy. Great care was taken in both procedures to preserve a distal triangle of bone at the piriform aperture to prevent narrowing of the vestibule at the head of the inferior turbinate.

After the osteotomies had been completed, the nasal bones were shaped into the right position. Subsequently, local pressure was applied to the nasal pyramid during the remaining of the procedure until nasal packing was complete. Standard internal nasal packing was applied at the end of surgery. An adhesive thermoplastic external nasal splint was used in all cases. The nasal packing was removed after four to five days and the external splint was removed after 14 days.

Pre- and postoperative 3D documentation

A 3D stereophotogrammetrical camera setup with an integrated software program modular system V 1.0 (3dMDface™ System, 3dMD LLC, Atlanta, GA, USA) was used to capture 3D photos of the face. The 3D photos were generated from 6 2D photos taken simultaneously (4 grey-scale photos and 2 full color photos). A polygon light pattern was projected onto the 4 grey-scale photos. Based on this pattern and its deformed image, a 3D photo was reconstructed. With this system, it was possible to capture 180 degrees of the subjects face, which concurred with an ear to ear 3D photo.
The 3D photos were taken in natural head position and habitual occlusion. Patients were asked to relax their facial musculature, swallow and keep their molars in occlusion after swallowing [5]. 3D photos were acquired preoperatively as well as at the first clinical control visit postoperatively.

3D Measurements

To isolate the region of interest on the 3D photos, the neck and parts of the hair were trimmed using 3dMDpatient V3.0.1 software. After this the 3D photo was imported into Maxilim® version 2.2.2.1 (Medicim NV, Mechelen, Belgium) and a surface based matching procedure of the pre- and postoperative 3D photos was performed in 5 steps as described by our group [6]. After registration, a distance map could be calculated, which gave an indication of the soft tissue changes (Figure 1). A modified 3D cephalometric analysis was performed to outline the region of interest for the volumetric measurements. This analysis was based on the 3D cephalometric soft tissue analysis for CT data [7]. This resulted in the matched 3D photos on a Cartesian coordinate system with the regions of interest confined by various planes (Figure 2). These planes defined the borders of the volume of the paranasal swelling and were used for further circumscription of the 3D photo. Finally, only the paranasal regions were left and a virtual volume could be computed. The left and right paranasal volumes of the pre- and postoperative 3D photos were then measured.

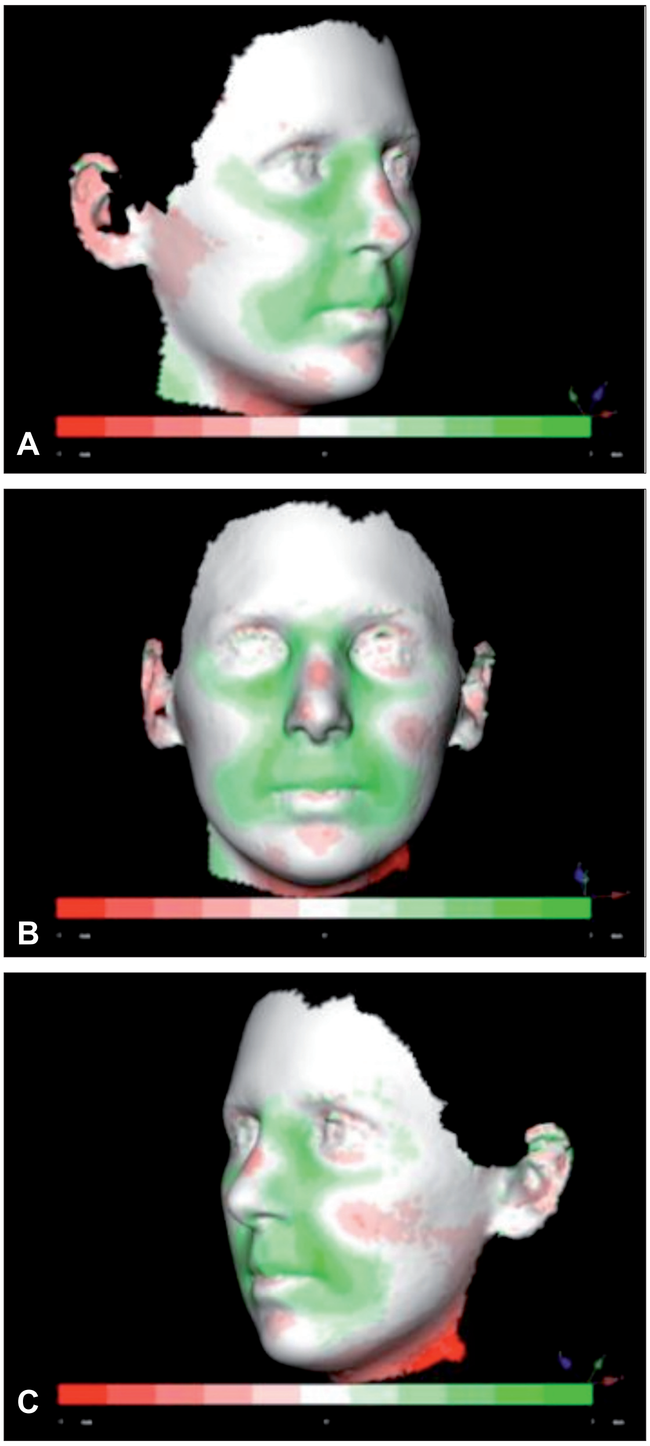

Figure 1. 3D distance map of the soft tissue changes after surgery. White indicates less than 0.5 mm difference between 3D photograps, red indicates decrease of volume and green an increase of volume.

Statistical analysis

The pre- and postoperative volume differences were calculated for the percutaneous and endonasal side for each patient. Pre- and postoperative differences were analysed using paired Student's t–tests and the Wilcoxon signed rank test statistics, with a p-value of < 0.05 indicating statistical significant differences. The statistical data analysis was performed with the SPSS software program, version 16.0 (SPSS Inc, Chicago, IL, USA).

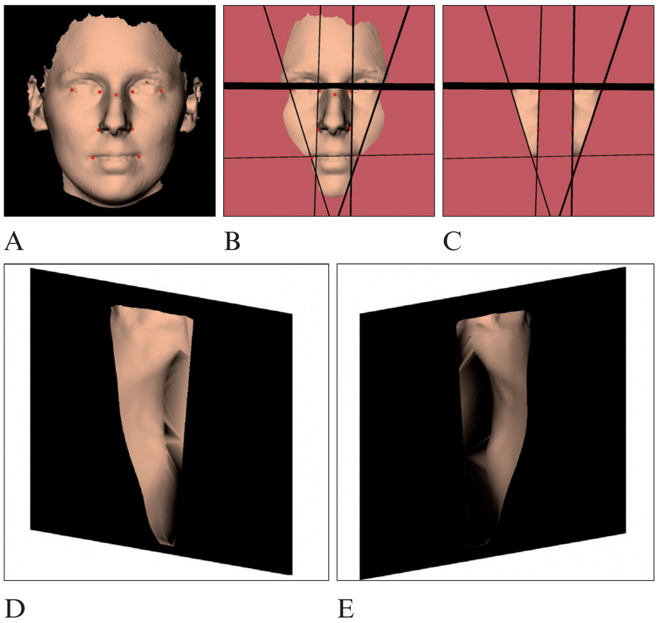

Figure 2. 3D stereophotogrammetric photograph of the face with the region of interested selected. A) Untextured 3D photograph with landmarks identified (red dots). B) and C) Planes derived from the landmarks to outline the paranasal area. D) right and E) left untextured cropped region of interest.

RESULTS

Patients

Twenty patients (10 male and 10 female) aged 20 to 55 years (median 35 years) were included in this study. Nine patients (5 male, 4 female) underwent a percutaneous osteotomy on the right side and an endonasal osteotomy on the left side, whereas 11 patients (5 male, 6 female) underwent a percutaneous osteotomy on the left side and an endonasal osteotomy on the right side.

Pre- and postoperative 3D documentation

Preoperative 3D photos were acquired 0-7 days prior to surgery (median 2 days) and postoperatively 3D photos were acquired after 4-5 days (median 4 days).

3D measurements

The volumes of the preoperative and postoperative paranasal regions are presented in Table 1. The preoperative volumes of the paranasal regions vary from 3,132 mm^3 to 10,638 mm^3 and the postoperative volumes vary from 3,993 mm^3 to 13,857 mm^3. The paired differences between the 3D photo's are given in Table 2 and illustrated in Figure 3. The total volume (mean volume difference = 3,149 mm^3, 95% CI: 2,339 mm^3 to 3,959 mm^3, p = 0.000) as well as the volume of the right paranasal (mean volume difference = 1,639 mm^3, 95% CI: 1,223 mm^3 to 2,053 mm^3, p = 0.000) and left paranasal region (mean volume difference = 1,510 mm^3, 95% CI: 1,053 mm^3 to 1,967 mm^3, p = 0.000) was significantly larger postoperative. No significant difference was found between the percutaneous and endonasal side (mean volume difference = 60 mm^3, 95% CI: -270 mm^3 to

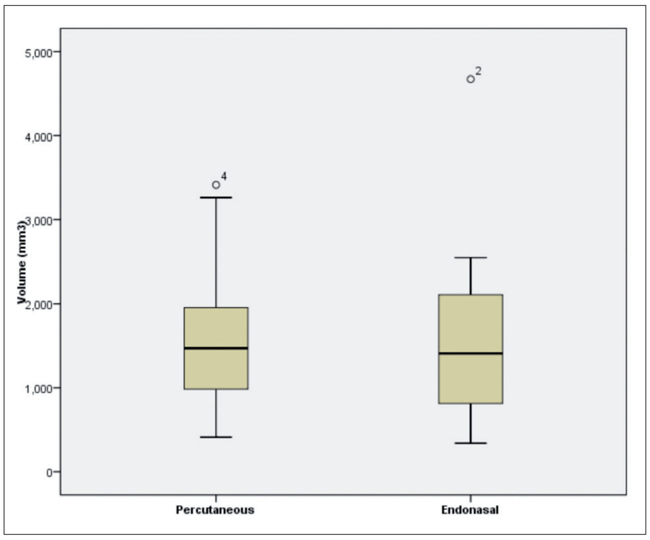

Figure 3. Boxplots of the percutaneous and endonasal osteotomie. The percutaneous and endonasal volumes are shown indicating no statistical difference.

390 mm^3, $p = 0.708$). The Wilcoxon signed rank test also indicated no statistical significant difference between the percutaneous and endonasal side ($p = 0.601$).

DISCUSSION

In this study, using 3D stereophotogrammetry, the degree of postoperative swelling was obvious in all patients (e.g. Figure 1). However, no difference was found concerning postoperative swelling when comparing the percutaneous perforating and endonasal continuous osteotomy technique. Previous studies that compared a variety of lateral nasal osteotomy techniques used various methods to analyse their results. Rohrich et al. [8] compared the results of both percutaneous perforating and endonasal continuous techniques endoscopically in fresh cadavers. They found that the percutaneous technique resulted in a more controlled fracture with less intranasal trauma measured by the occurrence of mucosal tears. In their clinical experience the percutaneous technique provides excellent control, is direct, and minimizes hemorrhage, edema, and ecchymosis postoperatively.

Gryskiewicz and Gryskiewicz studied several osteotomy techniques using clinical evaluation to compare them [9]. They compared the endonasal continuous osteotomy with the endonasal perforating osteotomy and percutaneous perforating osteotomy in different groups of patients and with different sides in the same patient. They used 2 mm osteotomes for the perforating osteotomies and 4 mm guarded osteotomes for continuous osteotomies. Three examiners determined whether a difference in ecchymosis and edema was present between the left and right side at 2, 7 and 21 days postoperatively. They demonstrated that the perforating technique performed through an endonasal approach caused less oedema and ecchymosis than the continuous technique performed endonasally. Although they concluded that their study confirms the clinical impression that percutaneous perforating lateral osteotomies with a 2 mm straight osteotome reduces postoperative ecchymosis and oedema compared with the endonasal continuous method, no statistical difference was found between these techniques. Concerning the comparison of the endonasal perforating and the percutaneous perforating technique, where the endonasal perforating osteotomy was superior to the percutaneous perforating method, also no statistical difference was found.

In another randomized study using clinical evaluation, Yücel [10] compared the percutaneous perforating technique in a group of patients with a group who underwent an endonasal continuous osteotomy by using a scoring diagram for oedema and ecchymosis. Two blinded surgeons made the comparisons. Yücel [10] found that ecchymosis was less on the second postoperative day in patients with the endonasal continuous osteotomy compared to the percutaneous perforating osteotomy group. However, on the seventh postoperative day, ecchymosis had already partly resolved and no difference was found anymore. During the postoperative period, no difference was found in degree of oedema [10].

In the 1850's, the first portfolio of stereoscopic photographs was created [11]. From that point on, stereography evolved from the crude dual camera systems of the past to modern 3D digital photographic systems, although both use the same principles. Offset images were merged together to create a stereoscopic image. With the advent of digital technology, digital photography has become an increasingly important tool in facial surgery [12]. The accuracy of these newly developed 3D imaging systems in recording facial morphologic features has recently been validated [13-15]. Several recent studies have focused on determining the reproducibility of identifying landmarks by using various 3D modalities including 3D stereophotogrammetry [2,13,14,16-20]. The results of these studies indicate the 3dMD system to be accurate and precise for facial purposes. Furthermore, the small error in placing landmarks doesn't lead to statistical significant different volumetric or symmetry measurements, as was found in a recent study by our group in which the pre- and postoperative volumes of the nose in cleft lip and palate patients was measured using 3D stereophoptogrammetry [3]. Nevertheless, several errors can be identified using this system. First, surface matching of the pre- and postoperative 3D photographs can result in minimal errors. Recently, our group published about the error of matching 3D photographs onto skin surfaces derived from CBCT data [6]. Results of matching two different 3D photos shows to be even more reliable [22]. In this way, a mean registration error of less than 0.6 mm was found that is clinically acceptable and valuable [13,22]. A second possible error exists in the definition of the planes and whether these define a representative area. The planes are based on the cephalometric analysis and define the region of interest and therefore the volume measured in this region. Volumes outside these planes are not measured and therefore, if the region of interest is not sufficient, data are missed. However, since the same planes are used for the

Table 1. Volumetric measurements of the 20 patients. Preoperative, postoperative and volume increase are given for the endonasal and percutaneous side.* indicates statistical significant increase between preoperative and postoperative.

		Endonasal side			Percutaneous side		
Perc side	Patient	Preop volume (mm³)	Postop volume (mm³)	Volume increase (mm³)	Preop volume (mm³)	Postop volume (mm³)	Volume increase (mm³)
Right	1	8654	9234	579	9106	9881	776
	2	6295	10968	4673	5866	8982	3116
	3	9450	11475	2025	9094	10749	1655
	4	7735	9922	2187	10443	13857	3413
	5	4119	5267	1148	9469	10940	1471
	6	6574	8899	2326	8147	11411	3264
	7	7656	8479	823	7572	9272	1700
	8	9053	10726	1673	6444	7941	1497
	9	6516	7202	686	7016	8126	1109
Left	10	7245	9793	2548	6606	8604	1998
	11	10639	12959	2321	7235	9144	1909
	12	9599	10699	1101	8126	9235	1109
	13	5845	6650	805	6475	7677	1201
	14	9386	10672	1285	9907	10319	412
	15	8558	8911	353	7738	8241	503
	16	4159	5449	1290	4157	6543	2386
	17	7045	7383	339	10082	10895	814
	18	7329	8916	1587	7542	8971	1430
	19	5561	7172	1612	3133	3993	860
	20	5604	7133	1529	5704	7169	1465
	Mean	7351	8895	1544*	7493	9097	1604*

Table 2. Paired Samples Test between the groups. Mean, SD and 95% Confidence intervals are given for the comparison of the difference between the percutaneous osteotomy and endonasal osteotomy side.

	Paired Differences					
	Mean difference	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Sig. (2-tailed)
				Lower	Upper	
Percutaneous pre-Percutaneous post	1604	871	195	1197	2012	< 0.001
Endonasal pre-Endonasal post	1544	994	222	1079	2010	< 0.001
Percutaneous -Endonasal	60	705	158	-270	390	0.708

pre- and postoperative 3D photographs, the volume difference measured gives a reliable indication of the volume in- or decrease caused by the osteotomy. Also, we do not know the influence of the 2 osteotomy techniques on the contralateral side. However, if one of the two techniques would have influenced the contralateral side more than the other technique, we would have found a difference in volume.

Although this study represents a small sample, significant statistical changes in the volume of the paranasal region could be proved postoperatively using 3D stereophotogrammetry. The power of this study is reflected in Table 2. A statistical significant difference would have been found if the difference between both techniques would be 330 or more (half the width of the confidence interval). The mean swelling for both techniques is about 1,600 mm³ (Table 1) indicating that a statistical significant difference would have been found when one of both techniques would reduce or increase swelling with 21 % (330/1,600). In this study, the mean difference between both techniques is just 60 mm³ (4%). The Student's t-test statistical analysis was used because of the small group with paired data. The Wilcoxon signed rank test was used as the group cannot be assumed to be normally distributed. Using these tests, the mean difference of the pre- and postoperative data could be analysed.

The above mentioned studies comparing the percutaneous and endonasal osteotomy technique all used clinical assessment as outcome measure. Although both the percutaneous as well as the endonasal technique are widely accepted and practiced, no studies have found statistical evidence of either the percutaneous osteotomy or the endonasal osteotomy resulting in differences concerning swelling. With the use of 3D digital images the rather qualitative outcome from the few studies that have been performed, is replaced by a quantitative outcome. Based on these data, apparently the suggested damaging of the mucosa by using the endonasal route doesn't lead to more or less swelling if compared to the percutaneous method. A tear in the mucosa on the inner side of the nasal bone at the level of the osteotomy, might even have a favorable effect on blood drainage.

CONCLUSIONS

The purpose of this study was to investigate and compare the degree of swelling caused by the percutaneous and endonasal osteotomy technique with the help of 3D stereophotogrammetry. No statistical significant difference was found between the percutaneous osteotomy and the endonasal osteotomy sides. With 3D stereophotogrammetry volumetric measurement data can be acquired from 3D photo's and these measurements can be compared to evaluate soft-tissue changes.

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CONFLICT OF INTEREST

None declared.

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