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Three-Dimensional Imaging in Rhinoplasty: A Comparison of the Simulated versus Actual Result

Sarah Persing[1,2] · Andrew Timberlake[2] · Sarika Madari[2] · Derek Steinbacher[1,2]

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Abstract

Purpose Computer imaging has become increasingly popular for rhinoplasty. Three-dimensional (3D) analysis permits a more comprehensive view from multiple vantage points. However, the predictability and concordance between the simulated and actual result have not been morphometrically studied. The purpose of this study was to aesthetically and quantitatively compare the simulated to actual rhinoplasty result.

Methods A retrospective review of 3D images (VECTRA, Canfield) for rhinoplasty patients was performed. Images (preop, simulated, and actual) were randomized. A blinded panel of physicians rated the images (1 = poor, 5 = excellent). The image series considered "best" was also recorded. A quantitative assessment of nasolabial angle and tip projection was compared. Paired and two-sample *t* tests were performed for statistical analysis ($P < 0.05$ as significant).

Results Forty patients were included. 67.5% of preoperative images were rated as poor (mean = 1.7). The simulation received a mean score of 2.9 (good in 60% of cases). 82.5% of actual cases were rated good to excellent (mean 3.4) ($P < 0.001$). Overall, the panel significantly preferred the actual postoperative result in 77.5% of cases compared to the simulation in 22.5% of cases ($P < 0.001$). The actual nasal tip was more projected compared to the simulations for both males and females. There was no significant difference in nasal tip rotation between simulated and postoperative groups.

Conclusion 3D simulation is a powerful communication and planning tool in rhinoplasty. In this study, the actual result was deemed more aesthetic than the simulated image. Surgeon experience is important to translate the plan and achieve favorable postoperative results.

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Keywords Three-dimensional imaging · Rhinoplasty · Simulation · Actual result

Introduction

Computer simulation is a powerful tool available during the cosmetic surgical consultation. It enables personalized visual information to improve the communication of both diagnostic and desired morphologies to the patient [1]. Traditionally, simulation was performed by hand or using a 2D computer image mock-up [2, 3].

Computer imaging has become increasingly useful for rhinoplasty procedures. One recent survey found that 63% of surgeons reported using computer imaging for their rhinoplasty consultations [2]. Previous research using two-dimensional (2D) computer imaging has shown a strong concordance between the simulated and postoperative results among both surgeons and patients [4]. The advent of three-dimensional (3D) computer imaging has helped to address some of the limitations of viewing structures in two dimensions. Three-dimensional simulation for rhinoplasty

✉ Derek Steinbacher
derek.steinbacher@yale.edu

[1] Yale New Haven Hospital, Section of Plastic and Reconstructive Surgery, New Haven, CT, USA

[2] Yale University, Section of Plastic Surgery, 333 Cedar Street, 3rd Floor, New Haven, CT 06511, USA

enables more precise evaluation of the nose for simulations and postoperative rhinoplasty result from more vantage points. It includes measurements for angle, distance, and area, as well as calculations of volume and topographic distances [5].

There are numerous studies that have compared various computer imaging modalities and their ability to accurately predict results based on the computer simulations [4, 6–10]. To date, a comparison of the simulated versus the actual or postoperative result has not been quantitatively studied using 3D computer imaging. The purpose of this study was to analyze the simulated versus actual rhinoplasty results according to their overall aesthetic appearance, as well as to quantify morphometric concordance of tip position between simulated and actual results.

Methods

Patients undergoing rhinoplasty at a large academic medical center by the senior author (DS) were retrospectively identified between the years 2013 and 2016. Inclusion criteria consisted of those patients with a complete panel of 3D imaging (VECTRA, Canfield Scientific) that included preoperative, simulation, and postoperative images. Acceptable postoperative images were collected at least 6 months after surgery. Patients were excluded from study if they had undergone concomitant orthognathic or cleft lip surgeries, were secondary cases, if their follow-up was less than 6 months after surgery, and/or without necessary 3D imaging.

3D rhinoplasty images were collected in frontal, lateral, and axial views for each patient and were randomly sorted into panels A, B, and C (Fig. 1). Participants were then asked to complete a survey based on the panel of images, where the participants were blinded as to whether the images were preoperative, simulated, or postoperative. The survey involved a visual rating Likert-type scale that was administered to a blinded panel of plastic surgeons and plastic surgery residents. Participants were asked to rate the images from 1 to 5, where 1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent. They were then asked to select the panel of rhinoplasty images they preferred (A, B, or C). These results were analyzed using descriptive statistics.

Independently, a quantitative assessment of nasolabial angle and tip projection was also compared. Statistical analysis involved paired t test ($P < 0.05$ as significant).

Results

There were 40 patients that met our inclusion criteria. Among our sample, 34 were female and 6 were male. The average age was 24 years. All patients had undergone open rhinoplasty. Preoperative and actual images were generated in VECTRA capture, with a mean follow-up period of 6.3 months (range: 6 months–1.2 years), and all simulation images were generated in the VECTRA rhinoplasty simulation module.

The surgeon panel rated the preoperative images as "Poor" in 67.5% of cases (mean score of 1.7). The simulation had a mean score of 2.9 ("Good" in 60% of cases and "Very Good" in 12.5% of cases), whereas the actual result had a mean score of 3.4, with 82.5% of actual cases rated as "Good" to "Excellent" ($P < 0.001$) (Fig. 2). Overall, the surgeon panel preferred the actual or

Fig. 1 A 27-year-old female with 3D preoperative, simulation, and 6-month postoperative images

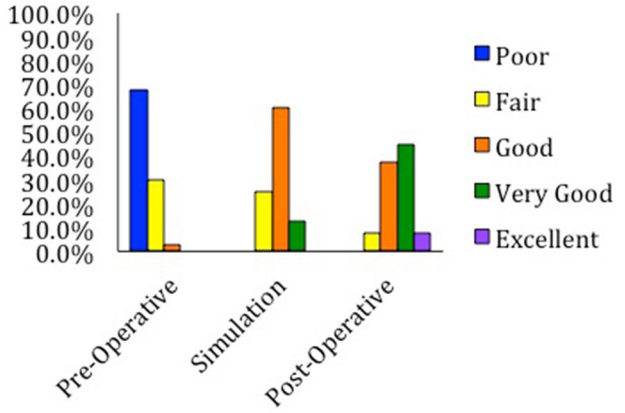

Fig. 2 Surgeon panel responses to the preoperative, simulated, and postoperative images

postoperative result in 77.5% of cases compared to the simulated images in 22.5% ($P < 0.001$) (Fig. 3).

Quantitative differences in tip projection (nasal tip to subnasale) and rotation (nasolabial angle) were assessed using paired t tests, with analyses performed independently for men ($n = 6$) and women ($n = 34$) (Table 1).

For preoperative and postoperative images among males, nasal tip projection and rotation were significantly greater in the actual images compared to the preoperative images ($P < 0.05$, $P < 0.05$). For preoperative and actual images among females, nasal tip projection and rotation were significantly greater in the actual images compared to the preoperative images ($P < 0.001$, $P < 0.001$).

The results for the simulated and postoperative images among males and females also show nasal tip projection to be significantly greater in the actual images compared to the simulated ($P < 0.05$, $P < 0.001$). However, tip rotation for simulated and actual images among males and females was not statistically different.

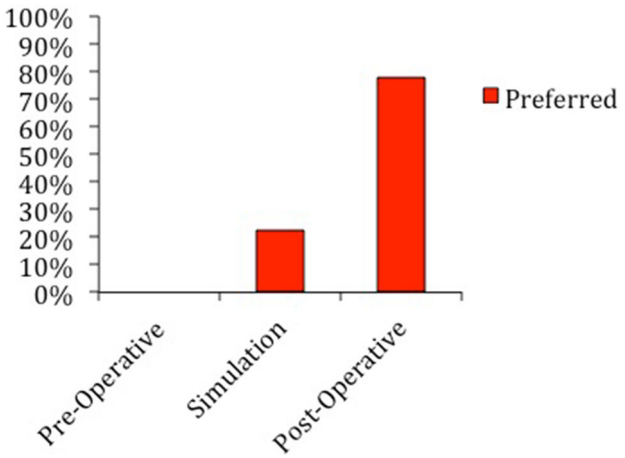

Fig. 3 Overall surgeon panel responses to the preoperative, simulated, and postoperative images

For preoperative and simulated images, tip rotation was significantly greater among both males and females ($P < 0.05$, $P < 0.001$). However, tip projection for preoperative and simulated images among both males and females was not statistically significant.

Discussion

Three-dimensional computer simulation has become popular for rhinoplasty procedures. It is an effective communication tool for surgeons and patients used to address problems, illustrate challenges, and view potential results, while permitting analysis from multiple vantage points. It also provides a mechanism for critical self-assessment and helps to identify patients who have unrealistic expectations for their rhinoplasty procedures. Although 3D simulation is a helpful adjunct to communicate possible outcomes, it is important for surgeons not to simulate something they cannot achieve. The surgeon should also be cognizant of his or her experience with the rhinoplasty procedure, its limitations, and the different techniques used to address variations in patient biology, as there is always some unpredictability with rhinoplasty. In this study, the overall postoperative rhinoplasty result was actually viewed more favorably by the surgeon panel than the 3D simulation in 77.5% of the cases.

Several previous studies have attempted to determine whether computer imaging is a reliable predictor of postoperative results in rhinoplasty. In 2002, Sharp et al. surveyed rhinoplasty patients who had 2D computer simulations and found that 64% of patients found the postoperative result to be equally or more aesthetic than predicted [9].

Muhlbauer and Holm [4] surveyed the ability of 2D computer imaging to accurately simulate the postoperative result among the surgeon authors and patients. They found that approximately 70 percent of the surgical results were rated identical or similar by the authors versus 80 percent by the patients [4].

In 2007, Agarwal et al. conducted a retrospective study of 25 consecutive rhinoplasty patients rated by 12 blinded surgeon raters, providing survey assessments of whether the 2D computer-morphed image was similar to the actual result. They found that approximately half of the surgeon raters felt that the computer-morphed image did realistically predict the postoperative result and 75 percent felt that the actual surgical result was either the same as or better than the predicted result.

Although there are prior studies comparing the simulated versus actual result in 2D analysis, there are no studies to date that have compared the simulation to the postoperative result in three dimensions. These previous

Table 1 Tip projection and tip rotation values among preoperative, simulated, and postoperative images

	Pre	Sim	*P* value	Pre	Post	*P* value	Sim	Post	*P* value
Males ($n = 6$)									
Nasal tip to subnasale (mm)	21.6	21.3	$P = 0.63$	21.6	23.5	$P < 0.05$	21.3	23.5	$P < 0.05$
Nasolabial angle (°)	101.8	114.5	$P < 0.05$	101.8	114.9	$P < 0.05$	114.5	114.9	$P = 0.53$
Females ($n = 34$)									
Nasal tip to subnasale (mm)	19.5	19.2	$P = 0.95$	19.5	20.9	$P < 0.001$	19.5	20.9	$P < 0.001$
Nasolabial angle (°)	114.4	123.7	$P < 0.001$	114.4	125.7	$P < 0.001$	123.7	125.7	$P = 0.12$

findings with the 2D technology, however, are consistent with our results. The actual result was consistently rated better than the simulation in our study. It is possible that the actual result was rated superiorly because the simulation may have been recognizably artificial. Whereas every effort was made to produce quality simulation images, tip refinements and manipulation of the dorsal aesthetic lines can be difficult using the software. Simulating a 3D aesthetic tip is a particular challenge, leading to images that may appear less smooth and thus less natural or aesthetic than actual photographs. There is also the possibility of selection bias, in that the surgeon may have also been inadvertently biased when performing the simulation, and may have unknowingly diminished, or "under-sold" the results he could achieve, making the actual results more aesthetically pleasing. Ultimately, however, it is the surgeon's experience and skill that have the greatest influence on an acceptable match of the simulation with the actual result.

The results also indicate that the actual result has significantly greater tip projection than the simulated images. There are several possible explanations for this observation. First, it is possible that a patient population seeking rhinoplasty could have underprojected noses to begin with, contributing to their decision to seek the procedure. It is also possible that the senior author's surgical technique is conducive to augmenting tip projection, as caudal septal extension grafts or columellar struts are often used to project the refined nasal tip or alter the nasolabial angle and thus tip rotation. Furthermore, it is also possible that a more projected tip tends to be rated as more aesthetic, or that increased tip projection is a reflection of efforts to create a supratip break, which contributes to a more aesthetic rating.

Despite our attempts to eliminate sources of bias by using independent, skilled observers in a blinded fashion, there were some limitations to our study. The 40 patients included in our study were only a subset of the total rhinoplasties, and may have been prone to selection bias, impacted by compliance and follow-up. There was also a strong female predominance in the sample (34 females, 6 males), so we may not have included a representative sample of the patients. Furthermore, we did not assess patient satisfaction for the simulated versus actual result, and we did not compare differences between trained and untrained observers as reviewers for the rhinoplasty result. We hope to include patient satisfaction and untrained reviewers of the rhinoplasty result in future study.

Conclusion

Computer imaging for patients undergoing rhinoplasty procedures is a helpful adjunct for operative planning and patient communication. The evolution of computer imaging into three dimensions has helped to address some of the limitations of viewing structures in two dimensions, enabling more precise evaluation of the rhinoplasty simulations and postoperative rhinoplasty result from more vantage points. In our study, the postoperative result was viewed more favorably by the surgeon panel than the 3D simulation. Additionally, the simulations and postoperative result also had greater measurements for nasal tip rotation and projection than the traditional "ideal" measurements. It is therefore important for both patients and surgeons to be aware of the limitations of 3D computer imaging and to consider that surgeon and/or patient aesthetic preferences may alter what is considered "ideal" for rhinoplasty. For future study, we plan to administer this survey to a patient sample to better understand perceptions about the simulation and postoperative result from the patient perspective.

Compliance with Ethical Standards

Conflict of interest The authors have no financial or conflicts of interest to disclose.

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