Three-Dimensional Printed Facial Models in Rhinoplasty

Tristan Klosterman, MD[1] Thomas Romo III, MD, FACS[2]

[1] Head and Neck Institute, Lenox Hill Hospital, New York
[2] Department of Otolaryngology, Manhattan Eye Ear and Throat Institute, New York

Facial Plast Surg

Address for correspondence Thomas Romo III, MD, FACS, Department of Otolaryngology, Manhattan Eye Ear and Throat Institute, 210 East 64th Street, NY 10021 (e-mail: dr.romo@romoplasticsurgery.com).

Abstract

Digital patient photography and morphing software have become an important part of rhinoplasty over the past few decades. Presented is a novel technology incorporating 3D photography and printing to produce life-size models for use in patient evaluation and treatment. Surveys were conducted to assess patient response and were universally positive. Early surgeon experience also indicates benefit for intraoperative use. Three-dimensional printing and modeling is a new technology that has exciting applications for rhinoplasty and facial plastic surgery.

Keywords
- rhinoplasty
- 3D printing
- technology
- facial plastics

Cosmetic and reconstructive surgeons have long-embraced innovative technologies such as digital photography and computer modeling to improve patient care.[1] As technology has advanced, surgeons have kept pace and incorporated photography morphing software to generate preoperative planning models.[2] Recently, practitioners have embraced 3D cameras to produce more comprehensive simulated models.[3,4]

While 3D computer models are useful, they are limited by their two-dimensional medium. Three-dimensional printing, which has seen recent remarkable applications ranging from organ generation to auricular frameworks in microtia repair, has an opportunity to bridge that gap.[4,5] Physical models made from 3D images can add this extra dimension and allow for new applications for both the surgeon and patient. Models can provide tactical and real-time feedback in consultation and offer a dramatic representation of surgical goals to patients.

Three-dimensional printed models are being used in our practice, but there are limited data on their clinical utility and patient perception. There is a significant potential benefit to the both the patient and the surgeon as a pre-, post-, and intraoperative aid. Patient responses have been initially positive, and therefore understanding their perspective will be uniquely important in evaluating the model's utility and application to rhinoplasty surgical evaluation and overall experience.

Methods

Six patients (1 male, 5 females, average age: 22) undergoing primary cosmetic rhinoplasty were electively asked to participate in this study using 3D printed model technology (MirrorMe3D Inc.). Standard evaluation practices were performed with both conventional and 3D (Canfield H1 Camera) photography. Computer morphing evaluations (Vectra Sculptor Software) were performed with the patients to produce 3D digital models. As with all morphing, patients were educated on the nature of simulation and discretion was used by the surgeon to produce models that were surgically feasible.

These 3D computer baseline and morphed models were then sent to MirrorMe3D Corporation for creation of life-sized 3D printed models of the patient's face (ProJet 660 using gypsum, wax, and cyanoacrylate). These models extended from the lateral pupil to lateral pupil and from the forehead to just above the chin (►**Fig. 1**). Models were produced overnight (5–8 hours) by the company's production facility and colored. Prices for individual models averaged U.S. $225 as of July 2016 and were purchased at retail price. There are no financial or academic affiliations between the authors and MirrorMe3D.

The baseline (base) and simulation printed models were then displayed to patients preoperatively and used to confirm procedure goals. Models were able to be referenced

Issue Theme The Aesthetics of the Upper face: Forehead, Brow and Upper Eyelid; Guest Editor: Fred Fedok, MD, FACS

DOI https://doi.org/10.1055/s-0038-1632398.
ISSN 0736-6825.

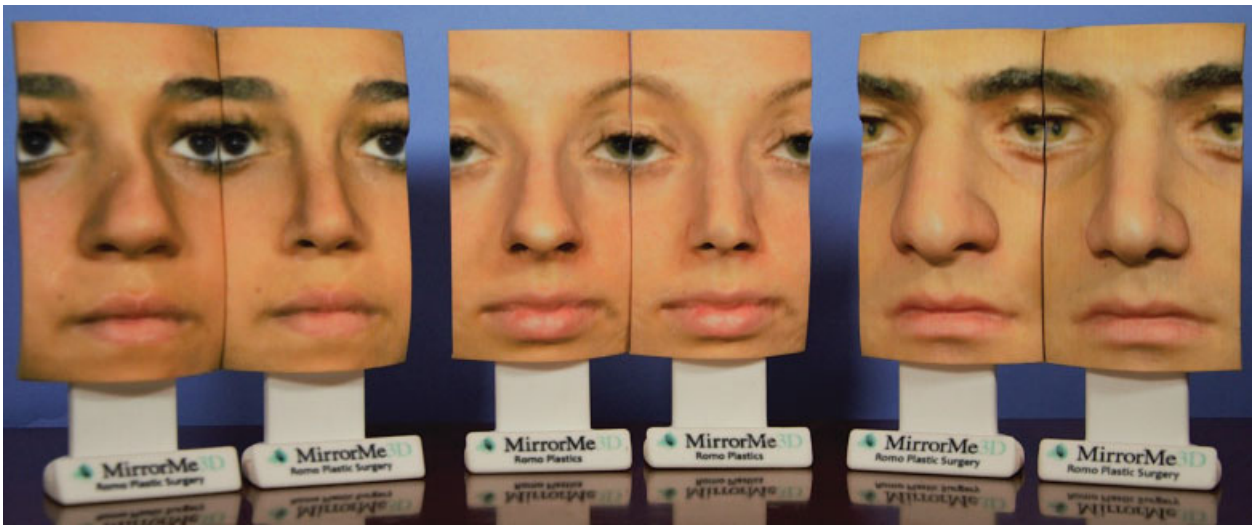

Fig. 1 Life-sized 3D printed models of three patients with the paired base (left) and simulation (right) noses.

intraoperatively by the surgical team (►**Fig. 2**). Close approximation of the model to the operative patient provided real-time feedback to the surgeon. Patients are seen for a routine postoperative visit where a 10-point postoperative survey was conducted regarding experience with the models and future model use (►**Fig. 3**). The models were additionally used as an outcome reference by the surgeon. Patients were otherwise followed in standard postoperative fashion. This project was approved by the institutional review board through the Human Research Protection Program at Northwell Health.

Results

Patient responses were highly complimentary of the models. All scored a 3 or 4, (somewhat or definitely agreed) with all categories (►**Table 1**). The only exception was that one patient reported that the models would not influence her choice of surgeon (score of 1).

Patients strongly agreed that the 3D models were useful and noted that they would request the use of models in the future. Patients expressed unanimous interest in using 3D models for future rhinoplasty or other cosmetic procedures. Comments from the survey showed a high regard being able to compare the preoperative and simulation model in real time, using tactile and visual feedback. Patients and their families reported a significant positive emotional response with the initial presentation of the models. At routine postoperative visits up to 6 months, subjective satisfaction remained high. Pre- and 6-month postoperative photography of the first patient to use the models is seen in ►**Fig. 4**.

The models were referenced intraoperatively in all cases. Specific comparisons such as bridge height, projection, and rotation facilitated decision making to better approximate the simulated model. The presence of intraoperative models allowed for minor modifications of surgical plan in a significant portion of the patients.

Fig. 2 Intraoperative photo comparing patient's preoperative nose to the simulation model.

Discussion

Digital photography, morphing software, and 3D cameras have offered patients and surgeons advanced tools in rhinoplasty, offering increasing patient satisfaction and cosmetic results.[4] Like many new technologies, adoption relies on proof of concept and data. We present a novel technology that is highly regarded by patients and advances existing technology.

These initial data are promising for the use of the 3D printed models for rhinoplasty. While this represents a focused view and primarily addresses the patient perspective, it introduces a technology that has application to many different plastic surgeries as well as rhinoplasty. Models can be created for facial augmentation (genioplasty and malar implants), otoplasty, rhytidectomy, blepharoplasty, and combined procedures with exciting promise. Survey data suggest that models may be requested by patients in the future, and their availability might affect their surgeon choice. Significantly, patients reported improved satisfaction

The use of the 3D Model:	Definitely Disagree	Somewhat Disagree	Somewhat Agree	Definitely Agree
Helped me feel confident in the procedure goals	1	2	3	4
Improved understanding of my nose	1	2	3	4
Is more helpful than the computer simulation alone	1	2	3	4
Improved my rhinoplasty evaluation	1	2	3	4
Positively changed my surgical expectations	1	2	3	4
Positively influenced my decision for rhinoplasty	1	2	3	4

In the future:	Definitely Disagree	Somewhat Disagree	Somewhat Agree	Definitely Agree
I would request a 3D model prior to rhinoplasty	1	2	3	4
I would recommend it to family and friends	1	2	3	4
Having it available might influence my choice of surgeon	1	2	3	4
I would be interested in using it for other cosmetic procedures	1	2	3	4

Fig. 3 3D model postoperative patient survey.

Table 1 Patient survey results with the number of individual answer selections

Patient	Age	Sex	Definitely disagree	Somewhat disagree	Somewhat agree	Definitely agree
1	18	F			4	6
2	19	F			5	5
3	16	F	1		7	2
4	18	M			1	9
5	44	F			3	7
6	26	F			2	8

Abbreviations: F, female; M, male.

and understanding of the goals of the procedure. Two patients reported that tactile interaction was specifically helpful in translating conceptual models into reality. Patients expressing apprehension or anxiety may benefit from the added feedback of a model before proceeding with surgery.

An additional facet of these models is as an intraoperative aid for the surgeon. Having both baseline and simulation models pre- and intraoperatively allow for added surgical precision. Full-sized morphed models can be held up to the patient as the operation progresses to better assess progress and goals. In our surgical practice, we have subjectively noted higher surgeon intra- and postoperative outcome satisfaction with the use of the models while also positively affecting surgical decision making. Significantly, this is an introductory study and is limited by its size and design. Further data are needed to fully assess these findings. Specifically, to compare this with other technologies and better identify the role of 3D printed models in contemporary rhinoplasty.

Conclusion

Rhinoplasty is an incredibly complex and difficult surgery that has benefited from new technology in the planning and operative stages. Three-dimensional photography and

Fig. 4 Pre- (**A**, **C**) and 6-month postoperative (**B**, **D**) images of second model pair in ►**Fig. 1**.

printed models are a novel advance that holds significant promise in the field of facial plastic surgery. These initial data are an important step in introducing and supporting this technology. Rhinoplasty-printed models are an exciting tool for assisting patients and surgeons in their planning and interventions.

References

1 Byrd HS, Hobar PC. Rhinoplasty: a practical guide for surgical planning. Plast Reconstr Surg 1993;91(04):642–654, discussion 655–656
2 Hamilton GS III. Morphing images to demonstrate potential surgical outcomes. Facial Plast Surg Clin North Am 2010;18 (02):267–282
3 Honrado CP, Larrabee WF Jr. Update in three-dimensional imaging in facial plastic surgery. Curr Opin Otolaryngol Head Neck Surg 2004;12(04):327–331
4 Toriumi DM, Dixon TK. Assessment of rhinoplasty techniques by overlay of before-and-after 3D images. Facial Plast Surg Clin North Am 2011;19(04):711–723, ix
5 Berens AM, Newman S, Bhrany AD, Murakami C, Sie KC, Zopf DA. Computer-aided design and 3D printing to produce a costal cartilage model for simulation of auricular reconstruction. Otolaryngol Head Neck Surg 2016;155(02):356–359