

Three-dimensional Morphing and Its Added Value in the Rhinoplasty Consult

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Background: The evolving literature on 3D surface imaging demonstrates that this technology is becoming the preferred simulation technique in hospitals and research centers. However, no study has demonstrated before the superiority of this facility over standard 2D simulation during preoperative evaluation in rhinoplasty.

Methods: One hundred seventy-two consecutive patients requesting rhinoplasty were included. Patients answered a questionnaire following a 2D simulation and subsequently experienced 3D morphing. A single question was answered regarding the added value of the latter by patients and surgeons, respectively.

Results: In our survey, satisfaction with 2D morphing reached 61%. Ninety-five percentage of the same group considered 3D simulation an added value over 2D. Additionally, 84% of patients requesting revision rhinoplasty admitted that 3D computer simulation has helped them understand the aims of surgery, in contrast to 61% of patients from the primary group. Furthermore, patients unsatisfied with their 2D simulation got reassured following 3D simulation to undergo surgery at a higher percentage (67%), compared with the group initially satisfied with 2D (48%). Women appeared reassured by 3D imaging in higher percentage (63%) compared with men (42%). The 2 surgeons, however, found 3D simulations to be an added value in 66% and 74% of all patients.

Conclusions: The overwhelming majority of our patients considered 3D simulation an added value over 2D. Patients initially unsatisfied with 2D morphing, revision rhinoplasty patients, and women seemed to be the groups that appreciated more 3D than 2D computer simulation. In contrast, surgeons considered the facility of 3D an added value in two-thirds of the patients. (*Plast Reconstr Surg Glob Open* 2019;7:e2063; doi: 10.1097/GOX.0000000000002063; Published online 4 January 2019.)

INTRODUCTION

Presently, computer imaging is progressing from 2D to 3D models, optimizing the surgeons' capacity to perform morphing in the most advantageous manner for both parties.¹ An appraisal of the literature on 3D surface imaging for rhinoplasty has revealed a number of studies that demonstrate for the first time the significant contribution of such technology in objectively measuring results and

demonstrating changes postoperatively.²⁻⁶ The ultimate question now is whether this type of emerging technology fulfills any unmet needs in the context of preoperative assessment for rhinoplasty, for patients and surgeons.

To our knowledge, this is the first study that compares 2D morphing with its 3D counterpart from the patient's and the surgeon's perspective with a view to identifying the added value of the latter in the interest of preoperative evaluation during the rhinoplasty consult.

METHODS

Participants

We designed a cross-sectional survey to compare the patients' and surgeons' opinion on 2D versus 3D simulation during the same preoperative visit. This prospective work was conducted in the Academic Rhinology Clinic and tertiary referral center for rhinoplasty, of the Otorhinolaryngology Department at the University Hospitals of

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Received for publication May 10, 2018; accepted October 17, 2018.

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DOI: 10.1097/GOX.0000000000002063

Disclosure: The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.

Leuven, in Belgium. The Medical Ethics Committee at the University Hospitals of Leuven approved the study with number S59724, and a written consent form was obtained from all participants. There were 172 consecutive patients (81 women and 43 men), that presented to our outpatients department with a request for rhinoplasty, and were recruited for the study. The mean age was 31 years and SD 10.9. Patients were also divided in subgroups according to sex (male/female), age (15–29 y)/(30–72 y), type of rhinoplasty procedure they were assessed for (primary/revision), and type of complaints they presented with (aesthetic only/functional aesthetic). Table 1 provides all the demographic data.

Instrument

We studied the patients’ views on 2D computer imaging by means of an ad hoc questionnaire, which was partially based on the work of Thomas et al.⁷ and is presented in Table 2. The patients’ responses were “Yes” (Y), “No” (N), or “Don’t Know” (DK). The patients’ and surgeons’ views on 3D morphing were sought by answering a single question regarding the added value of 3D simulation over 2D, and justifying it by choosing among 5 statements in support or 5 statements set against it. Patients and surgeons were free to choose from minimum 1 to maximum

5 statements. These questions are shown in Tables 3, 4, respectively.

Procedure

Patients registered with a request for rhinoplasty from November 2016 to November 2017 were enrolled in the study and seen by 2 surgeons (P.W.H. and G.L.) during the same preoperative consultation. All patients were evaluated initially with a complete history and a thorough nasal examination. This was followed by standard photography of the nose (frontal, lateral, oblique, and basal views) and facial analysis. The patient’s photographs were uploaded onto the computer screen, and 2-dimensional (2D) computer imaging was undertaken, using Photoshop CS3 Extended Version 10. Having taken into account the patients’ wishes, the morphed images were shared with the patient, and both parties embarked on a discussion that led sometimes to further simulation. The whole process took on average 3–5 minutes. Both surgeons were present during all 2D simulations. All patients completed an ad hoc questionnaire following 2D computer imaging and subsequently experienced 3D morphing. The Vectra H1 handheld imaging system (Canfield Scientific, Fairfield, New Jersey, N.Y.) was used for all 3D simulations. Three different photographs were taken from different angles,

Table 1. Demographic Characteristics of 172 Study Patients

Characteristic	Patient Population Group						
	Primary N = 124 (72%)	Revision N = 48 (28%)	Open N = 109 (63%)	Closed N = 63 (37%)	Functional Aesthetic N = 63 (37%)	Purely Aesthetic N = 109 (63%)	All N = 172 (100%)
Age, mean (SD), y	29,5 (10,7)	35,2 (10,5)	32,6 (11,3)	28,6 (9,8)	31,1 (11,7)	31,1 (10,5)	31,1 (10,9)
Sex							
Female	81	33	71	43	37	77	114
Male	43	15	38	20	26	32	58

Table 2. Questionnaire for 2D Morphing

Questions	Yes	No	I don’t know
1 Were you satisfied with the invitation for this 2D computer simulation?			
2 Were you satisfied with the proposed results of the simulation shown with computer imaging?			
3 Were you surprised seeing your original picture on the computer screen?			
4 Were you surprised seeing the expected result on the computer screen after simulation?			
5 Do you think the computer simulation benefits the patient-doctor interaction?			
6 Do you think the computer simulation is a disadvantage for the patient-doctor interaction?			
7 Do you think the computer simulation is a useful tool to communicate your desires and expectations?			
8 Were you able to visualize your possible postoperative appearance after computer imaging?			
9 Has computer simulation modified your desires and expectations?			
10 Did you refrain from certain surgical corrections that you had previously considered?			
11 Were there any additional surgical corrections proposed that were not planned in advance?			
12 Do you have more confidence in the judgment of your surgeon after this computer simulation?			
13 Are you more reassured to undergo the surgery after the computer simulation?			
14 Do you think computer simulation should become routine part of the preoperative evaluation before cosmetic surgery?			

Table 3. Three-dimensional Computer Simulation Questionnaire for the Patients

Do you think that the computer simulation in 3D is an added value over 2D for the preoperative consultation?	
YES	NO
<input type="checkbox"/> 3D simulation helped me better understand the deformity of my nose than 2D simulation	<input type="checkbox"/> 3D simulation was only repetition of the information I received during the 2D simulation
<input type="checkbox"/> 3D simulation helped me better understand the aims of the surgery than 2D simulation	<input type="checkbox"/> 3D simulation is more time consuming than 2D simulation
<input type="checkbox"/> 3D simulation is more attractive and innovative than 2D simulation	<input type="checkbox"/> 3D simulation shows my face without hair, which is very unrealistic and unattractive
<input type="checkbox"/> 3D simulation made me feel more reassured to undergo the surgery than 2D simulation	<input type="checkbox"/> 3D simulation was more overwhelming than 2D simulation
<input type="checkbox"/> Other.....	<input type="checkbox"/> Other.....

Table 4. Three-dimensional Computer Simulation Questionnaire for the Surgeons

Do you think that the computer simulation in 3D is an added value over 2D for the preoperative consultation?	
YES	NO
<input type="checkbox"/> 3D simulation was more useful than 2D regarding patients' understanding of the nasal deformity	<input type="checkbox"/> 3D simulation was repetition of all information given during the 2D computer simulation
<input type="checkbox"/> 3D simulation helped to overcome certain limitations that were encountered during 2D morphing	<input type="checkbox"/> 3D simulation is more time consuming than 2D simulation
<input type="checkbox"/> 3D simulation was more useful than 2D regarding the patients' understanding of the aims of surgery	<input type="checkbox"/> 3D simulation is more overwhelming for the patient than 2D simulation
<input type="checkbox"/> 3D simulation helped me more than 2D to solidify my surgical plan	<input type="checkbox"/> 3D simulation raised the patients' expectations to unrealistic levels
<input type="checkbox"/> Other.....	<input type="checkbox"/> Other.....

which were then digitally merged to produce a 3D image. A morphed image was subsequently created, respecting objective aesthetic ideals, taking into account limitations imposed by individual anatomy, and keeping in with the previously produced simulation (Fig. 1). The whole process took on average 10–15 minutes. All patients following 3D simulation responded to the question regarding its added value over 2D. The same question was addressed to both surgeons at the end of all consultations.

Statistical Analysis

An analysis between responses on question 4 (satisfaction with morphed images) of the 2D questionnaire with the multiple response variables provided by the patients' answers on the 3D questionnaire was performed. Additionally, all indicator variables that were constructed from the multiple response variables provided by the patients' answers on the 3D questionnaire were analyzed between different patients' subgroups: female versus male,



Fig. 1. 3D computer simulation preoperatively, on a female patient with the desire for augmentation rhinoplasty.

younger (15–29 years) versus older (30–72 years), primary versus revision rhinoplasty, and patients with solely aesthetic complaints versus functional-aesthetic. Data were analyzed with SPSS (v.22) software (IBM SPSS). Statistical analysis was performed using chi-square test on the dummy or indicator variables that were constructed from the multiple response variables provided by the patients' answers. Data are presented as percentages. $P < 0.05$ was considered statistically significant.

RESULTS

The majority of our 172 patients (95%) were satisfied with the invitation for a 2D computer imaging session. In our group of patients, satisfaction with 2D morphing reached 61%. The same patients considered 3D simulation an added value over 2D in 95% of cases (Fig. 2).

When we examined the reasons why 3D simulation was considered an added value over 2D from the 164 patients that responded positively, we saw that all responses were selected in similar percentages (Fig. 3). However, from

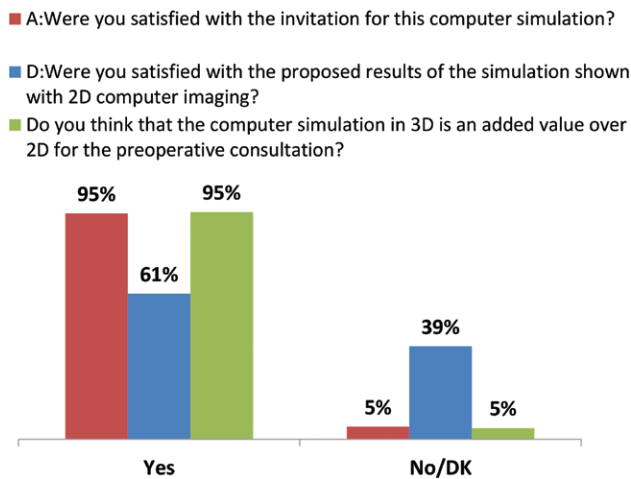


Fig. 2. Patients' satisfaction of 2D vs 3D simulation in the preoperative consult.

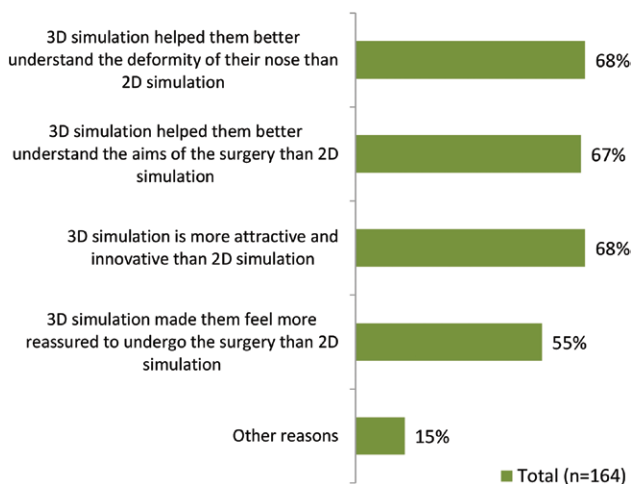


Fig. 3. Reasons why computer simulation in 3D is an added value over 2D for the preoperative consult according to patients.

further analysis between patients' subgroups and the indicator variables that were constructed from the multiple response variables provided by the patients' answers, some statistically significant differences were observed, as described below. Patients requesting revision rhinoplasty answered that 3D simulation helped them to better understand the aims of surgery compared with 2D simulation at a higher percentage (84%) than the patients from the primary group (61%), $P < 0.01$ (Fig. 4). Additionally, women appeared to get reassured by 3D imaging in higher percentage (63%), than men (42%), $P < 0.01$ (Fig. 5). No other significant relationship was found between patients' age or types of complaints they presented with and the responses on the reasons why 3D simulation was considered and added value over 2D.

Furthermore, patients nonsatisfied with the proposed results of the 2D simulation answered that 3D made them feel more reassured at a higher percentage (67%) than patients initially satisfied with the proposed results of 2D simulation (48%), $P < 0.05$ (Fig. 6).

The 2 surgeons, however, found 3D simulations to be an added value in 66–74% of all patients (Fig. 7). Interestingly enough in over 1/3 of the patients the 2 surgeons considered 3D simulation being an added value over 2D because it helped them to overcome limitations encountered during the latter (Fig. 8). Furthermore, it became clear that repetition of previously shared information with the patient during 2D morphing and the time consuming nature of 3D accounted for the main reasons surgeons did not consider 3D computer imaging an added value in 36–44% of cases (Fig. 9). Additional reasons were a concern of raising patients' expectations to unrealistic levels or that of overwhelming the patients with too much information.

DISCUSSION

Clear communication between surgeon and patient remains a key element of a successful preoperative consult for rhinoplasty. Computer imaging has been a concrete vehicle of communication during such consult for the last 30 years now.^{7–12} Given the limitations of a 2D medium like the inability to address facial depth, and nasal shape leading to loss of data^{13,14} and the recent advances in technology,¹⁵ computer simulation is fast progressing from 2D to 3D models. In addition, the increased availability of 3D printing has led to the creation of accurate patient-specific preoperative models for procedure planning, rehearsal, and patient consultation.^{16–18} The evolving literature on 3D surface imaging systems supports the notion that utilizing this technology optimizes the surgeons' capacity to perform morphing in the most advantageous manner for both parties.^{19–22} However, no study has yet to compare 2D morphing with its 3D counterpart in the context of preoperative consult for rhinoplasty, and the patients' opinion in this type of technology has not been previously sought.

Considering the importance of using patient-oriented outcome measures to evaluate the efficacy of specific procedures,^{23,24} we performed a study where rhinoplasty patients' views on 2D computer imaging versus 3D were

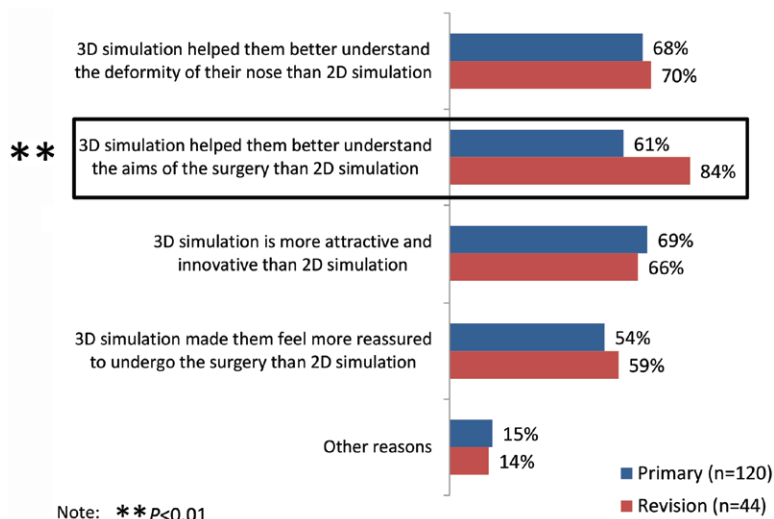


Fig. 4. Reasons why computer simulation in 3D is an added value over 2D for the preoperative consult by type of surgery.

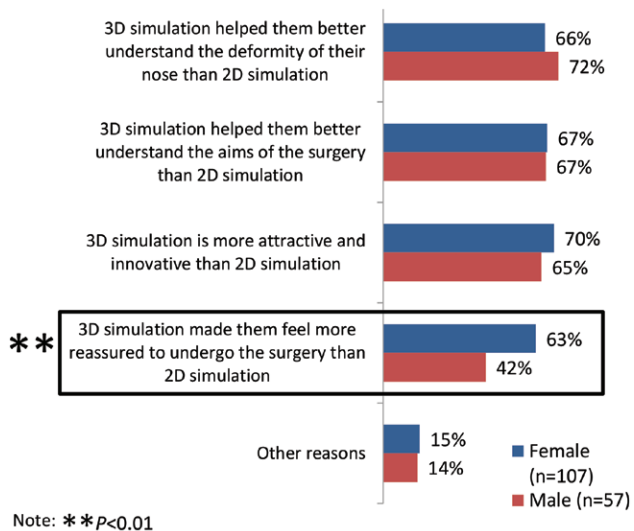


Fig. 5. Reasons why computer simulation in 3D is an added value over 2D for the preoperative consult by patients' sex.

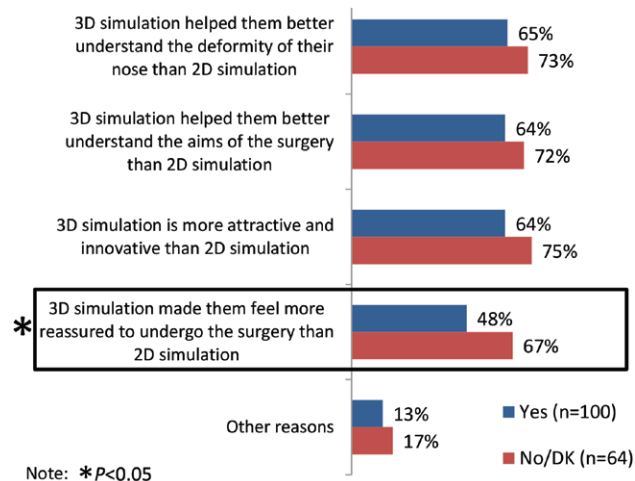


Fig. 6. Reasons why computer simulation in 3D is an added value over 2D for the preoperative consult by whether patients were satisfied with the initially proposed 2D simulation images.

assessed using patient-reported outcome tools. To our knowledge, this is the first study that looks into patients' responses on 2D versus 3D morphing in the same consultation, and demonstrates factors that may influence appreciation of 3D morphing as an added value over 2D. Additionally, the surgeons' views were looked at in the same setting.

In line with other series, the majority of our patients welcomed the opportunity to observe nasal changes during 2D computer imaging and before surgery (95%). After explaining to the patients that morphing represents an exercise to convey thoughts and surgical goals, patients generally accept the spirit in which their image is being altered.²⁵ As it is highlighted in the results, only 61% of our patient population was satisfied with the proposed 2D simulation images during the preoperative consult. Moreover, the same group of patients, during the same

consultation, considered the subsequent 3D simulation an added value over 2D in 95% of cases (Fig. 2). When we examined the reasons why 3D simulation was considered an added value over 2D from 164 patients who responded positively, we saw that all responses were selected in similar percentages (Fig. 3). As illustrated in Figure 3, from better understanding of their own nasal anatomy, deformity, and aims of surgery, up to feeling more reassured to undergo surgery and finding the application more innovative, all responses were chosen with percentages between 55% and 68%. This finding demonstrates the advantage of 3D imaging over 2D in our patient population, given the ability to capture 3D images, to analyze them with respect to the patient individual morphology, and to rotate them on all axes. Furthermore, rhinoplasty remains a patient-specific operation and it is both authors' (P.W.H. and G.L.) belief that patients appreciate such a personalized

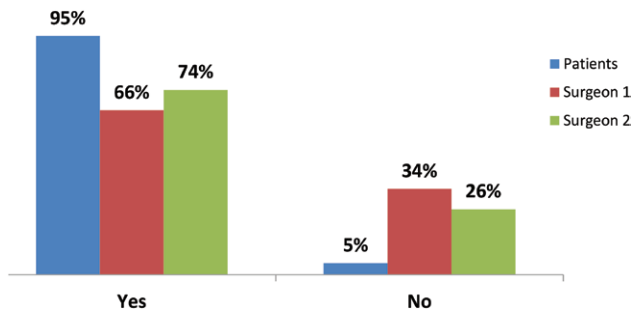


Fig. 7. How patients and surgeons responded to the question: “Do you think that computer simulation in 3D is an added value over 2D for the preoperative consult for Rhinoplasty?”

approach, particularly in the light of precision medicine.²⁶ Equally important was the role of educating the patient in relation to their own anatomy and deformity during the simulation. Taking into account that certain studies in the literature confirm that patients with poor understanding of their deformity are more prone to dissatisfaction,^{27,28} then the use of 3D imaging for education purposes becomes indispensable.

Further analysis between patients’ subgroups and the indicator variables constructed from the multiple response variables provided by the patients’ answers revealed some statistically significant differences, as described below. Patients requesting revision rhinoplasty answered that 3D simulation helped them better understand the aims of surgery than 2D simulation at a higher percentage than the patients from the primary group. Revision rhinoplasty patients are dissatisfied by what they perceive to be a less than satisfactory surgical result. To these patients, the first operation had either been wasted or done harm.²⁹ This group with their unique psychology remain more alert

regarding new surgical alterations and inevitably need to comprehend in depth the goals of the procedure before committing to secondary rhinoplasty. Women also appeared to get reassured by 3D imaging in higher percentage, than men. However, it was difficult to interpret this finding. Although neuroscientists over the years attempted to explain some sex differences in cognition and behavior, more recent research seems to debunk widely held beliefs about those differences.³⁰

Another finding of our study was that patients nonsatisfied with the proposed results of the 2D simulation answered that 3D made them feel more reassured than 2D at a higher percentage than patients initially satisfied with the proposed results of 2D simulation. Patients nowadays arrive in our offices with increased demands that often extend to the entire surgical experience, starting in the preoperative consultation and including all postoperative care and follow-ups. They have frequently consulted the internet beforehand. The internet gives patients a global perspective but at the same time raises expectations.³¹ In the same manner, rhinoplasty patients are becoming increasingly informed and discerning, being able to articulate specific concerns and often exacting in their demands and expectations.³² Some stoicism will always be needed during the preoperative consultation, as rhinoplasty remains a complex procedure and diligence matters. Surgeons must devote greater time to provide context, and broker information to the patients³¹ and in this frame of mind, find themselves in need for new and more powerful tools such as 3D surface imaging. With the continuous technologic innovation in plastic surgery, recent articles in the literature demonstrate that baseline and simulated 3D images can even be printed as tangible models for consultation purposes and for use as intraoperative blueprints.^{17,33}

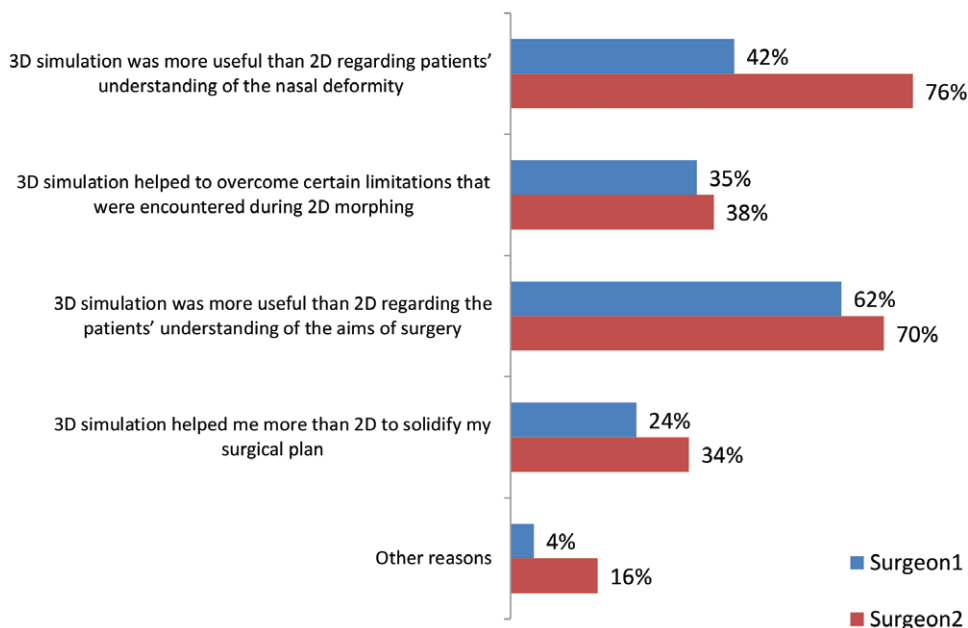


Fig. 8. Reasons why surgeons considered 3D simulation an added value over 2D in the preoperative consult.

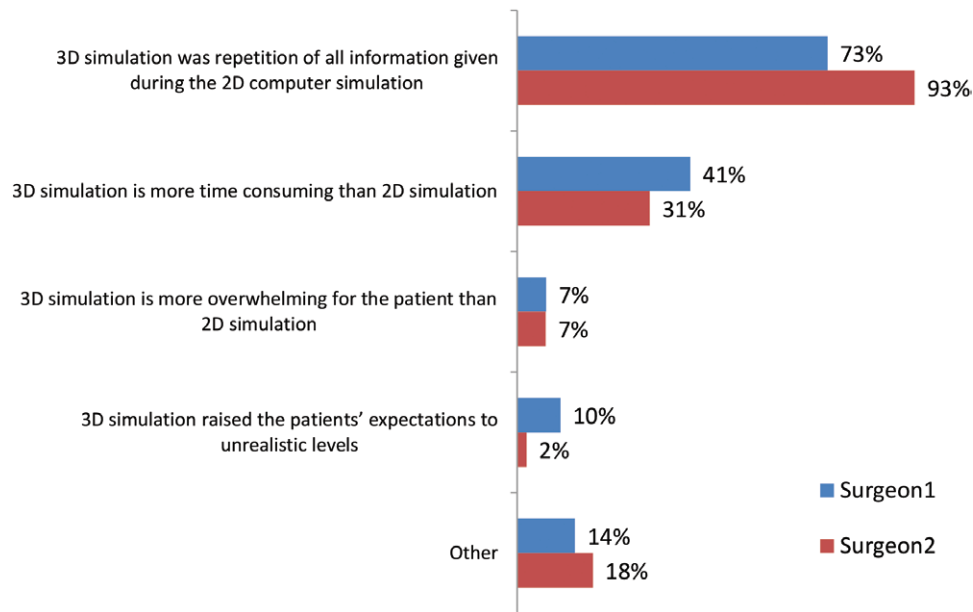


Fig. 9. Reasons why surgeons did not consider 3D simulation an added value over 2D in the preoperative consult.

Finally the 2 surgeons found 3D simulations to be an added value in 2/3 of all patients. Interestingly enough in over 1/3 of cases, surgeons considered 3D simulation an added value over 2D because it helped them to overcome limitations encountered during the latter. It also became clear that repetition of previously shared information with the patient during 2D morphing and the time-consuming nature of 3D accounted for the main reasons that surgeons did not consider 3D computer imaging an added value in 1/3 of cases. Additional reasons were raising patients' expectations to unrealistic levels or overwhelming the patients with too much information. As with all new technologies, some pitfalls will always accompany the promise. The risk of raising patients' expectations when utilizing 3D technology should be mitigated by the constant disclaimer oral or written to establish the objectives of imaging.

We acknowledge, however, the fact that this study was conducted in a single academic unit and a tertiary referral center for rhinoplasty, having a dedicated team and a 3D surface imaging system utilized for research purposes; thus, results may not be generalizable to other settings. This indeed remains a limitation of the study. Additionally, having directly asked our patients to rate their degree of satisfaction following the procedures of simulation, this work classifies as a surgeon-initiated patient survey and as such can be biased in favor of the procedure, since patients may be reluctant to express their true reasons for dissatisfaction to their surgeon. However, we tried to eliminate such bias, as there was a different surgeon being in charge of the patient (P.W.H.) and a different surgeon being in charge of the questionnaires (G.L.). Furthermore, all patients were encouraged to be honest with their responses, as this would have no bearing on their care. However, this study was about patients' and surgeons' perceptions, and

in that manner, inherent biases would be impossible to eliminate completely.

A cautious interpretation of our results would allow us to consider 3D morphing a useful tool particularly for revision cases, female patients, individuals that remain uncertain with standard 2d simulation, and finally for patients with anatomy somehow challenging for a 2D computer imaging program. As this is an area that has not received any scientific study, we cannot compare our results with other studies. In the absence of any other relevant evidence, the authors are the first to make a contribution in this field.

CONCLUSIONS

The overwhelming majority of our patients considered 3D simulation an added value over 2D. Patients initially unsatisfied with 2D morphing, revision rhinoplasty patients and women seemed to be the groups that appreciated more 3D computer simulation. In contrast, surgeons considered the facility of 3D an added value in two-thirds of the patients. Without being panacea, 3D surface imaging appears to be a useful tool in the surgeons armamentarium, during preoperative assessment in rhinoplasty.

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ACKNOWLEDGMENT

Mrs. Chrysoula Preza, MSc, Biostatistician, is acknowledged for her significant contribution on the statistical analysis on the data of this article.

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