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The value of virtual simulation for pre-operative planning in Rhinoplasty

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Abstract
Background: Rhinoplasty is widely recognized as one of the most difficult procedures in plastic surgeries, two-dimensional (2D) and three-dimensional (3D) digital imaging have played an important role in this field, being as a valuable tool throughout preoperative and intraoperative analysis to evaluate the use and efficacy of preoperative 3D virtual simulation and surgical planning in rhinoplasty.
Methods: This prospective randomised clinical work was performed on 30 patients with external nasal deformities of dorsum with or without tip deformities as dorsal hump, Nasal tip jobs, posttraumatic deformities. Participants had been subdivided into two groups equally: Group A: Conventional-procedure rhinoplasty and group B: Rhinoplasty with preoperative 3D-simulation. All patients were subjected to software CT scanners (giving the comprehensive 3-D digital visualization for the anatomy of the head and neck of the patient).
Results: Rhinoplasty outcome evaluation (ROE) questionnaire demonstrated that participants who had been satisfied with the look of their nose as well as the aesthetic score were significantly higher in group B. Surgical time had been significantly increased in group A. There was a significant agreement between the 3 raters in group B and no significant variation was existed among both groups as regard to complications, the average objective evaluation of the rhinoplasty, breathing from nose and functional score between the studied groups.
Conclusions: In rhinoplasty, virtual simulation using 3D technology and 3D printed anatomic surgical guide showed better promising results regarding surgical time, ROE and patients' satisfaction with more reliable results compared to conventional methods. Virtual simulation assists in harmonizing the aesthetic objectives of the patient and surgeon.

Keywords: Rhinoplasty, virtual simulation, preoperative planning, 3D technology

Introduction

Rhinoplasty is often regarded as one of the most difficult surgeries in the field of plastic surgical procedures. The nose is an organ that combines beauty and function in human beings [1, 2].

Two-dimensional (2D) and three-dimensional (3D) digital imaging have been crucial in this sector, providing as a tool for preoperative and intraoperative study [3]. Although there have been improvements in standardized digital photography, these photos are unable to accurately capture the 3D anatomy that is crucial for surgeons to examine complex anatomical inter-relationships, depth, and nasal topography [4]. Recently, plastic surgeons have utilized 3D designs to enhance the process of consultation [5, 6].

3D printing is a rapidly developing technology that offers advantages in creating customized designs for individuals using computer-aided design and manufacturing (CAD/CAM) techniques. Currently, there have been no reports discussing the implementation of 3D printing during aesthetic rhinoplasty surgeries. However, the application of 3D printing in both cosmetic and functional rhinoplasty is a new and innovative idea. This technology may be utilized to produce models for facial augmentation procedures such as genioplasty and malar implants, as well as for blepharoplasty, otoplasty, and combined procedures. These advancements show great potential and offer exciting possibilities for the future [7]. The precise 3D contours derived from the participants' computed tomography (CT) data helped to decrease the duration of surgery and minimize the discrepancies in shape between the implants and defects, resulting in a decrease of associated problems.

The utilization of patient-specific 3D-printed anatomic models at a scaled size is a valuable tool for managing expectations, training individuals, and devising a surgical strategy for intricate and technically demanding instances [8].

The majority of nasal implants, which includes autologous cartilage, are altered through hand trimming throughout augmentative rhinoplasty in order to get the appropriate form as requested by the patient [9, 10].

The nasal tip is commonly defined as the area that covers the lateral and medial crura of the lower lateral cartilages [11]. The findings of our research indicate that nasal models created through 3D printing can be utilized to plan the projection and rotation of the nasal tip [12].

Regarding the elimination of a dorsal hump, a patient-specific model is able to be used in rhinoplasty. This model can be created using 3D CT imaging and nasal anthropometries. We supplied basal, final, and profile guidelines, which allowed us to effectively address the dorsal hump [13].

The purpose of this study was to evaluate the use and efficiency of preoperative 3D virtual simulation and surgical planning in rhinoplasty.

Patients and Methods

This prospective randomized clinical work had been performed on 30 participants ranging in age from 18 to 65 years old, with external nasal deformities of dorsum with or without tip deformities as dorsal hump, nasal tip jobs, post-traumatic deformities from December 2019 to December 2021. The work was performed following permission from the Ethics Committee Tanta University Hospitals approval code (33518/11/19). All participants provided a well-informed written consent. Criteria for exclusion were sino-nasal inflammatory diseases and unrealistic expectations.

Participants had been categorized at random based on the sequence of their hospital admission into two equal groups traditional group (Group A: conventional-procedure Rhinoplasty) and preoperative simulation group (Group B: rhinoplasty with preoperative 3D-simulation

All participants had been exposed to taking of history, general examination, Local examination of the nose, preoperative photographs for analyzing the deformity, laboratory investigations, radiography (computed tomography (CT) images of the facial bones & paranasal sinus (PNS) in the preoperative simulation group, software CT scanners (TOSHIBA Aquilion One 320), (giving the a comprehensive 3-D digital visualization for the anatomy of the head and neck of the patient).

Preoperative Planning: 3D visualization and simulation composed of visualization of external nasal shape and present deformity, virtual simulation for correction of the deformity, 3D nasal shape prediction, creation of the guide for confirmation of the deformity correction.

The process of "3D" visualization enables the creation of virtual 3D models from images in the standard Digital Imaging and Communications in Medicine (DICOM) format, specifically from CT scans. The software allows for the division of the displayed model into separate sections, enabling the examination and study of various tissues and analyses. It also provides sophisticated capabilities for measuring both linear and surface dimensions, as well as analyzing nasal parameters from all views (frontal, lateral and basal). Figure 1.

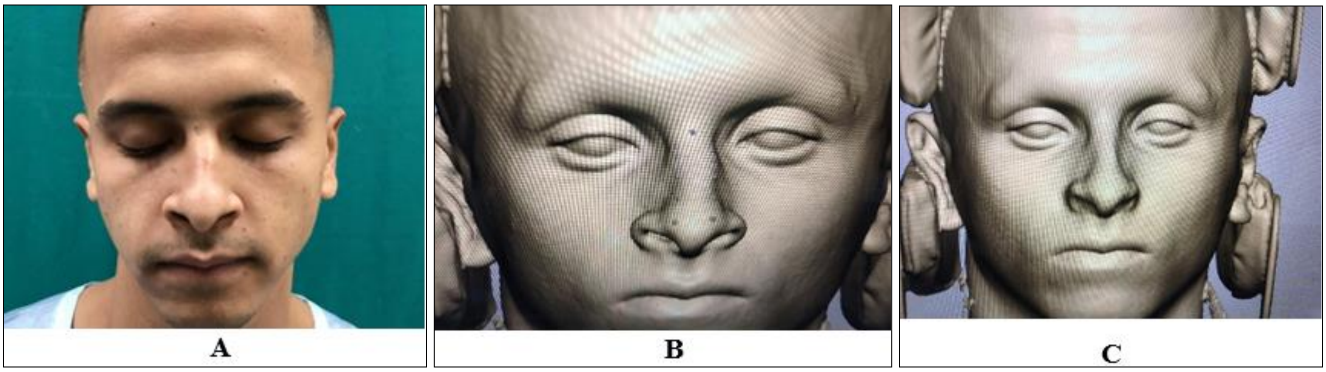

Fig 1: frontal view of case with nasal deviation (a) preoperative frontal view showing twisted nose (b) CT finding (c) virtual planning for correction of twisted nose

Operative: Conventional open procedures under general anesthesia were done in both groups. Local injection with 2% Lidocaine in combination with epinephrine 1/100000 was given to elevate the soft tissues (Hydro dissection) & to reduce the intraoperative bleeding, using a 'V' or an inverted 'V' shaped midcolumellar incision. The placement ought to be in close proximity to the skin where the underneath cartilage is sealed, in order to minimize the visibility of scars and prevent contracture. Using skin hooks and precise dissection tools like Converse scissors, the mid-columellar incision is extended to the marginal incisions. The soft tissue covering is extended upwards in a largely blood vessel-free layer above the cartilage to reveal the upper lateral cartilages (ULC). At this stage, the dissection of the ULC is shifted to a sub-perichondral plane with the use of precise dissection techniques. A periosteal elevator, such as the Joseph elevator, is employed to raise the periosteum above the nasal bones until it reaches the nasofrontal angle. The lower lateral cartilages are subsequently divided at the center to reveal the anterior septal angle (ASA) in readiness for septoplasty and/or the collection of septal cartilage.

Septoplasty: The ASA is carefully exposed, and a pocket is made below the mucoperichondrium, extending downwards from the nasal spine and backwards past the junction between the septal bone and cartilage on both sides. Basic principles of septoplasty are employed to remove bony irregularities and/or spurs. Furthermore, a "swinging-door" technique involving the removal of excessive inferior-caudal septal cartilage is able to be employed to address any present abnormalities in the caudal septum. In the preoperative simulation group (group B), the 3D-printed model is used as a reference alongside the actual situation, allowing for easy observation of any little alterations that occur in real-time.

Dorsal hump reduction in group (B) involves the reduction of the noticeable bony and cartilaginous hump utilizing a mix of osteotomes (such as Rubin) and rasps, as determined by our 3D planning. The amount of reduction in millimeters is determined based on this planning.

Spreader grafts are used to restore the disturbed aesthetic lines on the top of the nose and to correct the collapse of the middle part of the nose (internal nasal valve). They are considered as an alternative if there is enough height in the upper lateral cartilage after reducing the cartilaginous hump on the top of the nose.
Prior to conducting nasal tip contouring, it is advisable to first stabilize the nasal base. If the projection, rotation, and nasolabial angle don't need to be changed, a columellar strut is able to utilized to provide additional support to the tip without modifying its position. Additionally, to address projection and rotation, one can employ a tongue-in-groove procedure or a caudal septal extension graft, which involves placing cartilage side-by-side or end-to-end with the septum.
Nasal tip contouring, specifically in group B using a printed 3D guide, continues to be the most difficult area to accurately diagnose and treat. The rhinoplasty surgeon ought to have knowledge of different suture-based tip-plasty procedures. Additionally, they may use a graft of softened cartilage, such as a CAP tip graft, or stitch cartilage perichondrium over the domes to enhance the projection or concealment of the tip. Additional methods employed to modify the shape of the tip/supra-tip area involve the cephalic turnover flaps, cephalic trim, and lateral crural strut grafts. These approaches are very effective in rectifying lateral crural convexity or misalignment.
Dorsal augmentation, specifically in group B using a printed 3D guide, involves making modifications to the dorsum after setting the tip projection/rotation. If nasal elevation is required, a radix transplant can be performed via soft tissue, such as temporalis fascia, or diced cartilage in fibrin glue. If a minor increase in the size of the dorsal area is required, using septal cartilage onlay grafts, either individually or layered, is usually sufficient. For optimal results, it is recommended to use diced cartilage wrapped in either surgical or temporalis fascia when performing significant augmentations.
Alar base reduction was performed in group B using a printed 3D guide. The skin located between the nasal sill and the ala is surgically removed in order to achieve the appropriate size and width of the nostrils. Alar base reductions are usually required when reducing the projection of the tip results in a broader appearance of the alar base.
Osteotomies involve making precise incisions in the bone to correct open roof deformities resulting from the removal of a hump, as well as to realign deviated nasal bones and reduce the breadth of the bony dorsum and sidewalls [14].

Closure: It is possible to stitch a septal splint, such as a trimmed silicone sheet, in place. However, this step is not necessary as long as the septum has been adequately aligned. After performing the trans-columellar incision, it is sealed using either interrupted permanent sutures (6-0 or 7-0 nylon) or fast-absorbing sutures. The latter option provides comparable aesthetic results without the need for suture removal, therefore minimizing any related discomfort. The marginal wounds are sealed using interrupted absorbable sutures (5-0 fast).
Application of adhesive tape and immobilization with a cast: An adhesive tape that matches the color of the skin is carefully placed from the area between the nose and forehead to the area above the tip of the nose to help decrease swelling after surgery. A lengthier band is positioned around the infratip lobule, functioning as a sling to uphold the tip at its desired degree of rotation. Afterward, a nasal cast is placed using a thermoplastic splint material which becomes malleable and flexible when subjected to hot water and solidifies when it cools. An antibiotic ointment gets used to both nostrils, and a dressing is applied on the mustache area. Sutures were removed on 7th, external nasal splint removed on 10th postoperative days.

Statistical analysis
The statistical analysis was conducted utilizing SPSS v26 software (IBM Inc., Chicago, IL, USA). The normality of the data distribution was assessed utilizing the Shapiro-Wilks test and histograms. The mean and standard deviation (SD) of the quantitative parametric parameters were shown and contrasted between both groups using an unpaired Student's t-test. The quantitative non-parametric data were reported as the median and interquartile range (IQR) and analysed utilizing the Mann Whitney-test. The qualitative parameters were displayed as frequencies and percentages (%) and have been assessed using the Chi-square test or Fisher's exact test, when appropriate. A two tailed P value < 0.05 was considered statistically significant.

Results
No significant variation was existed in baseline characteristics (age, gender, and previous surgical operations), in types of patients' complaints and in patient's aesthetic complaints among the groups under the study, Table 1.

Table 1: Baseline characteristics and Types of patients' complaints in the groups under the study

		Group A (N=15)	Group B (N=15)	P-Value
Age (years)		26.67±4.17	25.93±3.15	0.591
Sex	Male	6 (40.0%)	4 (26.7%)	0.699
	Female	9 (60.0%)	11 (73.3%)	
Previous surgical operations	Yes	7 (46.7%)	6 (40.0%)	1
	No	8 (53.3%)	9 (60.0%)	
Previous rhinoplasty operations	Yes	1 (6.67%)	1 (6.67%)	1
	No	14 (93.3%)	14 (93.3%)	
Types of patients' complaints	Aesthetic only	8 (53%)	10 (67%)	0.710
	Functional only	0 (0%)	0 (0%)	-
	Aesthetic and functional	7 (47%)	5 (33%)	0.710
Patient's aesthetic complaints $^{\Delta}$	Dorsal hump	8 (53.3%)	10 (66.67%)	0.710
	Wide dorsum	13 (86.67%)	12 (80%)	1.000
	Post traumatic deformity	7 (46.67%)	5 (33.33%)	0.710
	Nasal tip problem	13 (86.67%)	14 (93.3%)	1.000
	Long nose	9 (60%)	10 (66.67%)	1.000
	Wide alar base	8 (53.33%)	9 (60%)	1.000
	Twisted nose	6 (40%)	5 (33.33%)	1.000
	Saddle nose	1 (6.67%)	2 (13.33%)	1.000

Date was presented as Mean ± SD or frequency (%), $^{\Delta}$ Each patient may have more than one complaint.

There was no significant difference in bony base, alar base width, tip rotation and nasofrontal angle in males, nasal length in females and Tip projection in males and females between CT findings and virtual planning, but bony base, alar base width and flaring in females (frontal, basal) and nasal length in males (lateral) in CT findings were significantly higher than virtual planning in patients undergoing rhinoplasty with preoperative 3D-simulation, tip rotation and nasofrontal angle in females were significantly higher in virtual planning compared to CT findings. Table 2

Table 2: Nasal anthropometric measurements by CT findings and virtual planning in frontal, lateral and basal views in group B.

	CT finding	Virtual planning	P-Value
Bony base width in males (mm)	31.63±5.24	24.65±2	0.057
Bony base width in females (mm)	30.23±3.12	24.35±1.47	<0.001*
Alar base width in males (mm)	35.61±5.75	31.88±1.26	0.343
Alar base width in females (mm)	34.76±3.17	31.62±1.44	0.007*
Nasal deviation (N. of Cases)	5 (33.3%)	0 (0%)	0.042*
Tip rotation in males (°)	91.63±13.64	93.7±2.81	0.343
Tip rotation in females (°)	82.44±5.15	104.66±5.73	<0.001*
Nasofrontal angle in males (°)	114.93±14.57	130.82±6.47	0.2
Nasofrontal angle in females (°)	125.55±9.88	140.34±10.01	0.002*
Nasal length in males (mm)	53.1±0.82	50.45±0.51	0.029*
Nasal length in females (mm)	47.34±4.71	45.77±2.4	0.338
Tip projection in males (mm)	33.9±2.11	35.2±1.22	0.486
Tip projection in females (mm)	32.16±1.41	32.55±1.26	0.506
Hump height (mm) (N=10)	2.48±0.84	-	<0.001*
Alar base width in males (mm)	35.61±5.75	31.88±1.26	0.343
Alar base width in females (mm)	34.76±3.17	31.62±1.44	0.007*
Alar flaring (mm) (N=4)	39.89±4.62	32.03±1.5	0.029*
Tip projection in males (mm)	33.9±2.11	35.2±1.22	0.486
Tip projection in females (mm)	32.16±1.41	32.55±1.26	0.506
Caudal septal deviation (N. of Cases)	5 (33.3%)	0 (0%)	0.042*

Date was presented as Mean ± SD or frequency (%), *Statistically significant as p value ≤0.05.

A significant variation was existed regarding surgical time no significant variation had been existed in the average follow-up period among the studied groups. Percentage of patient satisfaction based on ROE questionnaire was significantly greater in group B contrasted to group A. Table 3

Table 3: Surgical data, average follow-up and percentage of satisfaction according to rhinoplasty outcome evaluation questionnaire in the groups under the study

		Group A (N=15)	Group B (N=15)	P-Value
Surgical time (minute)		137±17	110±11.8	<0.001*
Septoplasty		10 (66.67%)	7 (46.67%)	0.710
Septal cartilage harvesting		13 (86.67%)	14 (93.33%)	1.000
Hump reduction		8 (53.3%)	10 (66.67%)	0.710
Columellar strut graft		13 (86.67%)	14 (93.33%)	1.000
Cephalic trimming		13 (86.67%)	14 (93.33%)	1.000
Caudal septal resection		7 (46.67%)	8 (53.33%)	1.000
Alar base reduction		8 (53.33%)	9 (60%)	1.000
Spreader (flap/graft)	Bilateral spreader flap	8 (53.33%)	9 (60%)	1.000
	Bilateral spreader graft	5 (33.33%)	5 (33.33%)	1.000
Percentage of satisfaction (%)		58±11	79±10	<0.001*
Average follow-up (months)		10.2±3.36	11.2±4.31	0.775
Total follow-up period	3 months	1 (7%)	0 (0%)	0.534
	9 months	10 (67%)	11 (73%)	
	15 months	4 (27%)	3 (20%)	
	24 months	0 (0%)	1 (7%)	

Data are presented as Mean ± SD or frequency (%).

There was no significant difference in complications and in the average objective evaluation of the rhinoplasty performed by the assessment of three specialists between the studied groups. Table 4. There was a significant agreement between the 3 raters in group A and B, there was moderate agreement among rater 1 and 2, rater 1 and 3 in both groups and among rater 2 and 3 in group B, and there was little agreement between rater 2 and 3 in group A. Table 5

Table 4: Postoperative complications and objective evaluation of the Rhinoplasty in the groups under the study

	Group A (N=15)	Group B (N=15)	P-Value
Residual breathing problems	1 (6.67%)	1 (6.67%)	1.000
New breathing problems	0 (0%)	0 (0%)	-
Temporarily hyposmia	1 (6.67%)	1 (6.67%)	1.000
Permanent hyposmia	0 (0%)	0 (0%)	-
Subconjunctival ecchymosis	1 (6.67%)	1 (6.67%)	1.000
Skin necrosis	0 (0%)	0 (0%)	-
Tip asymmetry	1 (6.67%)	0 (0%)	1.000
Stair step deformity	2 (13.3%)	2 (13.3%)	1.000
Septal hematoma	0 (0%)	0 (0%)	-
Open roof deformity	1 (6.67%)	0 (0%)	1.000
Residual hump	2 (13.3%)	0 (0%)	0.483
Total complications (N=14)	9 (64%)	5 (36%)	
Average evaluation score (Median (IQR))	3 (3-4)	3 (3-4)	0.324

Date was presented as frequency (%) or IQR: Interquartile range.

Table 5: Inter-rater reliability in each studied group

		Weighted Kappa	95% CI		P-Value
Group A	Rater 1 and 2	0.455	0.253	0.658	0.007*
	Rater 1 and 3	0.516	0.229	0.803	0.003*
	Rater 2 and 3	0.375	0.0758	0.674	0.035*
Group B	Rater 1 and 2	0.413	0.098	0.729	0.016*
	Rater 1 and 3	0.478	0.182	0.773	0.006*
	Rater 2 and 3	0.423	0.060	0.787	0.019*

CI: Confidence interval, *Statistically significant as P-Value ≤0.05.

No significant variation was existed in breathing from nose and in functional score between the studied groups while aesthetic score was significantly greater in group B contrasted to group A.

Table 6: The rhinoplasty outcome evaluation and functional and aesthetic scores (ROE) questionnaire and in the groups under the study after 3 months

	Group A (N=15)	Group B (N=15)	P-Value
The way they like their nose	2 (1-2)	3 (2-4)	0.019*
Breathing well through nose	2 (2-3)	3 (3-4)	0.061
Thinking that friends like their nose	2 (2-3)	4 (3-4)	0.041*
Aappearance of nose hampers social or professional activities	3 (2-3)	4 (3-4)	0.041*
Nose looks as good as it could be	2 (2-3)	3 (3-4)	0.029*
Undergo rhinoplasty to alter the aesthetic of your nose or to enhance your respiratory function?	2 (2-3)	4 (3-4)	0.029*
Functional	2 (2-2)	3 (3-4)	0.061
Aesthetic only	2 (2-2)	3 (3-4)	<0.001*

Data are presented as median (IQR). IQR: Interquartile range, * Statistically significant as p value ≤0.05.

Male patient aged 24 years, twisted nose correction & hump reduction, Figure 2.

Fig 2: lateral, oblique and basal views of preoperative and 2 months postoperative with ROE score percentage 89%. Group B

Male patient aged 19 years, hump reduction, lateral osteotomy, Figure 3

Fig 3: Oblique, lateral, and basal views of preoperative and 9 months postoperative with ROE score percentage 78%. Group A

Discussion

Imaging is widely acknowledged as a conventional technique in the field of facial plastic surgeries and offers significant benefits to both patients and surgeons [15]. The progress in computer technology and software has enabled the utilization of digital alteration of pre-operative imagery to assist in forecasting the result of a rhinoplasty [16]. The utilization of 3D technologies in computer simulations has grown more prevalent in the field of rhinoplasty [17]. This technology enables three-dimensional adjustments to the nose, ensuring that the surgeon's aesthetic objectives and expectations are aligned [18]. Nevertheless, the capabilities of this technology surpass the mere usage of a visual aid throughout the consultation procedure [19].

Furthermore, it serves as a significant clinical instrument for surgical planning, enabling the surgeon to simulate surgical procedures and anticipate the desired aesthetic outcome [20].

In recent years, there have been significant advancements in technology that have led to the development of 3D printed anatomic surgical guides, which are now being used in operating rooms [21].

Consistent with our findings, Choi *et al*. [22] examined the efficacy of a 3D rhinoplasty guide that utilized 3D simulation to establish a connection between the patient and the surgeon. Participants were surveyed regarding their preferred nasal form using preoperative 3D imaging. Moscatiello *et al*. [23] also discussed the use of preoperative digital planning for rhinoplasty. They utilized an innovative 3D radiologic viewer that enables both surgeons and patients to observe the nose's 3D structure, both internally and externally, on a shared monitor.

In the present study, there was a significant difference in tip rotation, nasofrontal angle, nasal length, and tip projection, Alar base width between in males and females CT findings. Also, lateral, basal, frontal view are significantly different between CT findings and virtual planning. Which came in line with study conducted by Mohammed Ali [24] Additionally, Sobral *et al*. [25] found that lateral and basal view of pre-surgical photogrammetry for rhinoplasty is significantly different between CT findings and 3D surgical planning. Also, Gordon *et al*. [26] found that there was a significant difference in tip rotation, nasofrontal angle, nasal length, tip projection, alar base width between males and females CT findings.

In the present study patients complained of combined aesthetic and functional problems. No significant variation was existed in the types of participants' complaints and patient's aesthetic complaints. Supporting our findings, Choi *et al*. [22] found that the most common aesthetic complaint was nasal tip problem and wide dorsum each occurred followed by long nose and dorsal hump. In accordance with the present study, Moscatiello *et al*. [23] found no significant difference in types of patients' complaints.

In the current work, in group A, septoplasty was performed in 10 (66.67%), Spreader was performed in 7 (46.67%) patients with bilateral spreader flap and 4 (26.67%) patients with bilateral spreader graft, hump reduction was performed in 8 (53.3%), columellar strut graft was performed in 13 (86.67%), cephalic trimming was performed in 13 (86.67%), caudal septal resection was performed in 7 (46.67%) and reduction of alar base was conducted in 8 (53.33%) patients. In group B, septoplasty was performed in 7 (46.67%) Spreader was performed in 8 (53.33%) patients with bilateral spreader flap and 4 (26.67%) patients with bilateral spreader graft, hump reduction was performed10 (66.67%), columellar strut graft was performed in 14 (93.33%), cephalic trimming was performed in 14 (93.33%), caudal septal resection was performed in 8 (53.33%) and alar base reduction was performed in 9 (60%) patients.

Parallel to our study, ElBestar *et al*. [27] found that the spreader flap is a viable substitute for the spreader graft in reconstructing the nasal dorsum following a significant hump removal, yielding comparable beneficial outcomes in terms of both function and appearance.

Elemam *et al*. [28] discovered that individuals who received dorsal hump remodelling and reinsertion experienced a more significant reduction in the breadth of their nasal bones compared to those who only had hump excision without dorsal grafting.

In the present work, surgical time was substantially increased in group A than group B (137 minutes in group A versus 110 minutes in group B) (p<0.001).

In line with our data, Herrero *et al*. [29] they stated that the implementation of a patient-specific model in rhinoplasty, using a 3D printed surgical guide, significantly reduced the duration of the intervention compared to the conventional method.

Moreover, Moscatiello *et al*. [23] found that surgical time lower in 3D group contrasted to the other two groups (p<0.001).

In the current work, in group A, the average follow-up period ranged from 3 to 15 months. In group B, it ranged from 9 to 24 months. No significant variation was existed in the average follow-up period among the studied groups. Unlike us in Klosterman *et al*. [30] they followed their patients on their routine visits for up to 6 months. Also, in Bilgin *et al*. [31] they follow the patients for 6 months after the procedure.

Regarding our findings, no significant variation was existed in the average objective evaluation of the rhinoplasty performed by the assessment of three specialists. Came in line with a work that was performed by Choi *et al*. [22].

In the present work, no significant variation was existed in complications among the studied groups. In agreement with our results, Elemam *et al*. [28] showed that there were no surgical problems, such as epistaxis or severe nasal deformities, observed in any of the participants in either group.

In the current work, a significant agreement was existed among the 3 raters in group B, there was a moderate agreement among rater 1 and 2, between rater 1 and 3 and among rater 2 and 3. Our findings are supported by Bashiri *et al*. [32] they came to conclusion that this procedure showed moderated reliability between raters in rhinoplasty surgeries.

Better reliability results were also obtained by Pausch *et al*. [33] the independent variable was the professional rating. Cohen's kappa coefficient was used to evaluate the inter-rater reliability. Inter-observer reliability was calculated in order to assess the level of agreement, or concordance, among raters. In our investigation, the correlation coefficient, Cohen's kappa, was κ = 0.385 (p<0.0001). The findings of Punthakee *et al*. [34] provide evidence that supports our results. A group of participants who were scheduled to undergo rhinoplasty were selected and their preoperative digital images were modified utilizing computer software. Postoperative pictures have been contrasted to preoperative modified images.

The agreement between the surgeon and patient was assessed using weighted kappa values. The frontal views showed a moderate strength of agreement (0.422), whereas the lateral views showed a strong strength of agreement (0.650).

Alsarraf *et al*. [35] were the pioneers in developing a reliable questionnaire specifically designed for various plastic surgery treatments. The ROE questionnaire, modified by Arima *et al*. [36], was specifically adapted for those after rhinoplasty [31].

The ROE scale is a valuable instrument for assessing patient satisfaction after cosmetic rhinoplasty, enabling clinicians and patients to objectively measure the advantages of the treatment. While the GBI and Sino-Nasal Outcome Test (SNOT-22) are newer scales that can be utilized to evaluate postoperative satisfaction with patients and health benefits, they don't specifically measure the enhancement in scores [17, 37].

Regarding the present work findings, the ROE questionnaire in the studied groups after 3 months showed that participants who had been satisfied with the look of their nose had been significantly increased in group B contrasted to in group A.

In accordance with our findings, Willaert *et al*. [17] presented a new comprehensive workflow in their meta-analysis facilitates precise and detailed planning, utilization of grafting templates, and 3D guided bone surgeries with the incorporation of piezotome and intraoperative navigation. The baseline, preoperative patient satisfaction levels determined by ROE ranged from 4.73 to 45.3, as reported by them. The postoperative scores varied between 18.02 and 82.59.

Regarding the application of ROE, Khan *et al*. [38] conducted a study to restore the function and youthful appearance of the nose and to enhance quality of life after rhinoplasty using the ROE questionnaire. They found a higher number of patients satisfied with the look of their nose. In the same context, Choi *et al*. [22] established the ROE questionnaire for patients underwent 3D printed model technology for rhinoplasty. They reported that the ROE questionnaire showed promising results regarding the patients and family satisfaction.

In agreement with our findings, Eldaly *et al*. [39] conducted a comprehensive review to investigate the possible applications of artificial intelligence (AI) and simulation models in rhinoplasty. Their conclusion states that the utilization of 3D simulation models and AI models has the potential to completely transform the field of functional and aesthetic rhinoplasty. Simulation systems offer advantages in preoperative planning, intra-operative decision making, and postoperative assessment.

In agreement with our results, Choi *et al*. [22] showed considerable results regarding aesthetic score in patients undergoing rhinoplasty with 3D technology. Parallel to our findings.

In the current study, the percentage of patient satisfaction based on ROE questionnaire was substantially greater in group B contrasted to group A (p<0.001).

Our results corroborated a recent investigation carried out by Li *et al*. [40] that examined the impact of 3D imaging on Asian rhinoplasty. The study comprised individuals who were randomly allocated into two groups one group underwent 3D imaging, while the other group did not. The researchers discovered that the level of satisfaction was considerably higher in the group that used 3D imaging compared to the group that did not use 3D imaging (P Value < 0.001). Consistent with our findings, Klosterman *et al*. [30] discovered that individuals who received a 3D printed model reported high levels of subjective satisfaction during routine postoperative visits for up to 6 months.

The outcome of rhinoplasty may be influenced by additional factors not indicated in this study. For example, the psychosocial condition of the patients. The perception of outcomes is subjective and can be influenced by both objective face analysis results and the psychosocial status of the patients [41].

In essence, the objective of designing a rhinoplasty procedure is to harmonize the objectives of the patients and surgeons, while taking into consideration the anatomical limitations of what can be realistically accomplished. Computer-aided planning facilitates this process and enables patients to comprehend the objectives that can be accomplished through their surgery. Hence, it serves as a valuable instrument in the process of planning for rhinoplasty (151).

There is an enormous amount of research demonstrating the benefits of utilizing the 3D radiologic viewer. These advantages include enhanced preoperative planning, decreased stress during surgeries, increased number of patients eligible for surgery, reduced need for postoperative corrections, shorter surgical time for functional interventions, greater improvement in nasal function, and higher levels of postoperative satisfaction [22, 29].

Limitations: It was a single-center study, and the results may differ elsewhere, the expenses associated with setting up a 3D simulation, including the necessary equipment and software, can be significant. It is important to note that using 3D technology that utilizes radiography instead of 3D photogrammetry may pose a potential risk of radiation exposure to the patient.

Conclusions

Rhinoplasty is a highly intricate and challenging surgical procedure that has been enhanced by advancements in technology during the planning and operative phases. Compared to conventional methods, virtual simulation using 3D technology and 3D printed anatomic surgical guide showed better promising results regarding surgical time, ROE, and patients' satisfaction with more reliable results. Virtual simulation assists in harmonizing the aesthetic objectives of both the patient and surgeon.

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References

1. Codazzi D, Bruschi S, Mazzola RF, Bocchiotti MA, Bogetti P, Ortelli L, *et al*. Bergamo 3D Rhinoplasty software: Select, store, and share surgical Maneuvers in a three-dimensional nasal model. Plastic and Reconstructive Surgery. 2016;137:313-7.
2. Tijerina JD, Morrison SD, Nolan IT, Vail DG, Lee GK, Nazerali R. Analysis and interpretation of Google trends data on public interest in cosmetic body procedures. Aesthetic Surgery Journal. 2020;40:34-43.
3. Lekakis G, Claes P, Hamilton GS 3rd, Hellings PW. Three-dimensional surface imaging and the continuous evolution of preoperative and postoperative assessment in Rhinoplasty. Facial Plastic Surgery. 2016;32:88-94.
4. Persichetti P, Simone P, Langella M, Marangi GF, Carusi C. Digital photography in plastic surgery: How to achieve reasonable standardization outside a photographic studio. Aesthetic Plastic Surgery. 2007;31:194-200.
5. Tepper OM, Sorice S, Hershman GN, Saadeh P, Levine JP, Hirsch D. Use of virtual 3-dimensional surgery in post-traumatic craniomaxillofacial reconstruction. Journal of Oral and Maxillofacial Surgery. 2011;69:733-41.
6. Choi JW, Kim N. Clinical application of three-dimensional printing technology in craniofacial plastic surgery. Archives of Plastic Surgery. 2015;42:267-77.
7. Jang J, Yi HG, Cho DW. 3D Printed Tissue Models: Present and Future. ACS Biomaterials Science & Engineering. 2016;2:1722-31.
8. Zheng YX, Yu DF, Zhao JG, Wu YL, Zheng B. 3D Printout Models vs. 3D-Rendered Images: Which Is Better for Preoperative Planning? Journal of Surgical Education. 2016;73:518-23.
9. Vuyk HD, Adamson PA. Biomaterials in rhinoplasty. Clinical Otolaryngology and Allied Sciences. 1998;23:209-17.
10. Kim DW, Shah AR, Toriumi DM. Concentric and eccentric carved costal cartilage: A comparison of warping. Archives of Facial Plastic Surgery. 2006;8:42-6.
11. Westreich RW, Lawson W. The tripod theory of nasal tip support revisited: The cantilevered spring model. Archives of Facial Plastic Surgery. 2008;10:170-9.
12. Baskaran M, Packiaraj I, Arularasan SG, Divakar TK. Cleft rhinoplasty. Journal of Pharmacy & Bioallied Sciences. 2015;7:691-4.
13. Anton de Vez H, Herrero Jover J. Personalized medicine: Technological bridge between patient and surgeon by 3D printed surgical guide in rhinoplasty. Journal of Plastic, Reconstructive & Aesthetic Surgery. 2018;4:1-3.
14. Gruber R, Chang TN, Kahn D, Sullivan P. Broad nasal bone reduction: An algorithm for osteotomies. Plastic and Reconstructive Surgery. 2007;119:1044-53.
15. Bertossi D, Magagnotto N, Chirumbolo S, D'Souza A, Nocini R. Nonsurgical Rhinoplasty: Long-Term follow-up of high G' HA Nasal Injections. Facial Plastic Surgery. 2022;38:96-101.
16. Vu NH, Trieu NM, Tuan AHN, Khoa TD, Thinh NT. Review: Facial anthropometric, landmark extraction, and nasal reconstruction technology. Applied Sciences. 2022;12:9548-66.
17. Willaert RV, Opdenakker Y, Sun Y, Politis C, Vermeersch H. New Technologies in Rhinoplasty: A comprehensive workflow for computer-assisted planning and execution. Plastic and Reconstructive Surgery Global Open. 2019;7:2121-26.
18. Hammond DC, Kim K, Bageris MH, Chaudhry A. Use of three-dimensional imaging to assess the effectiveness of volume as a critical variable in breast implant selection. Plastic and Reconstructive Surgery. 2022;149:70-9.
19. Escandón JM, Morrison CS, Langstein HN, Ciudad P, Corral DG, Manrique OJ. Applications of three-dimensional surgical planning in facial feminization surgery: A systematic review. Journal of Plastic, Reconstructive & Aesthetic Surgery. 2022;75:1-14.
20. Agrawal N, Turner A, Grome L, Ghname AA, Davis MJ, Reece EM, *et al*. Use of simulation in plastic surgery training. Plastic and Reconstructive Surgery Global Open. 2020;8:2896-903.
21. Cornejo J, Aguilar CJA, Vargas M, Helguero CG, Andrade MDR, Montoya TS, *et al*. Anatomical Engineering and 3D printing for surgery and medical devices: International Review and Future Exponential Innovations. BioMed Research International. 2022;2022:6797745-56.
22. Choi JW, Kim MJ, Kang MK, Kim SC, Jeong WS, Kim DH, *et al*. Clinical application of a patient-specific, three-

dimensional printing guide based on computer simulation for Rhinoplasty. Plastic and Reconstructive Surgery. 2020;145:365-74.
23. Moscatiello F, Jover HJ, Ballester GMA, Hernández CE, Piombino P, Califano L. Preoperative digital three-dimensional planning for rhinoplasty. Aesthetic Plastic Surgery. 2010;34:232-8.
24. Ali MMH. External nasal parameters in Egyptians: An in-depth nasal photogrammatic analysis. Surgical and Radiologic Anatomy. 2014;36:633-41.
25. Sobral DS, Duarte DW, Dornelles RFV, Moraes CAC. 3D Virtual Planning for Rhinoplasty using a free add-on for open-source software. Aesthetic Surgery Journal. 2021;41:1024-32.
26. Gordon AR, Schreiber JE, Patel A, Tepper OM. 3D printed surgical guides applied in Rhinoplasty to help obtain ideal nasal profile. Aesthetic Plastic Surgery. 2021;45:2852-9.
27. ElBestar M, Zeid AMA, Lasheen H, Farahat A, ElFouly M, Sabaa M, *et al*. Spreader flap versus spreader graft in dorsal reconstruction following hump resection in primary closed Rhinoplasty. Egyptian Journal of Ear, Nose, Throat and Allied Sciences. 2020;21:192-201.
28. Elemam A, Dewidar HM, Shawky A, Elfouly M, Sabaa MAE. Outcome after dorsal hump resection versus hump remodelling and re-insertion: A Randomized Controlled Trial. Egyptian Journal of Ear, Nose, Throat and Allied Sciences. 2022;23:1-9.
29. Vez HADH, Jover HJ, Vergara SC. Personalized 3D printed surgical tool for guiding the chisel during hump reduction in Rhinoplasty. Plastic and Reconstructive Surgery Global Open. 2018;6:1668-75.
30. Klosterman T, Romo T. Three-dimensional printed facial models in Rhinoplasty. Facial Plastic Surgery. 2018;34:201-4.
31. Bilgin E, Say MA, Baklacı D. Assessment of patient satisfaction with primary Septorhinoplasty using the rhinoplasty outcome evaluation questionnaire. Cureus. 2020;12:11777-81.
32. Bawil BM, Ezabadi RS, Sadeghi M, Zoroofi RA, Amali A. Preoperative computer simulation in rhinoplasty using previous postoperative images. Facial Plastic Surgery & Aesthetic Medicine. 2020;22:406-11.
33. Pausch NC, Unger C, Arnnop PP, Subbalekha K. Nasal appearance after secondary cleft rhinoplasty: Comparison of professional rating with patient satisfaction. Oral and Maxillofacial Surgery. 2016;20:195-201.
34. Punthakee X, Rival R, Solomon P. Digital imaging in rhinoplasty. Aesthetic Plastic Surgery. 2009;33:635-8.
35. Alsarraf R. Outcomes research in facial plastic surgery: A review and new directions. Aesthetic Plastic Surgery. 2000;24:192-7.
36. Arima LM, Velasco LC, Tiago RSL. Crooked nose: Outcome evaluations in rhinoplasty. Brazilian Journal of Otorhinolaryngology. 2011;77:510-5.
37. Valsamidis K, Titelis K, Rachovitsas D, Konstantinidis I, Markou K, Triaridis S. Long-term evaluation of nasal septoplasty followed by inferior turbinate cauterization for the treatment of nasal obstruction using objective and subjective methods. International Archives of Otorhinolaryngology. 2018;22:284-90.
38. Khan N, Rashid M, Khan I, Sarwar URS, Rashid UH, Khurshid M, *et al*. Satisfaction in patients after Rhinoplasty using the Rhinoplasty outcome evaluation questionnaire. Cureus. 2019;11:5283-90.
39. Eldaly AS, Avila FR, Guzman TRA, Maita K, Garcia JP, Serrano PL, *et al*. Simulation and Artificial Intelligence in Rhinoplasty: A Systematic Review. Aesthetic Plastic Surgery. 2022;46:2368-77.
40. Li W, Liang Y, Sun Y, Xiong X, Meng X, Yi Z, *et al*. Application of three-dimensional imaging in Asian Rhinoplasty with costal cartilage. Aesthetic Plastic Surgery. 2021;45:1714-20.
41. Ozturk K, Gode S, Karahan C, Midilli R. Assessing the rhinoplasty outcome: Inter-rater variability of aesthetic perception in the light of objective facial analysis. European Archives of Oto-Rhino-Laryngology. 2015;272:3709-13.

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