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ORIGINAL ARTICLE

Advancing Precision Rhinoplasty: Preoperative Digital 3D Surgical Planning

Rahul Kumar Pitale Ashok[1] · **Anand Acharya**[1] · **Divya Nayani**[1]

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Abstract

The aim of the study is to assess the efficacy and advantages of utilizing state-of-the-art three-dimensional (3D) reconstruction technology in preoperative planning for rhinoplasty surgery. It is a study of a single rhinoplasty case that was operated at a tertiary hospital. The patient was assessed through a detailed history, blood investigations, radiological investigations and preoperative 3D (three-dimensional) reconstruction of the face and nose. The study utilized high-resolution CT scans and 3D reconstruction software like 3D (three-dimensional) Slicer and Blender 3D (three-dimensional) to analyze nasal anatomy for preoperative planning in rhinoplasty. External and internal nasal measurements were taken, and axial cross-section analysis was conducted to assess nasal structure deviation. The benefits of 3D (three-dimensional) visualization in surgical planning were evaluated, and surgical management was based on preoperative reconstructions. Comprehensive preoperative evaluations were performed, adhering to ethical guidelines. Preoperative 3D (three-dimensional) reconstruction planning methods facilitated precise surgical planning and execution in rhinoplasty with satisfactory outcomes for both the patient and the surgeon. Incorporating 3D (three-dimensional) reconstruction technology in rhinoplasty preoperative planning enhances surgical precision and patient satisfaction, ensuring optimized surgical outcomes while adhering to ethical standards.

Keywords Rhinoplasty · Three-dimensional (3D) reconstruction · Preoperative planning · Surgical precision · Surgical outcomes

Introduction

Ensuring effective communication between surgeons and patients is paramount in the meticulous planning of plastic and reconstructive surgeries, including nasal surgeries such as rhinoplasty [1–3]. Over the years, numerous methods have been employed to facilitate this communication, ranging from traditional techniques like drawings on photographs to more modern approaches utilizing digitized photography and photo-editing software like Adobe Photoshop [4]. While surface scanners [5, 6] have allowed for some simulation of facial surgeries, they are limited in their ability to capture internal structures.

In recent times, there has been a surge of enthusiasm surrounding the adoption of advanced computer technology in preoperative planning. One such innovation is the three-dimensional (3D) reconstructions from digital computed tomography (CT) images. These reconstructions offer enhanced visualization of anatomical features and surgical corrections, providing a shared platform for both patients and surgeons to review and discuss.

This study aims to assess the efficacy and advantages of utilizing state-of-the-art three-dimensional (3D) reconstruction technology in preoperative planning for rhinoplasty surgery. This technology has significantly improved communication between surgeons and patients.

✉ Divya Nayani
divyanayani.9@gmail.com

Rahul Kumar Pitale Ashok
rahul1987doc@gmail.com

Anand Acharya
acharya.is.anand@gmail.com

[1] Department of Otorhinolaryngology, Government ENT Hospital, Osmania Medical College, Door No.5-1-174, Opposite State Bank of India Head Office, Bank Street Road, Koti, Hyderabad 500095, India

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Materials and Methods

We are discussing the prospective study of a single rhinoplasty case that was operated at a tertiary hospital. The patient was assessed through a detailed history, blood investigations, radiological investigations and preoperative 3D (three-dimensional) reconstruction planning.

(1) *Preoperative Evaluation* Thorough preoperative assessments were performed, encompassing haematological and radiological investigations, to ascertain the patient's candidacy for surgery and to detect any possible risks or contraindications. Figure 1a–i shows multiple pictures of the patient taken from different angles.
(2) *Ethical Considerations* Ethical guidelines and patient consent procedures were followed throughout the study to ensure patient confidentiality and adherence to ethical standards in medical research.
(3) *Preoperative Visualization* High-resolution computed tomography (CT) scans were obtained for the patient to capture detailed anatomical structures of the nasal region. Various 3D (three-dimensional) reconstruction software tools were utilized, including 3D (three-dimensional) Slicer, Blender 3D (three-dimensional), and Micro-DICOM (Digital Imaging and Communications in Medicine). These software packages enable the conversion of CT scan data into three-dimensional models, facilitating detailed visualization of nasal anatomy (Fig. 2).

Preoperative Measurements

External Measurements

Dimensions of the nose were measured externally, including length, anteroposterior dimensions, and inter-alar distance. Table 1 shows the External measurements of the patient's nose. Figure 3a–d shows the External measurement of the patient's nose.

Internal Measurements

Internal dimensions of nasal components such as nasal bones, naso-maxillary angle, and nasal septal angle were measured. Figure 4a, b shows the internal measurement pictures of the patient, c shows the axial cross-sectional image obtained from a computed tomography scan of the

Fig.1 **a–i** Multiple pictures of the patient taken from different angles

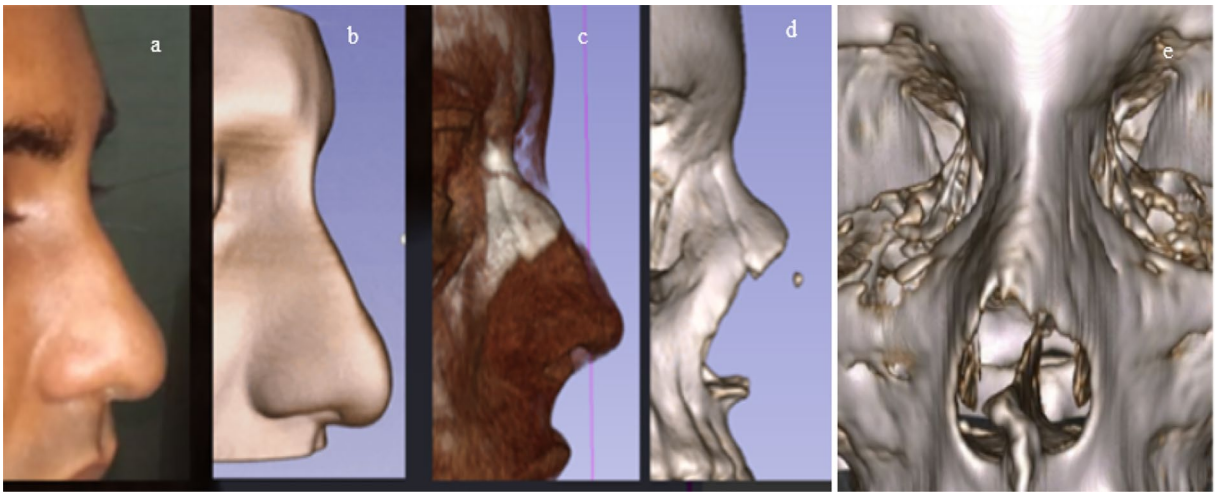

Fig. 2 **a** The normal image of the patient's nose, **b** the 3D view of the patient's nose, **c** the soft tissue view of the patient's nose, **d, e** the bony window of the patient's nose

Table 1 shows the External measurements of the patient's nose

	External measurments	Value (mm)
1	Nasal length	44.51
2	Glabella to subnasal length	55.3
3	Antero-posterior distance	35.1
4	Inter-alar distance	30

patient. Table 2: shows the internal measurements of the patient's nose.

Axial Cross-Section Analysis

Axial cross-sectional images obtained from CT scans were analyzed to assess the deviation and orientation of nasal structures along different axes. Figure 4c shows the axial cross-sectional image obtained from CT scan of the patient.

Advantages of Assessment

The advantages of utilizing 3D (three-dimensional) visualization in surgical planning were assessed, including understanding structures along the X, Y, and Z axes, orientation, and proximity of nasal structures, as well as anatomical outlines of individual nasal components.

Surgical Management

A surgical management strategy was formulated based on the findings from preoperative 3D (three-dimensional) reconstructions and measurements. The surgical plan was tailored to address specific nasal deformities identified

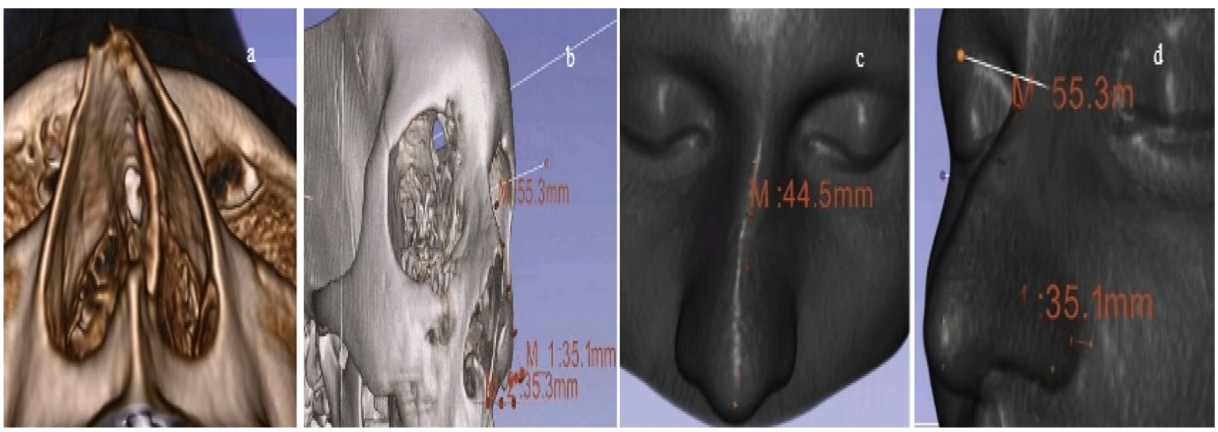

Fig. 3 **a**–**d** The external measurements of the patient's nose

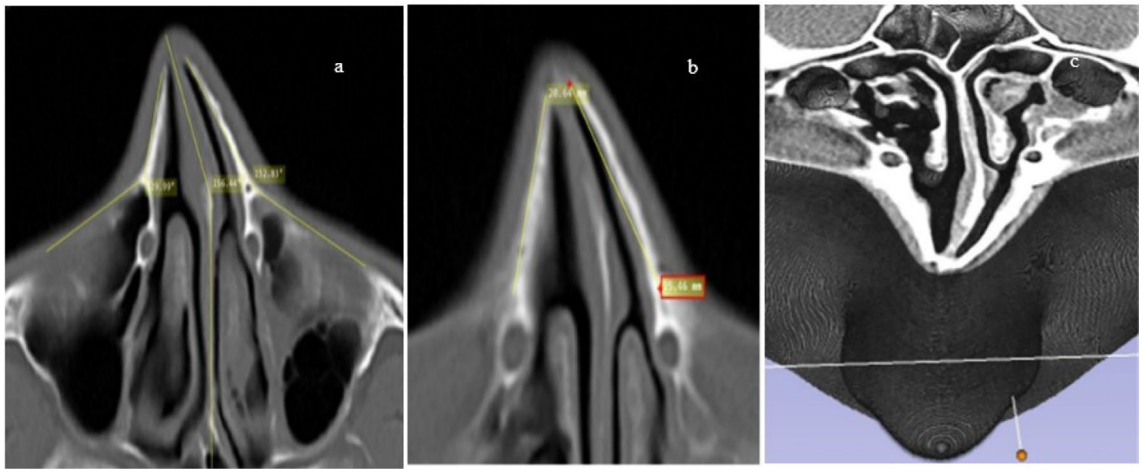

Fig. 4 **a**, **b** shows the internal measurement pictures of the patient **c** the axial cross-sectional image obtained from a computed tomography scan of the patient

Table 2 shows the internal measurments of the patient's nose

	Internal measurments	Right	Left
1	Naso-Maxillary angle	129.99 degrees	152.83 degrees
2	Nasal bone length	20 mm	25.46 mm
3	Nasal septal angle	156.44 degrees–direction towards right side	

during preoperative planning. An open rhinoplasty was performed under general anaesthesia. A mid-collumellar incision was done followed by elevation of sub-periosteal and sub-perichondrial planes. Nasal septum reconstruction was done. Medial and lateral osteotomy was done.

In our case, the left nasal bone was longer than the right nasal bone by around 6 mm. Excess bone from the left nasal bone was excised and removed. Using cartilage grafts, the middle nasal vault was corrected. The incision was closed with monocryl sutures and nasal packing done. An external nasal splint was placed for support. Figure 5a–h shows the surgical pictures of the patient.

Results

Preoperative 3D (three-dimensional) reconstruction planning methods facilitated precise surgical planning and execution in rhinoplasty with satisfactory outcomes for both patient and surgeon. Figure 6a shows the preoperative picture of the patient, and Fig. 6b shows the postoperative picture of the patient. Figure 7a–h shows the postoperative pictures of the patient taken from different angles.

Discussion

In the dynamic field of rhinoplasty, the integration of three-dimensional (3D) reconstruction technology stands out as a pivotal advancement in preoperative planning, offering an unprecedented level of detail and precision. Studies, such as those by Tzou et al. [7], highlight the utility of various 3D surface imaging systems in rhinoplasty, emphasizing their role in improving surgical planning and enhancing communication between surgeons and patients. Similarly, research by Smith et al. [8], while primarily focused on heart surgery, showcases the broader applicability of 3D printing and reconstruction from computed tomography (CT) scans, suggesting it potential to revolutionize precision surgery practices across specialities, thereby advancing spatial comprehension of complex aberrant anatomy. Persing et al. [9] study on aesthetically and quantitatively comparing the simulated to actual rhinoplasty result further emphasize the significance of simulation technology, demonstrating 3D simulation as a powerful communication and planning tool in rhinoplasty.

Adherence to ethical guidelines is crucial in medical research and clinical practice, as mentioned in the study. Obtaining informed consent and ensuring patient confidentiality are fundamental aspects that underscore the importance of ethics in surgical planning and execution. Moreover, the integration of such advanced technology into clinical practice raises considerations regarding access to care, the cost of procedures, and the need for surgeon training in these new technologies. The ethical considerations surrounding the adoption of such advanced technologies, as discussed by Lynn et al. [10], highlight the necessity for meticulous patient consent processes and managing expectations to ensure ethical standards are met. Collectively, all these

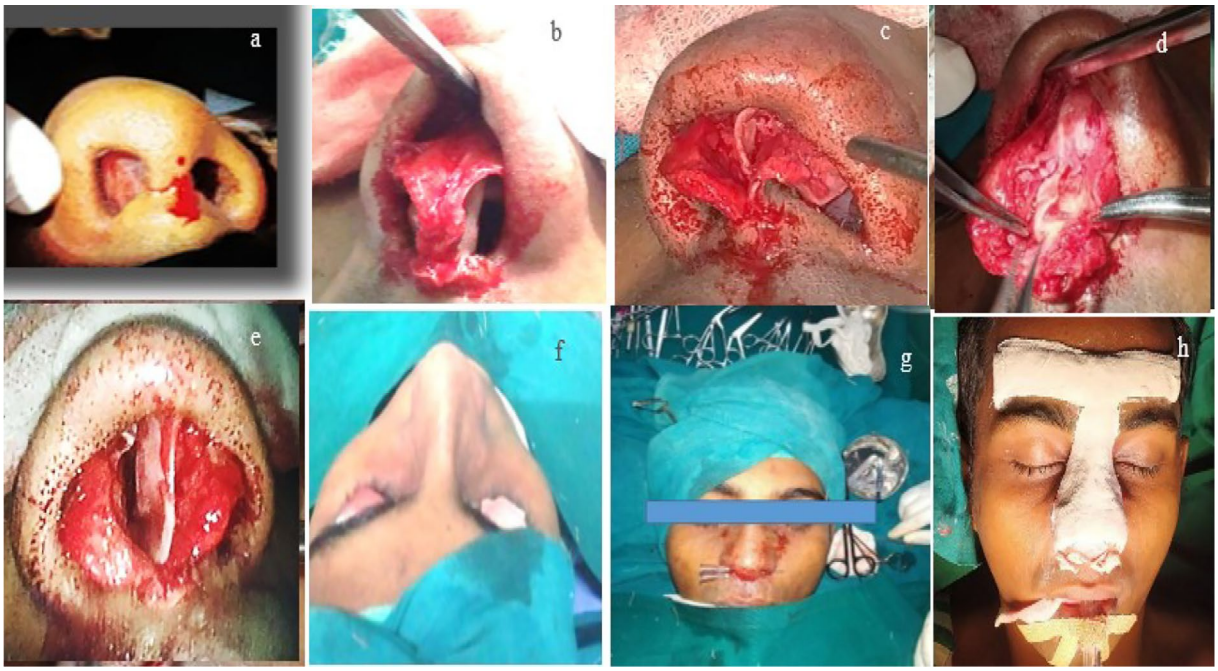

Fig. 5 **a**–**h** The surgical pictures of the patient

Fig. 6 **a** The preoperative picture of the patient, and **b** the postoperative picture of the patient

studies provide a compelling narrative on the transformative impact of 3D reconstruction technology which can be applied to rhinoplasty, setting a new benchmark for surgical planning and execution while fostering an environment of enhanced patient care and satisfaction.

The application of 3D reconstruction technology in preoperative rhinoplasty planning has garnered considerable interest among surgeons due to its ability to offer an unparalleled level of detail in visualizing nasal anatomical structures, thereby facilitating precise surgical interventions. Studies suggest that 3D planning improves surgical outcomes by allowing surgeons to simulate results before the procedure [11], identifying anatomical variations and pathologies that might not be apparent in 2D images for a more tailored approach. Traditional methods of surgical planning, including the use of two-dimensional photographs and manual drawings, have limitations in accurately conveying the complexities of nasal anatomy [12]. 3D reconstruction technology overcomes these limitations by providing a holistic view of the nasal structure, including the internal nasal passages, the septum, and the external nasal shape. This comprehensive visualization facilitates a shared understanding between the surgeon

Fig. 7 **a**–**h** The postoperative pictures of the patient taken from different angles

and patient regarding the surgical goals and expected outcomes, thus improving patient satisfaction [13].

Rapid technological advancements are driving the evolution of rhinoplasty and facial plastic surgery. Future research avenues may involve the integration of virtual reality (VR) and augmented reality (AR) with 3D reconstruction technology, offering more immersive preoperative planning and enhancing surgeon training. Furthermore, investigations into long-term patient outcomes and satisfaction following surgery, comparing the effectiveness of 3D planning against traditional methods, could provide valuable insights into the efficacy of this innovative technology.

Conclusion

The study highlights the effectiveness of utilizing state-of-the-art 3D (three-dimensional) reconstruction technology in preoperative planning for rhinoplasty surgery. By accurately visualizing nasal anatomy and obtaining precise measurements, surgeons can develop optimized surgical plans tailored to individual patients' needs. The comprehensive understanding gained from axial cross-section analysis enhances surgical decision-making and potentially improves surgical outcomes. Furthermore, adherence to ethical guidelines ensures patient confidentiality and upholds ethical standards in medical research. Overall, the integration of 3D (three-dimensional) reconstruction technology in rhinoplasty for preoperative planning offers promising benefits for enhancing surgical precision and patient satisfaction.

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Declarations

Conflict of interest The authors have disclosed no conflicts of interest.

Ethical Approval All procedures carried out in the study involving the human participant adhered to ethical standards.

Informed Consent Informed consent was obtained from the patient involved in the study.

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