Patient-Specific Implants in Maxillofacial Reconstruction - A Case Report

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Abstract

Rationale: The successful utilisation of three dimensional (3D) techniques in engineering a titanium patient specific implant (PSI) for a patient who underwent hemimaxillectomy following post COVID mucormycosis infection. **Patient Concerns:** Issues related to problems associated with resection following mucormycosis, such as occlusal function, aesthetics and facial asymmetry. **Diagnosis:** The patient affected by mucormycosis was left with Aramany class 1 and Cordeiro type II sub total maxillectomy defect. **Treatment:** The patient was operated for mucormycosis followed by reconstruction with patient specific implant. **Outcome:** Positive clinical outcomes, including improved facial symmetry, function and psychological well being with immediate replacement of the teeth, the benefits of which far outweigh the traditional approach. **Take away Lessons:** The advances in the use of PSI by integration of 3D printing and computer aided design computer aided manufacturing (CAD-CAM) technology for extensive and challenging defects in the maxillofacial region have been highlighted in this case report.

Keywords: Case report, occlusion, patient-specific implants, prosthetic rehabilitation, reconstructive surgery

Introduction

Extensive and challenging maxillofacial defects result in facial asymmetry accompanied by functional and aesthetic deformities, which unfavourably impact a patient's psychological well-being.[1,2] Furthermore, reconstruction of such defects becomes challenging owing to the uniqueness of each defect. Since the early 1980s, three-dimensional (3D) printing, along with integration into computer-aided design-computer-aided manufacturing (CAD-CAM), has dramatically changed the science of reconstruction by manufacturing customised patient-specific implants (PSIs).

The exact size and shape of the defects are being determined from computed tomography (CT) scans, which help in the reproduction of patients' anatomy into a 3D model offering higher accuracy and better site adaptation.[3] This considerably helps to overcome the disadvantages of autogenous grafts, which include the risk of infections, graft resorption, poor cosmetic outcomes and donor site morbidity.[2,4] In the present case report, the surgical and prosthetic concerns were addressed with real-time communication to fabricate PSI.

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Case Report

A 52-year-old patient reported to the Department of Oral and Maxillofacial Surgery, presenting a painless, progressively non-healing wound involving the right maxillary buccal mucosa region of canine to molar teeth for 3–4 months [Figure 1].

A biopsy of the involved region was performed for haematoxylin-eosin stain and KOH mount, confirming mucormycosis of the right maxilla, conforming to the clinical and radiological investigations. The treatment planned was hemimaxillectomy of the right side with debridement of the bone till healthy bone was observed. Amphotericin B was administered as a medicinal adjuvant. Regular follow-up for

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six months showed a healthy surgical site and no signs of any progression of disease.

The defect observed in the maxilla six months postoperatively was classified as an Aramany class 1 defect wherein the defect is located along the midline of the maxillary arch, which involves the incisive papilla and Cordeiro type II sub-total maxillectomy wherein five out of six walls are involved preserving the orbital floor[5] [Figure 2]. A decision was taken to utilise novel reconstruction techniques of PSI through the integration of 3D printing and CAD-CAM.

Initial pre-operative digital planning workflow included examination and processing of files in DICOM format obtained from cone beam CT scan. Using MIMICS Software® (Materialise 2023), a segmented 3D virtual model of the patient's hard tissue was obtained. The PSI was fabricated keeping surgical and prosthetic considerations in mind. The surgical aspect involved maximum anchoring possibilities of the remaining hard tissue structure to incorporate the maximum amount of screws/fixtures in the healthy bone to increase the longevity of the PSI [Figures 3 and 4].

Once the planning and the final treatment decision were made, the 3D projection of the maxilla was saved as a standard tessellation language file to the CAD of the implant. Following validation of the completed design by the surgeons, the implant was 3D printed to produce the physical titanium PSI employing grade 5 titanium alloy powder (Ti6Al4V) using a technique referred to as 'selective laser sintering' which is essentially selective fusion of the titanium powder by a laser beam giving highly accurate results [Figure 5].

Proper counselling of the patient to describe the risks and complications involved was done to procure the consent of the patient for the following surgery. The high vestibular degloving incision was utilised for the surgery through which the maxillary segment was exposed as a whole. The scar tissue was excised and the recipient bed was prepared. The mucoperiosteal flap was elevated to provide easy access to the malar segment on either side. The PSI was thus placed, fitting into the zygomatic bone snuggly on either side. Fixation was done using 2 mm diameter and 8 mm length screws. The designed PSI included 12 holes with 4 extensions on the affected side and contralateral support, including 14 holes. When the PSI was fixed, the prefabricated interim prosthesis was fixed intraoperatively as the prosthetic studs were fabricated in PSI as per the implant system (Cowellmedi). The mucoperiosteal flap was then closed using 3-0 Vicryl sutures [Figure 6].

The patient was monitored for nine months with regular follow-up with no evidence of post-operative infection or

Figure 1: Painless, progressively non-healing wound involving the right maxillary region and osteolytic lesion in the right maxilla causing break in the continuity of the floor of nasal fossa, maxillary sinus and right palatal bone

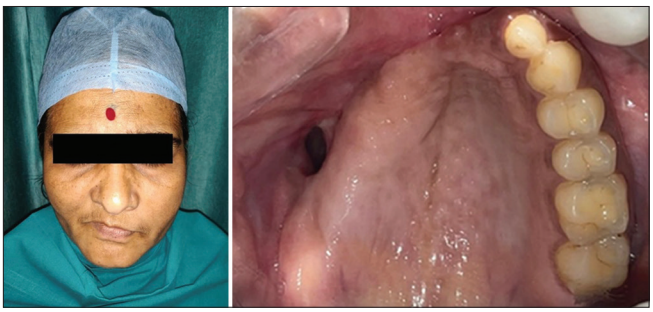

Figure 2: Pre-operative extra-oral clinical appearance demonstrating facial asymmetry, flattening of the nasolabial fold and asymmetrical lip line and pre-reconstructive intra-oral defect

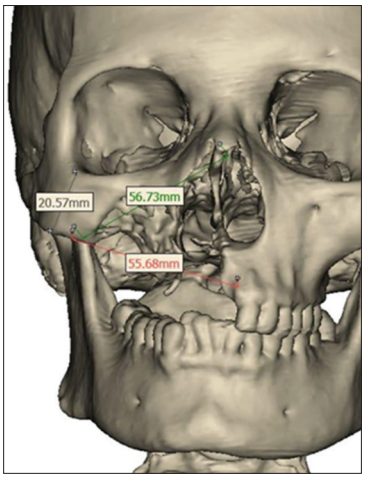

Figure 3: Outlines and extent of defect extending from the infraorbital region superiorly, tooth 22 anteriorly and involving the nasal floor

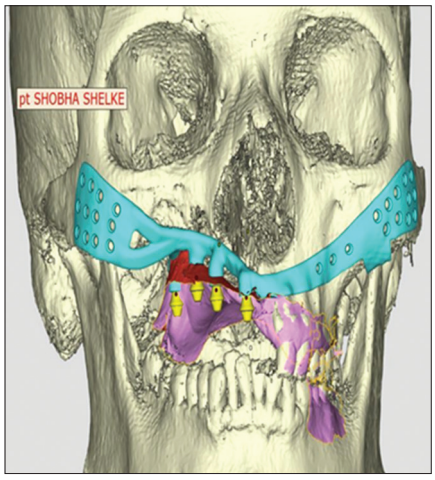

Figure 4: Planning of the patient-specific implant extending from the zygomatic arch bilaterally and includes occlusal studs and provision for hardware fixation

Figure 5: Fabricated patient-specific implant on the patient's anatomic model with provision for hardware fixation and occlusal studs demonstrating the fit of the patient-specific implant

Figure 7: The final Prosthesis and 9-month post-operative follow-up demonstrating facial symmetry, even smile line and improvement of the nasolabial fold

exposure to the PSI [Figure 7]. Post-operative X-ray showed appropriate fit and positioning of the PSI [Figure 8].

Discussion

PSI is the upcoming horizon in the field of reconstruction that allows simultaneous dental and maxillofacial rehabilitation to achieve immediate aesthetic and functional aspects.[1,6] With the advent of 3D printing and CAD-CAM technology, reconstruction of 3D facial forms to re-establish complex anatomical structures has become relatively simple.[7] Additive manufacturing techniques have facilitated the reconstruction of devices that can be designed to exactly fulfil the reconstructive requirements as per the customised demand of a case.[1,3] 3D printing technology can be used to overcome limitations associated with autologous bone grafts.[2,8]

In our case, selective laser sintering has been utilised for manufacturing PSI.[9,10] With the advances in computing power and 3D modelling software, a collaborative approach to implant design is being followed, which involves real-time communication between the implant designer and surgeon to produce precisely engineered PSI to match the bony defect.[11]

After the surgical placement of PSI, the pre-fabricated interim prosthesis was placed over multi-unit abutments and kept out of occlusion for non-function immediate loading. The

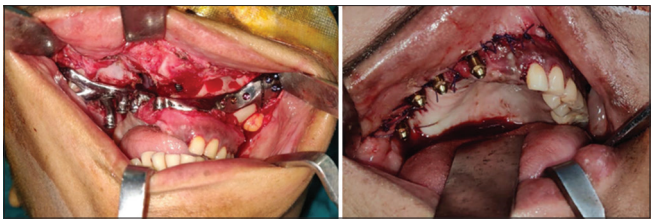

Figure 6: Intraoperative fixation of the patient-specific implant and intraoperative suturing done following fixation of the patient-specific implant

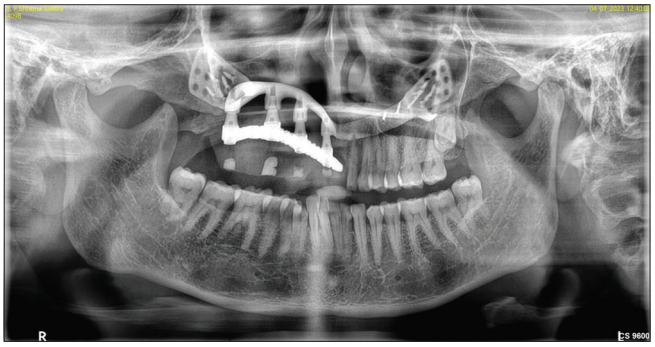

Figure 8: Post operative orthopantomogram (OPG) showing fixation of patient specific implant with rigid fixation screws along with the prosthetic components

definitive prosthesis was fabricated six months post-surgery with satisfactory results.

Although the PSI is precision-driven, it requires surgical experience and may require bone contouring for adequate stable fit and placement because of the limitation of access due to the intra-oral surgical approach. In some cases, it may be preferred to have a combined intraoral and extraoral approach for ease of placement of PSI. However, it was avoided for aesthetic concerns and scar formation.

Because of a paucity of adequate amount of soft tissue, it was difficult to achieve good primary closure of the PSI. The problem was addressed by undermining soft tissue and utilising a palatal rotational flap.

Conclusion

The hereby described case report highlights the successful utilisation of PSIs in maxillofacial surgery for the reconstruction of a large defect resulting from hemimaxillectomy. The integration of 3D printing and CAD-CAM technology has significantly improved the production of accurate and customised PSIs.

This novel technique can be utilised in the reconstruction of the majority of challenging maxillofacial defects such as cleft palate, post-traumatic and post-resection defects as well as congenital anomalies successfully.

The PSIs thus produced allow immediate non-functional loading of the prosthesis, thereby providing satisfactory aesthetic and occlusal rehabilitation. This novel treatment

approach far outweighs traditional autogenous bone graft rehabilitation in terms of surgical morbidity and single-stage occlusal rehabilitation.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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