Reconstruction of a Craniofacial Defect Using Rapid Prototyping and an Autograft - A Case Report

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Abstract

Rationale: Achieving predictable aesthetic results of large craniofacial defects has always been difficult, and it requires a multidisciplinary approach. **Patient Concern:** The chief concern of the patient was poor aesthetics due to a congenital craniofacial defect. **Diagnosis:** The patient was a known case of plexiform neurofibromatosis and had a congenital temporo-orbital bone defect of unknown origin. **Treatment:** The reconstruction of the defect was done using rapid prototyping (RPT) and iliac crest graft. Three-dimensional computed tomography imaging and RPT were used to obtain a customized titanium prosthesis to rehabilitate the temporal defect and the defect lateral to the orbit was reconstructed using an iliac crest graft. **Outcome:** Postoperative results were satisfactory and predictable. The positive change in appearance has improved the psychological well-being of the patient. **Take-away Lessons:** A multidisciplinary approach, use of advanced and improved technology helps in better treatment planning and achieving desired aesthetic results.

Keywords: Autograft, iliac crest graft, maxillofacial prosthesis, stereolithography, titanium

Introduction

Craniofacial defects commonly occur secondary to trauma, postablative tumour resection, infection, or due to congenital deformities.[1] Irrespective of the etiology, reconstruction of such defects is the only treatment of choice. Reconstruction can be achieved using different materials such as autografts, allografts, or alloplasts.[2] Autografts are acknowledged as the "gold standard" for reconstruction of craniofacial defects, as they have exceptional biocompatibility and osseointegration properties with the host cranial bone.[3] However, they cannot always be used to reconstruct large defects due to donor-site morbidities, and also bone resorption at the graft site is a significant problem, especially in young patients.[4]

Various alloplastic materials have been developed for the repair of such complex cranial defects.[2] The common synthetic material currently used for the reconstruction of cranial defects is polymethyl methacrylate (PMMA).[5] It is moldable, easy to use, and is suitable for the customized demands of asymmetrical cranial defects.[3] However, PMMA does come with drawbacks, such as local wound and systemic reactions due to the presence of residual organic monomer.[5] Polyether ether ketone (PEEK) is another popular polymeric material for craniofacial reconstruction. The density, modulus of elasticity, and strength of PEEK are comparable with the cortical bone.[3] However, PEEK is expensive and lacks osseointegrative properties.[6] The long-term follow-up studies investigating PEEK cranioplasty and the risk for infection are scarce.[3]

Titanium (Ti) is another popular biomaterial, and is a material of choice for cranial reconstruction due to its biocompatibility and osseointegrative properties.[1] It exhibits high mechanical strength, which ensures maximal stability of the prosthesis, resistance to additional trauma, and it can be easily fixed to the skull by means of Ti screws.[7] Custom-designed prefabricated Ti prostheses have the unique advantages of precise fit, reduced

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surgical time, lower possibility of infection, faster recovery, and excellent cosmetics in craniofacial reconstruction.[7,8]

We report a unique case of a 19-year-old male referred to the Department of Prosthodontics from the Department of Plastic Surgery for the fabrication of a temporal prosthesis for a congenital temporo-orbital depression. The patient was treated with a combination of custom-designed prefabricated Ti prosthesis and iliac crest graft. Using advanced techniques, we achieved desirable aesthetics with limited donor site morbidities and treated such a large defect with precision.

Case Report

Patient concerns

A 19-year-old male reported to the Department of Plastic Surgery with a chief complaint of facial asymmetry. The patient desired the correction of a congenital temporo-orbital depression and the hanging mass on the left side of the face. Important clinical findings included droopy left eyelid, multiple café-au-lait spots on the middle back region, scoliosis, and congenital temporo-orbital depression. The patient was diagnosed with a case of plexiform neurofibromatosis. The depression was seen on the left side of the skull extending superoinferiorly from the temporal bone to the upper border of the zygomatic arch and anteroposteriorly from mid-canthus to the preauricular region. The skin over the depression was pigmented and a plexiform neurofibromatosis fold was hanging in the preauricular region of approximately 3 cm × 5 cm in size along the inferior border of the defect [Figure 1].

Diagnostic aids

A full-head computed tomography scan (Brivo CT385; GE Healthcare) at 0.5 mm slice thickness was done and the results were saved as digital imaging and communications in medicine (DICOM) file [Figure 2]. The DICOM file was then converted to stereolithography (STL) format. This STL file was used for digital processing and creating a virtual model with the help of software (Mimics; Materialise). On the virtual model, mirroring of the unaffected side was done. This mirror image was superimposed and adapted to the defect side to ensure proper fit and merging of edges [Figure 3a]. STL data from the virtually designed prosthesis were exported to a polyjet printer (Objet Eden260VS; Stratasys) for prototype fabrication. The fabricated prototype was provisionally assessed over the defect for its tentative fit.

Treatment

The treatment included combination of Ti (allograft) prosthesis by rapid prototyping (RPT) and iliac crest graft (autograft). The fabrication of Ti prosthesis for the entire temporo-orbital defect was not advised as it would have required two different pieces of Ti. Therefore, temporal depression was reconstructed with Ti prosthesis and infraorbital rim part of the zygomatic bone was reconstructed by means of iliac crest graft.

After approval of the prototype from the operating surgeon, fabrication of the definitive Ti prosthesis with mesh design was finalized [Figure 3b]. Holes were provided for cranial screws along the periphery of the prosthesis for fixation. The definitive prosthesis was sterilized by autoclaving before surgery. Under general anaesthesia, a marking was made with an indelible marker for the hemicoronal incision and the flap was elevated to expose the underlying defect [Figure 4]. The prosthesis was placed on the defect site and its position and fit was evaluated [Figure 5a]. Fixation of the prosthesis to the cranial vault was achieved with seven cranial screws of dimension 2.5 mm in diameter and 6 mm in length. The defect lateral to the orbit was reconstructed using an iliac crest graft harvested at the time of surgery and was fixed with X-shaped five hole Ti plate of 1 mm thickness and mini-screws [Figure 5b]. The scalp flap was sutured back with the surgical drain *in situ*, which was removed 2 days postoperatively. The resection of hanging neurofibroma [Figure 6a and b] was done 3 months postoperatively.

Outcome

The postoperative aesthetic outcome was satisfactory, the depressed external contour showed symmetry and the results were as predicted.

Follow up

The patient was recalled for regular follow-up every 3 months. The 1-year follow-up result of improved aesthetics is shown in Figures 7a and b.

Discussion

The Ti prostheses can be fabricated using RPT and conventional manufacturing techniques such as investment casting.[9] Conventional casting methods for fabrication are technique sensitive and time-consuming. The emergence of RPT in prosthodontics has transformed clinical and laboratory procedures by eliminating some intermediate stages.[10]

RPT specifically focuses on enhanced imagining tools providing the operator with the ability for precise preoperative planning, mirroring of the unaffected side, and designing a patient-specific prosthesis.[8] In our experience, RPT eliminates any discrepancy caused while making of impressions and models.[11] The prototype fabrication helps in the three-dimensional appearance and feel of the prosthesis, which was useful in surgical planning.[11] Furthermore, fabricating a prosthesis with a mesh design had the advantages of reduced weight of the prosthesis, promoted osseointegration, and ensured no buildup of cranial fluid.[5]

In conclusion, custom-made prosthesis with RPT had a better aesthetic result, shorter surgical time, and allowed ease for the operator. However, a major limitation of the custom-made prosthesis is its cost and availability. Furthermore, currently, not many biocompatible materials such as Ti are available for three-dimensional printing.[11] The long-term complications such as skin erosion have been observed with Ti prosthesis, but in patients with multiple

Figure 1: Preoperative view

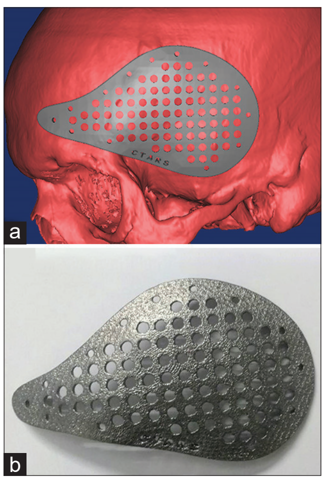

Figure 3: (a) Virtual model with prosthesis (b) Fabricated Titanium implant by means of mirroring of the opposite side

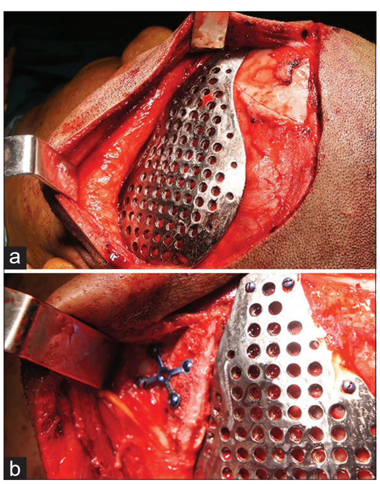

Figure 5: (a) Prosthesis in position (b) Titanium prosthesis and iliac crest graft secured with screws and plate

craniotomies and diabetes.[12] However, the advantages of custom-made Ti prosthesis outweigh the limitations, thus it

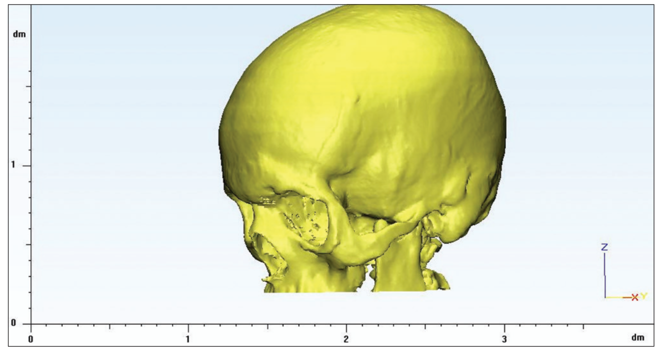

Figure 2: Preoperative three-dimensional computed tomography image

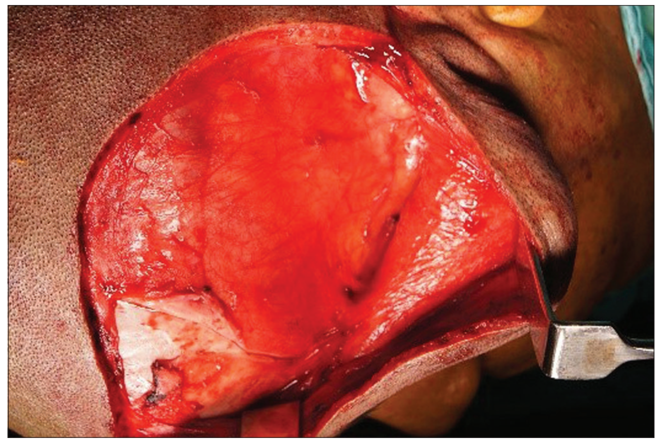

Figure 4: Flap raised

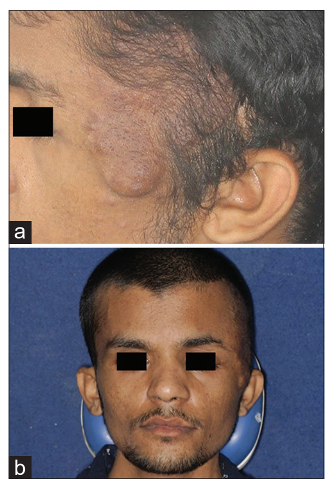

Figure 6: (a) Postoperative after 3 months (lateral view) (b) Postoperative after 3 months (frontal view)

should be the first choice for reconstruction of craniofacial defects in young patients.

Summary

A multidisciplinary approach involving a surgeon and a prosthodontist with the use of RPT technology has resulted in fulfilling the functional and aesthetic demands of the patient. The positive change in appearance has boosted the

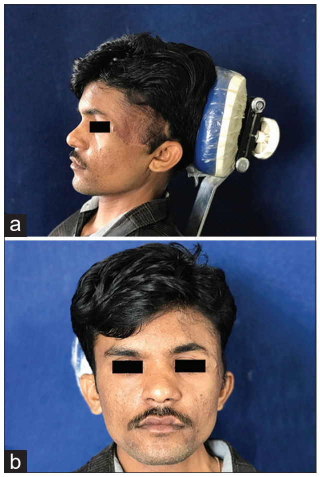

Figure 7: (a) One-year follow-up (lateral view) (b) One-year follow-up (frontal view)

psychological well-being of the patient and had an enormous impact on his personality, confidence, and quality of life.

Declaration of patient consent

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

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Conflicts of interest

There are no conflicts of interest.

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