Prosthetic Rehabilitation of an Orbital Defect Using Computer Aided Designing and Rapid Prototyping

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ABSTRACT

Introduction: The conventional methods of fabrication of orbital prosthesis by facial moulage fabrication and hand sculpting are time consuming, error-prone and very much subjective in terms of quality. Prosthesis development using contemporary technologies like computer aided designing and rapid prototyping is simple, cost effective and also improves productivity ensuring enhancement of the technical quality of care.

Case report: The present case report describes rehabilitation of a patient of left anophthalmic residual defect with a custom made silicone orbital prosthesis retained with spectacle, developed with the help of computer aided designing and rapid prototyping technology.

Conclusion: Consistent good quality prosthesis may be obtained using advanced digital technologies that include optical scanning, computer-aided designing and rapid prototyping which are more objective in nature.

Key words: Orbital Prosthesis, Maxillofacial Prosthesis, Orbital Exenteration, CAD/CAM, Rapid Prototyping, RP, Optical Scanner, Stereolithography, SLA.

INTRODUCTION

Maxillofacial defects, particularly orbital defects being in the central location of face, have a profound negative impact on both the personal and social life of the individual. These defects arise due to the surgical management of tumors that originate from the orbital tissues or from the spread of tumors originating from the adjacent structures like paranasal sinus, palate, nasal cavity, overlying skin and intraoral mucosa. Mid-facial trauma with concomitant damage to the orbital contents and related surgeries also results in such defects. Patients with an orbital defect have loss of vision and associated change in their lifestyle. Their compromised facial appearance is difficult to camouflage and even with the recent advancement of microvascular surgery and free tissue transfers, it is not possible always to reconstruct orbital defects upto the expectation of the individual.[1] Reconstruction is required to obtain a clear separation between the oral and nasal cavities to allow unobstructed and unimpaired breathing and also for acceptable aesthetics.[2] The rehabilitation with orbital prostheses allows restoration of the facial appearance. These prostheses provide patients with a satisfactory camouflage that resolves their esthetic concerns but accurate fabrication is probably the most challenging task.[3] The conventional method of fabrication of prosthesis includes a variety of complex, labour intensive and time consuming production steps where in the end result is heavily dependent on the experience of the treating clinician. Utilisation of advanced technologies like Computer-aided designing (CAD) and Rapid prototyping (RP) for the restoration of orbital and complex facial defects have been well documented.[4-6] Prosthesis development using these contemporary technologies for prototype modelling is simple, cost effective and also improves productivity ensuring enhancement of the technical quality of care.

The present case report describes rehabilitation of a patient of left anophthalmic residual defect with a custom made silicone orbital prosthesis retained with spectacle, developed with the help of computer aided manufacturing and rapid prototyping technology.

CASE REPORT

A 39 years old male patient reported to the Division of Prosthodontics with the chief complaint of missing left eye (Fig.1). The patient lost his eye in a road traffic accident one and half years ago. Multiple surgeries were carried out along with exenteration of left eye subsequent to the accident. On extra oral examination, the individual was found to be calm, conscious and alert. He was well oriented to time, place and person. His built was moderate and vitals were within normal range. On examination of the defect, the left globe and eye lids were found to be missing. There was insufficient negative volume of the defect and drooping of the left eye brow was found due to wound contracture. On ophthalmologic evaluation, normal vision of right eye was

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Figure-1:

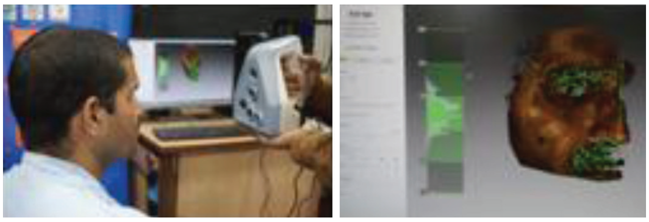

Figure-2:

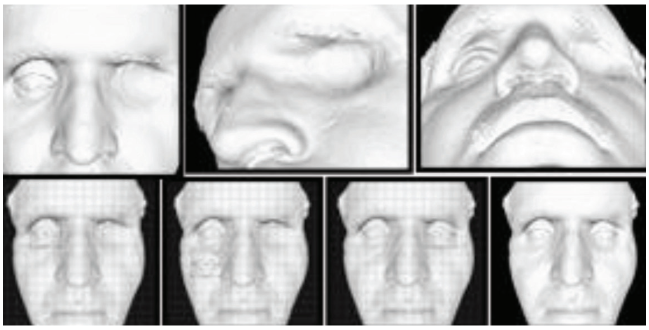

Figure-3:

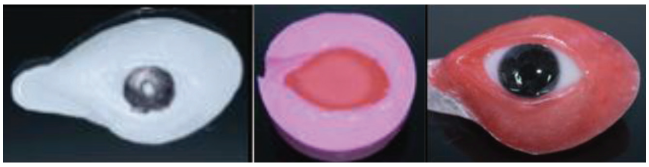

Figure-4:

Figure-5:

Figure-6:

Figure-7:

ascertained.
A diagnosis of residual defect due to left orbital exenteration was made after thorough clinical and radiological examination. A spectacle retained silicone orbital prosthesis was planned to rehabilitate the patient.
The treatment plan was discussed in detail with the patient and an informed written consent was taken.

Data acquisition: optical scanning

The data acquisition in the form of optical 3 dimensional scanning of the patients' face was performed with Artec Space spider 3-dimensional (3D) scanning system (Artec 3D, Luxembourg) (Fig.2). The patient was made to sit with his head stabilised and with the remaining eye open with a normal relaxed gaze. To prevent incomplete data capture due to the presence of anatomical undercuts related to a particular scanning perspective, anterior left and right 45-degree scans were performed. The 3D facial model of the patient was reconstructed by merging the perspective data sets and were saved in STL format with Osto3D (COEP, Pune, India) software. Prefabricated stock ocular pattern was selected after proper matching with the contralateral normal eye.

Design process

An indigenously developed CAD software Osto3D (Developed by COEP, pune, India) was used for the designing purpose. The 3D facial models were oriented to the natural head position. The mid-plane was generated through the nasion, pronasale and gnathion. The normal eye along with the adjacent soft tissue was selected and sectioned in layers. Subsequently they were reverse stacked and a mirrored pattern was obtained. The generated mirrored pattern was positioned on the defect side. Bilateral symmetry was ascertained by evaluating and comparing the distances from the midline to the medial and lateral canthus and from the midline to the tentative location of the pupil as well as the horizontal lines referring to the center, inferior and superior limits of the iris. The generated mirrored 3 dimensional pattern was superimposed and modified until its position was acceptable from the front, left-right, and superior-inferior views and was approved by the patient and his family members. The prosthesis margin was extended and modified to cover the border of the defect area. The wrinkles, surface textures, double eyelid and other detailed features of the pattern were sculpted (Fig.3).

Prosthesis fabrication

The reconstructed virtual left orbit was extracted in '*.stl*' format and was printed using an stereolithography (SLA) 3D printer. Subsequently a prototype model of the intended left orbital prosthesis was obtained (Fig.4a). The model was duplicated in polyvinyl duplicating material (Elite double 22, Zhermack) and wax was poured into it to obtain a wax pattern of the prototype (Fig.4b). The selected stock iris was incorporated (Fig.4c) and the wax pattern was tried on the patient for its location, orientation and projection (Fig.5) and invested to fabricate a stone mold. Room temperature vulcanizing silicones (MP Sai, MP SAI BIOMED, Mumbai) was packed after proper base shade matching and intrinsic staining. After curing the prosthesis was retrieved and characterization was achieved by extrinsic pigments to exactly match the shade and texture of the patients opposing eye (Fig.6). The prosthesis was retained with the help of a spectacle and necessary post insertion instructions were prescribed to the patient (Fig.7)

DISCUSSION

Rapid Prototyping is a process that creates parts in an additive, layer-by-layer manner. It is a special class of machine technology that quickly produces models and prototype parts from 3D data using an additive approach to form the physical models. Rapid prototyping (RP) is a relatively new class of technology used for building physical models and prototype parts from 3D CAD data. It was developed by Chuck Hull of 3D Systems of Valencia, CA, USA in 1984.[7]

Rapid prototyping technology is being used successfully for the last two decades in the field of maxillofacial prosthetics. At present there are four primary options through which RP can be applied in Maxillofacial prosthetics[2]:

- Prototype development
- Direct wax pattern development
- Direct negative mold fabrication and silicone packing
- Direct 3D printed prosthesis fabrication

In this present case the first option has been utilised. After the 3D model fabrication through RP, it was duplicated and a wax pattern has been developed. Subsequently the wax pattern was processed in a conventional manner. In this particular approach the tissue distortion while making a conventional impression has been nullified with the use of optical surface scanner. More over time consuming and highly arbitrary wax pattern sculpting steps have also been avoided with the computer aided designing process. These modifications have enabled the generation of a highly accurate and individualistic prosthesis using a unique combination of contemporary and existing conventional workflow thereby saving additional time and expense.

The physical model was produced in increments with stereolithography (SLA) technology. This system consists of a bath of photosensitive liquid resin, a model-building platform, and an ultraviolet (UV) laser for curing the resin.[8] The layers are cured sequentially and bond together to form a solid object beginning from the bottom of the model and building up. The model is then removed from the bath and cured for a further period of time in a UV cabinet.[9] The advantages of SLA are that it is highly accurate, has high mechanical strength and it gives a good surface finish.[10]

However, the wax pattern still needs to be adapted clinically on the patient and manually textured before the final prosthesis is fabricated. The new technology comes with a long learning curve and it will take some time to get incorporated in the regular laboratory workflow. Nevertheless, the final prosthesis made with the help of rapid prototyping produced more aesthetic and refined results as compared to hand sculpturing in minimum time. The developed digital data can be stored and shared to facilitate the fabrication of a replacement prosthesis in the unfortunate event of loss or degradation of the prosthesis. It can also help to build a digital library of maxillofacial 3D patterns.

CONCLUSION

Contemporary advances in 3D-printing technology promises tremendous potential for future rehabilitation options available to patients as well as to the clinicians. The ongoing digital revolution in the field of maxillofacial prosthetics will result in a more patient specific and economical rehabilitation outcome in times to come.

REFERENCES

1. Bi Y, Wu S, Zhao Y, Bai S. A new method for fabricating orbital prosthesis with a CAD CAM negative mold. The Journal of prosthetic dentistry. 2013;110:424-8.
2. Shrestha B, Thaworanunta S. Orbital prosthesis fabrication: current challenges and future aspects. Open Access Surgery. 2016;9:21-8.
3. Taylor TD. Facial prosthesis fabrication—technical aspects clinical maxillofacial prosthesis. Quintessence, Chicago. 2000;233.
4. Ciocca L, Scotti R. CAD-CAM generated ear cast by means of a laser scanner and rapid prototyping machine. J Prosthet Dent 2004;92:591-5.
5. Chandra A, Watson J, Rowson J, Holland J, Harris R, Williams D. Application of rapid manufacturing techniques in support of maxillofacial treatment: evidence of the requirements of clinical applications. Proc IME B J Eng Manufact 2005;219:469-75.
6. Feng Z, Dong Y, Zhao Y, Bai S, Zhou B, Bi Y, et al. Computer-assisted technique for the design and manufacture of realistic facial prostheses. Br J Oral Maxillofac Surg 2010;48:105-9.
7. Freedman, David H. Layer By Layer. Technology Review. 2012;115: 50–53.
8. Hull C. Apparatus for the production of three dimensional objects by stereolithography. US Patent No. 4,575,330, USPTO, Alexandria, VA.
9. Truitt HP, James RA, Lindley PE and Boyne P. Morphologic replication of the mandible using computerized tomography for the fabrication of a subperiosteal implant. Oral Surg Oral Med Oral Pathol 1988; 65: 499- 504.
10. D'Urso PS, Earwaker WJ, Barker TM, Redmond MJ, Thompson RG, Effeney DJ, Tomlinson FH. Custom cranioplasty using stereolithography and acrylic. Br J Plast Surg 2000; 53:200-4.

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