Case Report

Fabrication of a Cranial Prosthesis Combined with an Ocular Prosthesis Using Rapid Prototyping: A Case Report

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Abstract

Rapid prototyping (RP) is a technique of manufacturing parts by the additive layer manufacturing technology; where, a three-dimensional (3D) model created in a computer aided design (CAD) system is sectioned into 2D profiles, which are further constructed by RP layer by layer. Its use is not limited to industrial or engineering fields and has extended to the medical field for the manufacturing of custom implants and prostheses, the study of anatomy and surgical planning. Nowadays, dentists are more frequently encountered with the individuals affected with craniofacial defects due to trauma. In such cases, the cranio-maxillofacial rehabilitation is a real challenge to bring the patients back to society and promote their well-being. The conventional impression technique for facial prosthesis fabrication has the disadvantage of deforming the soft tissue and causing discomfort for the patient. Herein, we describe the fabrication of a cranial prosthesis combined with an ocular prosthesis with RP and stereolithography.

Keywords: Eye; Artificial; Dentistry; Prosthesis

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INTRODUCTION

Facial defects secondary to the treatment of neoplasms, congenital malformations and trauma result in multiple functional and psychosocial difficulties. Prosthetic rehabilitation to restore these facial disfigurements may improve not only the level of function but also the self-esteem of patients [1]. The disfigurement associated with the loss of an eye causes significant stress, primarily adjusting to the functional disability that results.

Eye is an even organ and therefore its reproduction is challenging, since the prosthesis must be similar to the natural eye as much as possible [2]. The conventional impression techniques for manufacturing facial prosthesis have the disadvantage of deforming the soft tissues due to the tension caused by the impression material and also cause discomfort for the patient [3].

Recently, Rapid prototyping (RP) system was developed as a simple method for fabricating models and prosthesis without a facial impression [4]. Using stereolithography, a RP technique, 3D computer models are converted to solid physical models, which allows better planning of the prosthesis. This technique was first used in oral and maxillofacial surgery by Brix and Lambrecht in 1987 [5].

CASE REPORT

A 28-year-old patient was referred to the Department of Prosthodontics seeking treatment for a left ocular defect. The patient revealed a history of severe facial injury sustained from a roadside accident two months back for which he had undergone primary treatment. Extraoral examination showed that the patient had a large ocular defect on the left side extending to the supraorbital region. Due to extensive soft tissue and hard tissue loss, the defect had a hollowed out appearance. The skin covering the defect was in satisfactory condition (Fig. 1). Intraoral examination was not significant.

Fig. 1: Pre-operative photograph

Fig 2: Anterior-posterior radiograph

Fig. 3: Stereolithography

Fig. 4: Wax pattern fabrication

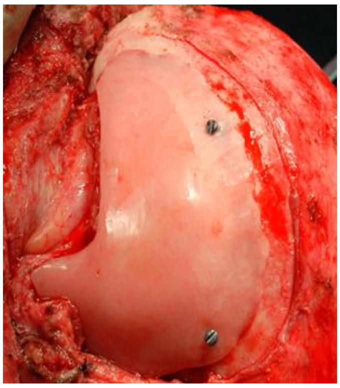

Fig. 5: Acrylic plate fixed

Fig. 6: Intra-ocular tissue bed

Radiographic examination

Lateral cephalogram and anterior-posterior view of the skull revealed that the defect extended superiorly involving the supraorbital ridge, the frontal and parietal regions and inferiorly the infraorbital ridge and anterior one-third of the zygomatic arch (Fig. 2).

Considering the multidisciplinary approach, a pre-prosthetic surgical intervention was planned to optimize the patient's quality of life and success of the prosthetic treatment. After detailed discussion and thorough examination of the defect, it was planned to first surgically reconstruct the bony defect with heat cure acrylic resin plate.

Data were extracted from the patient's computed tomographic (CT) scan to make a computer 3D model of the defect. Then, by stereolithography, a RP technique (layer-wise additive manufacturing), a solid physical model of the defect was fabricated (Fig. 3).

Material used was Thermoplastic Build Material i.e. ABS-M30 Thermoplastic. Wax pattern (Modeling Wax, DPI, Mumbai, India) was made on the stereolithographic model and then the acrylic resin plate (DPI, Mumbai, India) was fabricated accurately (Fig. 4).

The acrylic plate was then surgically fixed with titanium screws to obtain proper contour of the defect (Fig. 5). The patient was then recalled after one month following complete healing of the surgical site for the management of the ocular defect. Ocular examination revealed a healthy intraocular tissue bed. There was adequate depth and undercut between the upper and lower fornices for retention of the prosthesis (Fig. 6).

Fabrication of prosthesis

An impression of the ocular defect was made with an ocular acrylic impression tray attached to a 5 mL modified disposable syringe (Dispo Van). Light viscosity polyvinyl siloxane (Reprosil; Dentsply DeTrey GmbH, Konstanz, Germany)

was injected into the socket through the modified tray syringe assembly (Figs. 7A, B, and C).
Sufficient material was injected to elevate the lid contour similar to the normal side and the patient was instructed to perform eye movements until the impression material sets. The impression was removed from the socket and initially poured to the level of the height of contour with type IV dental stone (KALROCK, Kalabhai Karson Pvt. Ltd., Mumbai, India). After setting of the stone, keyholes were made and the assembly was boxed and second layer was poured, to obtain a two-piece cast for the orientation of the ocular prosthesis. Wax pattern was fabricated with modeling wax (DPI, Mumbai, India). The fit was evaluated by observing the extensions into the fornices. Acrylic resin stock eye was selected with matching iris size, color, and approximate sclera shape. Peripheral and posterior surfaces were reduced and retentive grooves were made on the posterior surface (Fig. 8A).The modified stock eye was adapted to the wax pattern. A plastic sleeve was secured with sticky wax over the pupil, perpendicular to the plane of iris for aligning the prosthesis in correct relationship to the natural eye (Fig. 8B).
Try-in was done to evaluate the bulk, lid contour and esthetics of the artificial eye. At this stage a wash impression was made with irreversible hydrocolloid of the stock eye to redefine the contour of the socket bed for proper retention and stability (Fig. 8C). After satisfactory adjustments, flasking and dewaxing were done. The mold was then packed with clear, heat cure acrylic resin (DPI, Mumbai, India).
A tinge of pink colored resin was given at the inner and outer canthus of the eye mold to simulate the natural eye and then curing was done (Fig. 9). After final finishing and polishing, the prosthesis was inserted (Fig. 10).

DISCUSSION

Although various reconstructive and regenerative treatments have been developed, a facial prosthesis is an effective rehabilitation for the patients with congenital or acquired defects. The fabrication of a facial prosthesis requires numerous complicated techniques to obtain a morphologically satisfactory outcome [4]. A conventional impression can be uncomfortable for patients because most of the face has to be covered with impression material until it sets. Furthermore, the weight of the impression material or the patient's body posture during impression may lead to deformation and inaccuracies. Sculpting the wax prototype is also time consuming and requires professional training and skills [4,5].

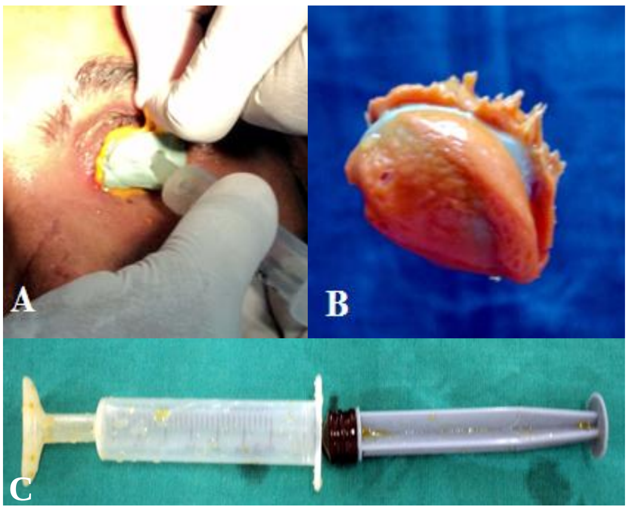

Fig. 7: (A) Polyvinyl siloxane injected, **(B)** Impression obtained, **(C)** Modified tray-syringe assembly

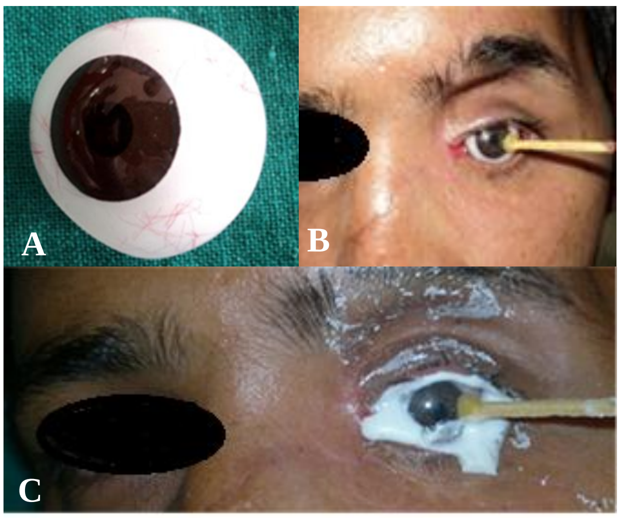

Fig. 8: (A) Selected stock eye **(B)** Alignment of prosthesis; **(C)** Wash impression with irreversible hydrocolloid

Fig. 9: Packing of eye prosthesis

Fig. 10: Post-operative photograph

Technologies such as 3D surface capture (3D scanning), 3D-CAD and layer additive manufacturing process (RP and manufacturing) have been investigated for maxillofacial prosthetic applications to create models for diagnosis, treatment planning and surgical simulation [6]. In our case also similar method was used to fabricate solid physical model of the defect using CT scan of the patient and ABS-M30 Thermoplastic.

It not only eliminated the tedious conventional impression making procedure but also made the fabrication of the prosthesis much easier. Various other materials that can be used for the fabrication of these models are thermoplastic polymeric materials such as ABS-M30i Thermoplastic, PC Thermoplastic, PC-150 Thermoplastic, ULTEM 9085 Thermoplastic and etc. The fabrication of an artificial eye is not limited to this modern age. They have been used for centuries, with the earliest known examples found in mummies dating back to the fourth dynasty in Egypt (1613-2494 BC) [8]. Ambroise Pare a French surgeon dentist is considered to be the pioneer of modern artificial eye. In 1575, Pare fabricated artificial eye made of glass as well as porcelain [9]. Techniques and materials were constantly improved and now the currently available prosthetic materials most commonly used are methacrylate or acrylic resins, polyurethane elastomers and silicones [10]. In this case, a stock acrylic eye (20R/5, SMR, Ophthalmic, Mumbai, India) matching the patient's normal eye was selected to serve the purpose. Unlike glass eye, an acrylic eye is easier to fit and adjust, unbreakable, inert to ocular fluids, esthetically good, longer lasting and easy to fabricate [8-10]. As the patient had a large extensive defect involving the supraorbital ridge, frontal, parietal and infraorbital ridges along with the anterior one-third of the zygomatic arch, it was quite difficult to restore the defect. But the patient was satisfied with the outcomes of treatment. The patient was given proper instructions and recalled on regular basis.

CONCLUSION

Despite remarkable advances in surgical management of maxillofacial defects, ocular and orbital defects cannot be satisfactorily managed by plastic surgery alone. Implant-retained ocular prosthesis is always a better option but may not be always feasible mainly due to economical reasons. In such cases, the conventional method of fabrication of ocular prosthesis using stock eye provides good results both functionally and esthetically. It actually rehabilitates the patient to live a normal socially acceptable life.

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