Revolutionizing Maxillofacial Rehabilitation with a Novel 3D-Printed Ocular Prosthesis with Sublimation Transfer Technique: A Case Report

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ABSTRACT

Psychological trauma usually comes with the loss or disfiguration of an eye. Defects of the eye can be caused by conditions like cysts, road traffic accidents, or the excision of the eye for infection. A patient with a prosthetic eye complained of dissatisfaction caused by asymmetry and opacification. He had lost his eye in a road traffic accident and had been wearing the prosthesis for 8 to 12 months but was not satisfied with its cosmetic appearance. To improve the cosmetic result, a new prosthesis was created by combining sublimation transfer technology with three-dimensional printing, resulting in a replica of the healthy eye. Digital scanning, 3D printing of the scleral shell, and sublimation transfer of iris and scleral details were performed. A 3D printed ocular prosthesis was obtained with the above-mentioned technique; the prosthesis was perfectly fitting with proper shade matching to the contralateral normal eye, giving better aesthetic results. As compared to convention method of fabrication, this technique improves iris positioning, color fidelity, surface finish and patient satisfaction. This case report describes a better algorithm for producing personalised ocular prostheses, integrating classic and digital methods to obtain the best results.

Keywords: 3D Printing; CAD-CAM; Ocular prosthesis; Sublimation Transfer Technique

INTRODUCTION

Physical and psychological impairments resulting from the loss of an eye lead to severe mental and emotional incapacities in the patient. Restoration of ocular defects in such unfortunate patients reduces psychosocial morbidity and enhances the patient's confidence level.[1,2] Loss or absence of an eye may be due to trauma, birth defects, or enucleation for cancer. Rehabilitation with a prosthetic eye promotes psychological well-being and recovery of self-esteem.[3]

Optimal aesthetic results are obtained by symmetry and a perfect match in color and form between the artificial and the natural eye.[3] Both custom-fabricated artificial eyes and preformed eye shells may be employed to correct such

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defects, but bilateral symmetry of the iris is a must.

Conventional fabrication techniques rely on manual wax pattern fabrication, iris positioning and hand painted iris characterization. These are time consuming procedures, furthermore leading to color instability and inaccuracies in iris positioning & is totally dependent on the skill of the operator.

With the advancement in digital dentistry and maxillofacial prosthetics these limitations can be resolved with the help of 3D printing, CAD-CAM technology and dye sublimation transfer printing technique, in which a high-resolution image is transferred on to a curved surface by embedding ink within the polymer substrate, making it suitable particularly for ocular prosthesis. This provides anatomical accuracy due to 3D printing and better detailing of prosthesis.

This case report provides an account of rehabilitation of eye defects through exchange of old-fashioned prostheses with newer forms. It reports the incorporation of both traditional and digital methods of improving the site, hue, and shape of the iris employing the sublimation transfer method for better cosmesis and patient satisfaction.[4]

CASE REPORT

A 58-year-old patient reported to the department of maxillofacial prosthodontics for correction of facial disfigurement and asymmetry due to loss of his right eye. The medical history indicated that he had no symptoms till two years prior, when an accident resulted in secondary infection, which finally required enucleation of the right eye. Since then, he wore a prosthesis but complained about its cosmetics because of misaligned iris and squint. The socket was healthy with no signs of discharge and inflammation. Adequate depth was present which was suitable for custom prosthesis fabrication as shown in Figure 1. To promote the aesthetics and symmetry, an individualized ocular prosthesis was contemplated with a new technique.

First impression was made with irreversible hydrocolloid and final impression by light-body polyvinyl siloxane as shown in Fig 2A.

The cast was then made using Type IV dental stone, which captures the finest details of the impression, as shown in Fig 2B. Following the fabrication of cast, the cast was scanned employing computer-aided designing (CAD) software (Exocad 5xt software). An inEos X5 scanner (Dentsply Sirona, USA) was employed to scan the cast.

As seen in Figure 3, scanned images were created at various angles from the model, and artifacts on the scanned model were eliminated before being displayed on CAD software.

The data of the 3D model was translated into a stereolithographic (STL) file and retained in storage for use later. A 3D (SLA based) printer was utilized to print the necessary ocular model. The desired range of colors exists within a color library and one with the closest approximation to the sclera was selected. Once the 3D printer was ready, a slicing file with the full data of the 3D model was generated and the material used was biocompatible photopolymer resin. This file was sent to the printer, and the prosthesis was printed.

To obtain detailed graphical information of the iris and blood vessels, the patient's contralateral normal eye was imaged with a Canon 450D digital camera, held approximately one foot away.

With the same, iris positioning was done by digital overlay taking into consideration the facial midline. A mirroring device was employed to copy the image, and the blood vessels were adjusted while maintaining the iris size at 11 mm. With Adobe Photoshop CS4, the areas of the image like the pupil, iris, and blood vessels were outlined with great care. Brightness and contrast levels were also adjusted to prepare a calibrated image file for printing.

For the printing of the iris, the sublimation transfer method was used. A frame to suit the curve of the ocular prosthesis was fitted over the sublimation transfer device. The 3D-printed prosthesis was inserted into the frame and the printed transfer paper was flipped. Here print orientation is important to note it should be placed such that convex surface orients upwards. Once the transfer paper had been vacuumed onto the 3D-printed prosthesis, heat was applied of temperature around 190-200 °C under controlled vacuum assisted pressure for 60-90 seconds. When the sublimation ink had been transferred and stuck onto the prosthesis, the transfer paper was peeled away. The picture was then printed onto the transfer paper. With the aid of the sublimation transfer method, the ink was properly sealed using clear medical grade acrylic resin coating which protect it against abrasion and color degradation. Curved surface printing was optimized using this method in order to yield a high-quality, customized ocular prosthesis. (Figure 4)

The prosthesis was inserted once it had been fully finished. When compared to the previous prosthesis, the iris's location, color, contour and centralization were highly appreciated (Fig 5).

Insertion instructions were given, including suggestions that the prosthesis should be removed nightly. The patient was also taught how to practice good hygiene. Follow-up appointments were also arranged, the first of which was to be done three days post-insertion. The patient was satisfied with the prosthesis, especially its aesthetics, functionality, and comfort.

Figure 1: *Patients existing eye socket*

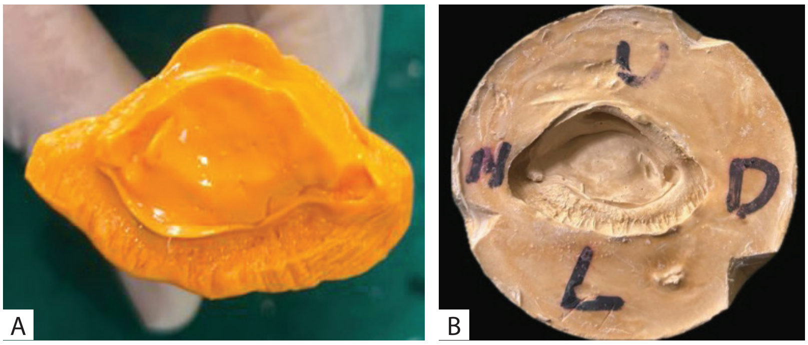

Figure 2: *A) Final impression recorded with light body polyvinyl siloxane material B) Fabrication of cast with die stone material*

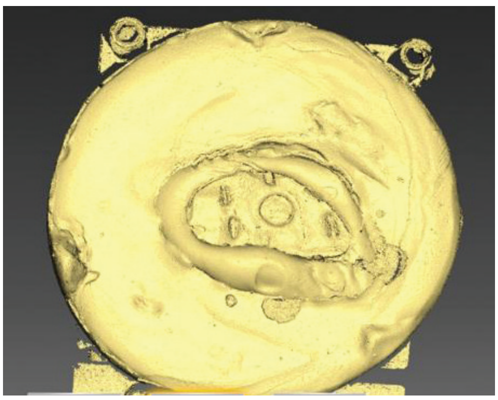

Figure 3: *Scanned model*

Figure 4: *Photograph of final 3D printed prosthesis*

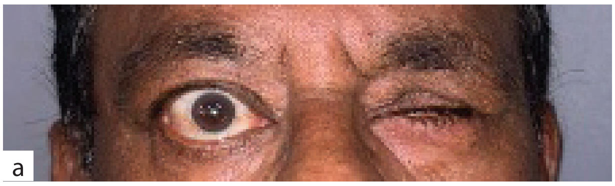

Figure 5a: *Remaining scleral tissue in the right eye*

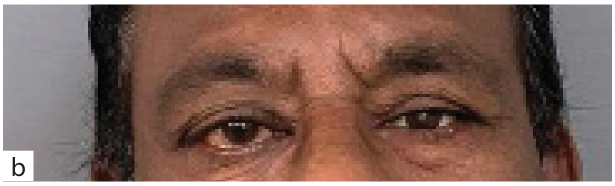

Figure 5b: *Insertion of prosthesis fabricated by sublimation transfer technique*

DISCUSSION

The conventional process of creating an ocular prosthesis is time-consuming, labor-intensive and requires several manual steps. Although commercially prefabricated eye shells can be used as an alternative, custom-made ocular prostheses designed for individual patients yield better aesthetic results.[4,5] The sublimation transfer method provides a semi-automated process that harmoniously combines both traditional and digital approaches. In contrast to the traditional process, which takes about ten hours, the new method shortens fabrication time to about eight hours.[6] Due to the curved shape of the ocular prosthesis, the dye sublimation transfer method was used for this purpose. Also the dye sublimation ink are UV stable, non-toxic and protective acrylic sealing reduces fading.[7]

Compared to the semi-automated fabrication method suggested by Ko et al, the present technique emphasizes on clinical adaptability, chairside feasibility and simplified digital integration rather than complete automation.

One of the main limitations of the suggested method is that it needs specialized skills and expertise during the fabrication of the prosthesis which are the challenges faced during this case.[8,9] Furthermore, the total cost is marginally higher than in conventional methods. The time of production is greatly decreased and much of the labor is substituted by a semi-automated process, minimizing the need for extensive technical know-how. Additionally, 3D graphics and modelling, not available before, now become integral parts of this method.[10] The capability of 3D modeling data storage is of especial value since the prosthesis can be simply reproduced in case of damage or loss. Overall, this approach improves patient's quality of life considerably through easier access to high-quality personalized ocular prostheses. The progress in the development of digital technologies such as 3D printing and dye sublimation transfer is likely to be beneficial in the future of the development of ocular prostheses. The integration of artificial intelligence and machine learning technologies is likely to be beneficial in the future in the development of iris pattern recognition technologies. The development of advanced biomaterials with improved biocompatibility, color stability, and longevity is likely to be beneficial in the development of more life-like prostheses. The integration of facial scanning technologies and augmented reality is likely to be beneficial in the future in the development of more patient-specific prostheses. The digital process is likely to be more accessible and cost-effective in the future; therefore, it is likely to be adopted in routine patient management.

CONCLUSION

The integration of 3D printing and dye sublimation transfer technology provides a predictable, reproducible and esthetically superior method for customized ocular prosthesis fabrication. This technique allows accurate iris replication, improved centration and enhanced patient satisfaction while reducing operator dependency. With further refinement, this digital workflow has the potential to become a valuable alternative to conventional ocular prosthesis fabrication.

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