Review Article

Prosthetic management of ocular defect: Esthetics for social acceptance

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It is quite usual for a person to have a natural eye removed as a result of a severe trauma; congenital abnormality; or disease such as an infection, a tumor or untreatable painful glaucoma. In such situations, the natural eye is removed by an acceptable medical procedure, for example, by enucleation or evisceration. It is also usual for a person to have a smaller than normal or phthisical eye that is blind. An ocular prosthesis is created to restore a more normal anatomical structure and the cosmetic defect created by these conditions in a person. The initial step in creating this prosthesis is the preparation of an impression of the ocular socket. From this impression, an ocular prosthesis is created that simulates a person's natural eye and is inserted into the ocular socket posterior to the lids and anterior to the orbital implant or phthisical globe. With such a procedure, a person's psychological trauma associated with the loss of the eye is reduced, and a more cosmetically acceptable appearance results from the use of these prostheses. Although implant eye prosthesis has a superior outcome, due to economic factors it may not be advisable in all patients. Therefore, a custom-made ocular prosthesis is an excellent alternative. Here, we present a case of a custom- made ocular acrylic prosthesis, which showed excellent fit, retention and esthetics.
These prostheses usually comprise a scleral region with veins, an iris, a pupil and a clear corneal layer.

Key words: Custom-made ocular prosthesis, corneal-pupil piece, phthisical eye

INTRODUCTION

Man's need for artificial substitutes to replace missing body parts has probably existed as long as man himself.

Socially the deformed body is not completely accepted. Physical abnormalities or defects that compromise appearance and function are sufficient to render an individual incapable of leading a relatively normal life.[1]

An ocular prosthesis is an artificial replacement for the bulb of the eye (bulbus oculi, eyeball). The eyeball, or the organ of sight, is contained in this cavity of the orbit, where it is protected from injury and moves with the aid of the ocular muscles.

When the entire content of the orbit (including muscles fascia, eyelids, conjunctiva and the lacrimal apparatus) is removed, the artificial replacement is referred to as an orbital prosthesis.

HISTORY

Artificial eyes, ears and noses have been found in Egyptian mummies.

Chinese people have reconstructed missing noses and ears by using waxes and resins.

It was not until the 16th century that reliable documentation became available. Tycho Brahe, a Danish astronomer in the 16th century, lost his nose in a duel and had it replaced with an artificial nose made of silver and gold.

Ambroise Pare was first to use an obturator to close palatal perforations (pioneer in maxillofacial prosthetics). Pierre Fauchard (1728) used the perforations of the palate to retain artificial dentures. All prostheses utilized extremely crude methods for retention of artificial dentures; moreover, the complications were probably compounded by the amount of metal and ceramic material used in denture construction. The London medical gazette of 1832 reported 'gunner with the silver mask', a French soldier, whose face was mutilated in a war, and he used to wear a silver mask. Kingsley (1880) described the artificial appliances used for the restoration of congenital as well as acquired defects of the palate, nose and orbit. Tetamore (1894) illustrated nine cases of nasal deformities that received prosthetic restorations; the prostheses were prepared using a 'very light plastic material' that approximated the natural color of the nose.

In the late 19th century, certain workers began using

vulcanite for constructing facial restorations. The surface of this material was painted in order to match the color of the skin.

In the early 20th century, prosthetic restorations were carried out through collaboration of dentists and plastic surgeons. In 1953, a group of dentists founded the American Academy of Maxillofacial Prosthetics.

Currently, almost all patients with oral or facial defects are referred to dentists for the construction of maxillofacial prostheses. Profession of dentistry encompasses the knowledge, artistic skills, materials and techniques used for the prosthetic repair of these defects.

Until World War II, the glass eye was the most popular prosthetic eye manufactured. The glass eye however was difficult to manufacture and hazardous when it imploded. One of the pioneers to use the glass eye was Ambroise Pare (1510–1590). In 1944, Murphy and Nirronen fabricated physiologic ocular prosthesis in the United States Navy Dental Corps.[2]

OBJECTIVES OF MAXILLOFACIAL REHABILITATION

1. Restoration of esthetics or cosmetic appearance of the patient.
2. Restoration of function.
3. Protection of tissues.
4. Therapeutic or healing effect.
5. Psychologic therapy.

The maxillofacial prosthetic approach has the following three main advantages:

1. It requires little or no surgery.
2. The patient spends less time away from home and job.
3. The reconstruction often has a more natural appearance.

The drawbacks of this approach include the following:

1. The necessity of fastening the appliance to the skin daily.
2. Removing the appliance daily.
3. The occasional need of constructing a new prosthesis.

INDICATIONS AND LIMITATIONS OF OCULAR PROSTHESIS

It is quite usual for a person to have a natural eye removed as a result of a severe trauma; congenital abnormality; or disease such as an infection, tumor or untreatable painful glaucoma. In such situations, the natural eye is removed by an acceptable medical procedure, for example, by enucleation or evisceration; during this procedure, an orbital implant is surgically fitted to replace the lost orbital volume. It is also usual for a person to have a smaller than normal or phthisical eye that is blind. An ocular prosthesis is created to restore the eye to a more normal anatomical structure and the cosmetic defect created by these conditions.[3] Allergic reactions due to residual monomer have also been reported by the users of the prosthesis.

Conventional fabrication methods produce ocular prosthetics whose shapes are usually inaccurate and difficult to reproduce, are time-consuming, employ materials and methods of curing the materials that can cause undesirable allergic reactions and are labor intensive.

DIFFERENT AVAILABLE METHODS

Although several improvements in the general art of ocular prosthesis have been reported, the fabrication methods currently in use are based on obsolete technologies, are cumbersome, lack a high degree of precision and are time-consuming. Examples of improvements in the art of fabrication of prosthesis include magnetically coupling a prosthesis with an ocular implant described by Garonzik (U.S. Patent no.6,530,953) designed to eliminate the use of a coupling post in the process of integration of the prosthesis with the ocular implant. Moreover, a self-lubricating ocular prosthesis has been designed to dispense a lubricating fluid by using a dispensing ball or a button that can be depressed on demand. An ocular prosthesis containing a pupil has also been designed that can alter its diameter to simulate the behavior of a natural eye when exposed to light of varying intensity. An ocular prosthesis has been designed that can simulate human pupil dilation because of the use of photochromic pigments that changes the density of their color in response to different wavelengths of light from clear to opaque. An ocular prosthesis prepared with light-cured urethane dimethacrylate can minimize allergic reactions by the user of the prosthesis by essentially eliminating any residual monomers.

A method of manufacturing an ocular prosthesis has also been described; the steps include providing an impression of an eye socket or existing ocular prosthesis, scanning the impression or the existing ocular prosthesis, fabricating a posterior scleral portion and an anterior clear portion based on the scanning of the impression or the existing ocular prosthesis, and preparing the ocular prosthesis by joining the fabricated posterior sclera portion to the anterior clear portion. In fabrication method, an ocular prosthesis is fabricated by providing an impression of an eye socket and a photograph of the iris, scanning the impression of the eye socket, fabricating a posterior sclera and an anterior clear portion based on the scanning of the impression of the eye socket, preparing an iris disk

on the basis of the iris photograph, depositing the iris disk on the fabricated posterior sclera portion, and forming an ocular prosthesis by joining the fabricated posterior sclera portion containing the iris disk to the anterior clear portion.

Generating geometrical models by using CAD/CAM software.

Another method according to which, preparing the iris disk comprises the following: the iris photograph is imported into a photo-editing software, the color of the imported photograph is adjusted, the imported photograph is modified in order to remove aberrations, the imported photograph is sized to correct the diameter of the iris and pupil, multiple-depth layers are created by adjusting the percentage fuzziness of the imported photograph, a base layer and a pupil color layer are printed on a photograph paper, partial color depth layers are printed on a transparent medium, all prints are cut out to correct the iris diameter, a pupil area in the base color print to the pupil diameter is cut out, and the layers are arranged for insertion in the posterior sclera portion.

Another method, wherein the generation of a model comprises the following steps: a center of the iris is determined using the remnant of an impression tray stem, the impression is globally reoriented, circular boundary lines are set for a cornea, surfaces and curves of the anterior surface of the prosthesis are smoothed, the stem remnant is replaced with a corneal curve, the corneal curve is blended into the anterior surface, transitions are smoothed, a copy is created with an offset of 1.5 mm, a table is created on the anterior portion of the offset piece, a posterior surface is projected back to a plane in space, the projected piece is subtracted from the initial shape leaving an anterior clear piece, the anterior clear piece is subtracted from the total shape leaving the posterior scleral portion, a circular depression is cut in the iris table on the posterior scleral portion, milling flanges are applied to each model, and an STL file is exported for the anterior and posterior portions.

CASE REPORT

A 45-year-old female patient reported to the Department of Prosthetic Dentistry for the fabrication of denture. Examination and history revealed that the patient had suffered from a traumatic injury to the right eye by a hand-held fan that is commonly found in rural India. Following trauma, there was swelling for which she took some homemade medicines; the eye ball had progressively shrunk [Figure 1]. Initially, she was quite apprehensive regarding an ocular prosthesis, but after informing about it and showing the results of previous cases she was convinced for a custom-made ocular prosthesis.

Fabrication procedure

Conventional processes that are currently in use for manufacturing ocular prosthetics have been used for more than 6 years. The esthetic and functional outcome of the prosthesis is superior than the stock ocular prosthesis.[4] They traditionally begin with the preparation of an impression of the anophthalmic or enophthalmic eye socket in a process similar to that used in preparing a dental impression. First, a conforming impression tray is selected and placed into the socket anterior to the globe or implant and posterior to the eyelids. An impression material is then introduced into the eye socket via a tube protruding from the anterior surface of the impression tray and projecting out between the lids by means of a syringe connected to the tube [Figure 2]. After the impression material is set, the impression is removed and invested in dental gypsum in order to obtain a positive cast of the posterior aspect of the eye socket.

Subsequently, the gypsum cast is coated with a separating medium; further, either a dental base-plate wax or inlay wax is then shaped in an empirical approximation of the anterior curves of the wax form that will comprise the form for investment. These anterior curves and the posterior surface of the wax are modified in order to achieve patient comfort, appropriate anterior/posterior dimension, palpebral fissure curvature and iris center position. The iris center position is then identified with a wax-coated screw or an iris peg that identifies the iris center and plane. Because of the empirical nature of iris center of the conventional fabrication processes, an undesirable variation occurs in the accuracy of the iris shape.

Try in of the wax pattern was performed. The wax pattern was examined for the size support from tissue simulation of the eye movement and eyelid coverage.

A prefabricated iris button, whose shape matched with the contralateral eye, was selected. The position of the iris was determined with the help of landmarks to make the patient look in a straight line. Later the final try in was performed keeping the iris in its defined position [Figure 3]. The color for the sclera portion was selected using the tooth-color acrylic shade guide.[5]

After the wax investment form is complete, a two part mold is constructed by the prototype ocular prosthesis by using dental gypsum within a stainless steel or brass flask. The anterior portion of the mold is invested, a separating medium is applied and the posterior portion of the mold is then invested. After the mold sections are set, the flask is opened and the wax form and iris center are removed from the mold.

In the most common form of iris duplication, the iris is painted using a viscous monomer-polymer

solution and dry artist's pigments onto a polymethyl methacrylate acrylic (PMMA) disc. A PMMA corneal-pupil piece (CPP) that approximates the clear cornea is then adhered to the painted surface with a viscous monomer-polymer solution. In other process, the iris is painted on a thin sheet of tin foil placed over the convex side of a steel die which is then cured with PMMA to form the CCP, or the iris is painted at the appropriate location on a slightly convex anterior surface of the white portion of the prosthesis. The problems associated with hand-painted irises are the inherent inaccuracy of hand painting and the fact that the effect of only a limited three-dimensional depth can be portrayed [Figure 4].

Figure 1: Patient before fabrication of ocular prosthesis

Figure 4: Hand-painted iris

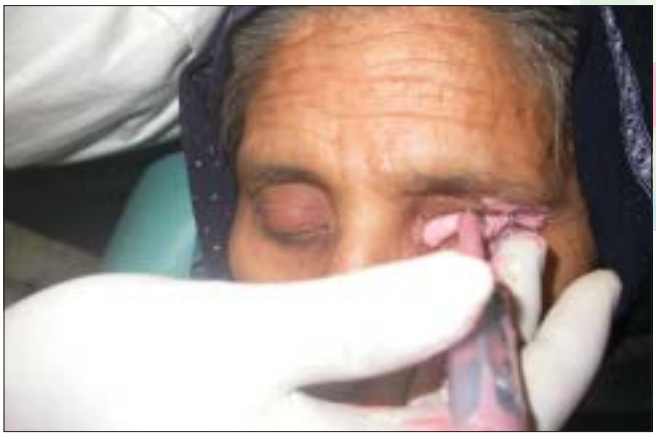

Figure 2: Preparing impression with alginate

Figure 5: Completed prosthesis

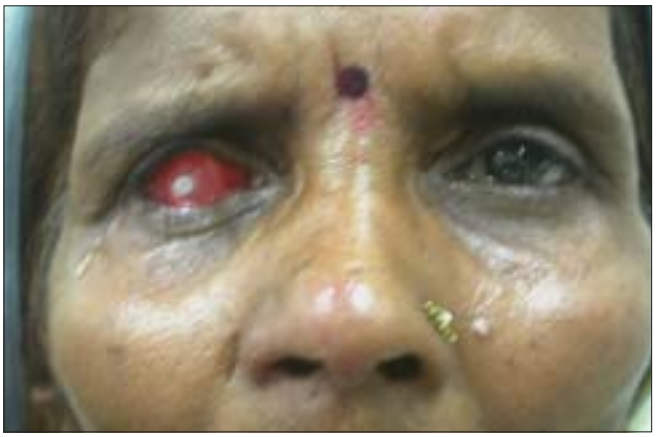

Figure 3: Final try in of the wax pattern

Figure 6: Final prosthesis in place

While preparing the white posterior section of the prosthesis, the abovementioned two-part mold is cleaned and examined, and a liquid separator is applied to each gypsum section. The corneal-pupil-iris piece (CPIP) is then placed into its predetermined location in the anterior mold section. PMMA powder in which intrinsic pigments had been added in order to replicate the base colors of the natural sclera of the eye is then mixed with PMMA monomer. This mixture is allowed to polymerize until it reaches a consistency that pulls apart with a snap. The polymerized scleral acrylic mixture is then packed into the anterior mold section to overflow and the posterior section of the mold is then placed onto the anterior portion. The mold is placed in a mechanical or hydraulic press and excess PMMA is squeezed out; the mold is then placed in a curing device and heat alone or both heat and or pressure are applied until polymerization is complete. Because of the amount of undesirable monomers that may remain in the prosthesis, the curing process is time-consuming. Once cured, it is not practical to test the material by destructive methods in order to ensure proper polymerization since the batch size is necessarily small; the prosthesis itself would be destroyed in such a case. After curing, the scleral portion of the prosthesis is removed from the mould, the parting line flash is removed, the corneal area is reduced until the iris is exposed to a desired diameter and the anterior-posterior surface of the scleral area is reduced by hand.

Subsequently, iris tones are enhanced over the CPIP or applied to the anterior surface. The colors of the sclera are duplicated on the surface and silk fibers are added to duplicate the veining patterns of the contralateral eye. The prosthesis is then placed in a drying oven to prepare it for the placement of a clear acrylic over the anterior surface. The mold is again examined, repaired and a liquid separator is applied to both gypsum sections in preparation for the application of a clear capping. Clear PMMA polymer and monomer are mixed and polymerized until the same snappy state is reached as previously described. The clear acrylic is then placed on the anterior surface of the painted section and the anterior and posterior flask sections are closed and the excess acrylic is pressed out. Polymerization and cooling are performed as previously described. The material concerns are the same as previously described and apply to this process of polymerization.

Finally, the prosthesis is removed from the mold, parting line flash and surface irregularities caused by latent air bubbles or other defects in the mould are then removed, and the surfaces are smoothed with a fine hand piece burr. The prosthesis is then smoothed with a paste of pumice flour and water. Progressively, finer abrasives are used until all surfaces are smooth and show no scratches under magnification of ×10 [Figure 5]. The prosthesis undergoes a final examination, is cleaned and disinfected and prepared for delivery to the patient[6] [Figure 6].

CONCLUSION

The replacement of anatomical parts is a singular challenge to the specialized people who are adequately trained to construct acceptable substitutes. The use of custom-made ocular prosthesis has been a boon to the average patient who cannot afford the expensive treatment options available. The esthetic and functional outcome of the prosthesis is superior to the stock ocular prosthesis. Patients are quite satisfied with the results and have realized the importance of consulting qualified personnel in the required field. Although many treatment options are currently available, but the conventional method is the most widely followed method all over India.

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