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Review Article

# Ocular prosthesis: An esthetic vision

**Jain DC[1], Hegde V[2], Aparna IN[3], B Dhanasekar[4]**

[1]Assistant Professor, Faculty of Dentistry, Melaka Manipal Medical College, Manipal University, Karnataka India, [2]Professor & Head, [3]Professor, [4]Associate Professor, Department of Prosthodontics, Manipal College of Dental Sciences, Manipal University, Karnataka, India.

**Abstract**

Throughout history, the human eye has been mentioned by authors as the most precious of gifts. It unveils the entire outer world to our consciousness, gives life, expression and dignity to the face. The loss of an eye therefore has always been regarded as the greatest misfortune. Disfigurement resulting from loss of an eye can cause significant visual, psychological as well as social consequences. The aim of the rehabilitation procedure is to return the patient to the society with a normal appearance, comfort and reasonable mobility of ocular prosthesis. Much stress is given to the accurate duplication of natural colour, contour, size and ocular orientation which will provide realism and symmetry for patients and contribute to enhanced tissue health of the anophthalmic socket.

**Key words:** Enucleation, Ocular implants, Custom-made acrylic eyes, Iris setting.

## Introduction

An ocular prosthesis is a simulation of human anatomy using prosthetic materials to create an illusion of a perfectly normal healthy eye and surrounding tissue. A person in need of an ocular prosthesis may have lost or damaged his/her natural eye due to trauma, malignancy or a congenital deficiency. The primary purpose of an ocular prosthesis is to maintain the volume of eye socket and create the illusion of a perfectly normal healthy eye and surrounding tissue.

## Applied anatomy of the eye

The eyeball occupies only the anterior part of the orbit. The globe of the eye is a slightly asymmetrical sphere somewhat flattened from above downwards. The adult eyeball measures about 2.5cm (one inch) in diameter[1]. The globe is widest at its antero-posterior diameter (24mm) and is flattened from above downwards[2].

The corneoscleral envelope is fibrous and anterior sixth is perfectly transparent, while its posterior five-sixths, the sclera is white and opaque. The cornea is a transparent coat that covers the coloured iris.

## Surgical considerations

The surgical procedures in the removal of an eye are classified into -

### 1) Evisceration

It involves the removal of the contents of the globe leaving in place the sclera and sometimes the cornea. A loss of volume results from its removal. The mobility of the eviscerated globe implant is excellent, since the extra ocular muscles are intact.

The prosthesis best suited is the custom cosmetic cover shell or the sclera cover shell prosthesis. A minimum of one mm thickness is required. Most patients remove the sclera shells at night since the remaining globe is usually very sensitive.

### 2) Enucleation

It is the surgical removal of the eyeball after the eye muscles and the optic nerve has been severed. Adequate space is created for fabricating the ocular prosthesis. It is the movement of the fornix in the enucleated socket that provides the mobility to the artificial eye.

An ideal socket for the fitting of an ocular prosthesis should have

1. A well placed implant with the extra ocular muscle attached.
2. Adequate superior and inferior fornices for positive retention of the prosthesis.

**Correspondence**
Dr. Deepti C Jain, Assistant Professor, Faculty of Dentistry, Melaka Manipal Medical College, Manipal University, Karnataka, India
E-mail: dr_deepticjain@yahoo.co.in

3. A palpebral fissure equal in size and shape to the tissues of the natural eye.
4. Adequate anterior-posterior depth to the socket.
5. Adequate support of the superior and inferior tarsal plates.
6. Minimum scar tissue adhesions in the socket.
7. Adequate mobility of the eyelids.
8. Some type of tissue irregularities in the depth of the socket for the positive adaptation of the prosthesis.

A contracted socket with inadequate superior and inferior fornices, with palpebral fissures of unique size and shape and with inadequate anterior- posterior socket depth presents with numerous retention and cosmetic complications. Prosthetic treatment of a contracted socket involves the construction of sequentially larger pressure conformers to expand and shape it.

**3) Exenteration**

It is the removal of the entire contents of the orbit, including the extra ocular muscles. The eyelids may or may not be involved. Exenteration defects in some instances may be allowed to heal by secondary intent but adequate space must remain in the resultant defect to allow the prosthesis to be positioned superiorly and posteriorly enough for a good cosmetic appearance[3].

## History

The artificial eyes have been used for centuries with the earliest known examples dating back to the fourth dynasty in Egypt (1613-2494 BC), Romans, Greeks, early Hebrews, Peruvians and the Ethiopians[1]. Artificial eyes were constructed of such varied materials as gold, rock crystal, shell and coloured stones.

Ambrose Pare (1510-1590) a Frenchman, the pioneer of modern artificial eyes in 1575, fabricated artificial eyes made of glass as well as porcelain[1,4,5,6].

The glass eye originally came from Greeks of Dalmatia after the Latin war. From Greece, the knowledge travelled to Venice and then to Germany which later became the main producer of artificial eyes for the entire world. A German glass blower, Ludwig Muller –Uri, is credited with the development of fine artificial glass eyes[6].

During the two world wars, the supply of glass eyes from Germany to the United States was halted and naval dental school (1940) tested the use of acrylic resin in fabricating a custom ocular prosthesis.

## Various types of artificial eyes

**Glass eyes**

It is a combination of fusible opaque glass for sclera portion and transparent glass for corneal portion. The opaque is obtained from a combination of 30% silicone and 20% potassium and 30% lead oxide and 10% tin oxides. The transparent corneal glass is obtained by merely omitting the metal oxide.

Glass eyes are rarely used because of the difficulty in handling and adjusting the material[1]. They are useful in cases of allergy to resin.

**Acrylic resin eyes**

Developed in 1939 by the armed forces of the United States and it makes use of poly methyl methacrylate (PMMA). It is compatible with tissues, is easy to work with, costs less than glass, has easy colour modification abilities and more aesthetic appearance than glass.

**Custom eyes**

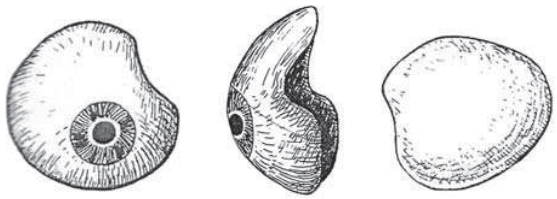
Are individually constructed, hand painted acrylic resin artificial eyes. It, however, necessitates the service of a skilled artist for the iris and sclera, and is an involved and time-consuming process[7]. The optimum cosmetic and functional results enhance the patients' rehabilitation to a normal life style.

**Stock eyes**

Developed by commercial eye optical companies. The procedure may be done in a very short period of time; but the esthetic and functional results are not satisfactory. It may be used as interim prosthesis, as a conformer or stent immediately, post operatively to aid in the regrowth and orientation of the tissues in surgical area[8].

Stock prosthesis can be broadly divided into following categories[1].

Snellen conventional reform eyes



Front Side Back

Most frequently used artificial eye with a horizontal diameter 10% greater than the vertical one. The posterior surface is concave. Indicated following enucleation and evisceration.

**Variations in the reform eye**

1) *Conventional shell type*: Indicated where orbital tissues are protuberant and leave too little space for a reform eye. The thickness of the scleral portion is about 1-1.5mm.
2) *Hook or shelf type:* It is indicated in the eyes with the shallow lower fornix and lax lower lid which leads to a tendency for the prosthesis to slip out from below.

A hook at $90^0$ supports the prosthesis by resting over the stump taking away some weight being exerted on the lower lid.

3) *Curled back shell:* The upper portion of prosthesis itself extends back at right angle to the vertical fold of the eye. Indicated in cases of shallow or deficient inferior fornix.
4) *Forty five degree bent eye:* When an ordinary reform eye would lean back at an angle of 45° from the horizontal, the band prevents drooping of the temporal portion of the upper eyelid.
5) *Peanut eye:* These eyes, shortened in vertical direction and elongated horizontally with a temporal curve are used when a conventional reform eye tends to sink back temporarily and pulling away from the inner canthus.
6) *Reversed shape:* The vertical dimension is greater nasally and temporally. It is used when the prosthesis has a tendency to rotate in the socket.

### Clinical considerations

A patient's history including the details of the nature of the disease, its mode of onset with reference to the visual status and recurrence should be taken. Family history is important, congenital or hereditary anomalies such as cataract, albinism and iris deformities etc[1].

During the post operative period, it is important that the patient wore a conformer. The presence of a conformer will aid in the preservation of cul-de-sac of the fornices and in stabilization of the implant during healing. The construction of a custom conformer may be indicated when the construction of a definitive ocular prosthesis will be delayed because of slow patient recovery, medical complication or patient preference[9].

The socket is examined to determine the presence of an implant and the degree of mobility. Mobility may be noted by observing the movement of the tissue bed when the natural eye moves. If the patient has previously worn any prosthesis, the type, tolerance and difficulties if any, experienced are also noted.

A growing child will require periodic enlargement of the prosthesis gradually over a period of years to aid in the development of the lids and other soft tissues lining the orbital bone margins which must be stretched to enhance the development of the fornices, which is necessary for good cosmetic result.

The amount of orbital adipose tissue present and the extent of atrophy of muscle and other tissues incident to the removal of the eye, as well as the contour and tonus of the eyelids, should be particularly evaluated at the time of examination[5].

### Fabrication of ocular prosthesis

When the surgical site is well healed and dimensionally stable, fabrication of an ocular prosthesis can begin. Irreversible hydrocolloid is the material of choice as it is inexpensive, easy to use and readily available. The impression techniques include:

**1. Moulded shell/ stock tray impression technique**

Developed by Allen and Webster, the impression tray is shaped like an ocular prosthesis. The patient should be seated upright with head rest. The trays are made of acrylic resin and have a hollow handle which accommodates an impression syringe. Ophthalmic quality irreversible hydrocolloid is injected into the socket. Impression tray is rinsed with water, replaced in the defect to check for proper lid contour and mobility of the impression.

Iris placement can be done either in the wax pattern and processed, or in the fabricated sclera.

Positioning of the iris lens assembly on the wax pattern is the most important phase in the fabrication of the prosthesis. By comparison with the natural eye, the centre of the pupil of the prosthesis is located and marked with a pointed applicator stick dipped in water proof ink. A cylindrical portion of wax larger than the lens button and approximately 1-2mm thick is removed from the marked area. The lens button is then attached in the depression. A more precise measurement for lens placement can be done using a pupillometer.

*Fabrication of sclera:* The wax pattern is invested with white orthodontic stone to prevent contamination of acrylic resin with pigments from yellow or green dental stone. Sclera white acrylic is available commercially or can be made by mixing 1.5gm of zinc oxide powder with 100 gm clear acrylic resin. Monomer is then mixed with this shade in 1:3 ratios.

*Iris setting in acrylic conformer*: By placing the point of an architect compass at the pupil center, a circle is scribed the same diameter as the natural iris. A recess 1.5-2 mm deep is prepared with a carbide inverted cone bur flattening the floor of the cut down and also undercut the walls around the edges. When painted, this undercut will show through and produce effect of the limbus[10].

**2. External tray impression technique**

While the patient gazes at the fixed point at least 6 feet away, alginate impression material is expressed into the defect. A perforated acrylic resin backing tray loaded with alginate is placed over the defect and allowed to set. The impression is boxed, poured in dental stone up to the height of contour of the impression. A separating agent is placed and remainder of the impression is

poured after making at least two keyways. Thus a two piece split cast is obtained. From the stone mould, a wax pattern is prepared.

The fit of the wax pattern is observed by gently lifting the lids and observing its extension into the fornices. The eyelids should close completely over the wax pattern without which the mucous and dried tears accumulate on the anterior curved surface of the prosthesis leading to irritation of the adjacent tissues.

*Selection of iris components*: Iris discs used in iris painting are available in 0.5mm sized increments, ranging from 11-13mm. An iris disc that is one mm smaller than the diameter of patient's iris is selected. Thus compensating for the magnification caused by the over lay of clear acrylic resin in the completed prosthesis.

**Various techniques of iris painting are:**

i. Paper iris disc technique
ii. Black iris disc technique
iii. Monopoly with dry earth pigment

In the recent years, digital photography has been used to replicate iris of the patient[11].

Modification of the sclera: The anterior curvature of the prosthesis is reduced by one mm and corneal surface by two mm. Natural sclera has veins present at nasal and temporal corners. Modifying oil pigments are mixed with monomer polymer syrup and applied to the sclera. The area of caruncle is tinted as required. Cover the rayon thread with clear syrup before applying pigments or the color of the vessels may be changed. Next a layer of clear acrylic resin is made over the eye by packing in the original molds and processing at 212 degree F for two hours. After the curing the anterior and posterior surfaces of the prosthesis are finished with a rubber Burlew cup and polished with wet fine pumice. All surfaces are finished and polished using Tripoli and high shine white compound. The artificial eye is washed with warm water and soap and inserted into the patient's socket.

**3. Modification of stock eye prosthesis**

The use of a stock ocular prosthesis of an appropriate size and color, adapted by selective grinding or addition of acrylic resin has been advocated by Laney and Gardener[12].

A stock eye is selected with the correct iris size, color and sclera shape. The periphery and posterior surface is reduced 2-3mm and retentive grooves are cut into it. Paint alginate adhesive over these surfaces, inject alginate into the defect and place the modified eye into it. Impression is then invested, packed and cured under 3500 psi pressure for at least one hour. Prior to inserting the polished prosthesis, disinfect in a solution of 0.5% chlorhexidine and 70% isopropyl alcohol for five min followed by rinsing in sterile saline solution to avoid chemical irritation.

Modification of stock eye prosthesis can also be done using a tissue conditioner. This is comfortable and produces a healthy clinical soft tissue response. Its biocompatibility allows the continued clinical use and evaluation of the ocular prosthesis over an extended period of 24-48 hours. This method is particularly suitable in growing children where the prosthesis needs to be regularly modified to suitably fit their growing orbits. After 48 hours, the elastic tissue conditioner must be converted into heat cured acrylic resin to complete the prosthesis.

**Post insertion care of ocular prosthesis**

During the adjustment period there will be an increased volume of secretions (watery mucoid/ mucopurulent). It is better to wear the prosthesis as long as it remains comfortable and is non-irritating. Very few patients need to leave their artificial eye out at night. It must be kept in water or contact lens soaking solution. Daily ocular hygiene consists of using ophthalmic irrigation solution as eye drops to clean the anterior surface of the prosthesis. Each patient must be trained in the method of removal and insertion of the prosthesis.

Cleaning is best done by hand with a simple liquid surfactant such as baby shampoo. Liquid soaps should be avoided because they contain oils that will interfere with the wetting of the surface of the prosthesis[13].

A one year recall system should be instituted for all eye prosthesis patients. Following surgery, some patients are left with an inadequate volume of tears to lubricate the artificial eye and lids causing discomfort and irritation due to friction or to adhesion of the conjunctiva to the prosthesis. Mineral oil/ sunflower oil may be used as artificial tear replacements.

Socket secretions provide lubrication and mild antibacterial functions and should be no cause for alarm unless their amount increases or their color turns from normal yellow-white to yellow-green/ yellow-brown. If this occurs, infection should be suspected and ophthalmologist consulted.

**Complications in fitting anophthalmic socket**

1. Aptosis: is a common finding following enucleation. It may be due to accidental or surgical trauma, volume loss in the orbit, migration or malposition of an implant or to pressure from malfitted prosthesis.
   a) Pseudoptosis occurs when the superior palpebrae is not properly supported by the

prosthetic eye. Usually occurs when a small, poorly fitted prosthesis is used. If the physiological function of the eyelids is intact, correction can be achieved by increasing the volume of the prosthesis in the socket.

a) Trueptosis exists because of inadequate musculature or lack of tissue tone, the superior lid droops over the prosthesis. Correction can be accomplished surgically by shortening a muscle or reducing the volume of tissue.

Allen(1976) described a method of contouring the prosthesis to overcome ptosis. First, the upper aspects of the corneal prominence are enlarged to raise the lid. Then superior aspect of the prosthesis is reduced to form a shelf /depressed area onto which the lid may rest to fold[4].

### Other methods include

**Extended shelf**- a thin transparent shelf can be made across the front surface of the eye to hold the upper eyelid at the desired position. Major drawback is that eye cannot blink or close.

**Incised shelf**- is used where the upper eyelid is so tight that the plastic eye would otherwise gaze upwards objectionably. The incised plane can be recessed almost 2mm without becoming noticeable.

**Crutch on spectacle frame**- a wire/ wire springs is mounted on spectacle frame and extends across into the supra orbital fold to press eyelid tissue upwards and backwards under the superior rim of the orbit. These, however cause restricted blinking.

2. Ectropion: the prosthesis has a tendency to slip down and out over the everted lower lid. The wax pattern is modified by extending a thin lower edge that will press downwards upon the tarsus, thus creating a lower fornix. The lower fornix will deepen within minutes of modification and retention will improve[14].
3. Sagging lower eyelid: due to the weight of the prosthesis per se and the backward and downward tension of the upper eyelid on the prosthesis. Wax is added to extend the nasal and temporal aspects of the inferior margin to create pressure in the medial and lateral areas of the lid. These modifications tilt the tarsus of the lower eyelid favorably so that eyelid margin is elevated[1].
4. Narrow palpebral fissure: a larger form of prosthesis is needed to project further forward, 'wedging' the eyelids open.
5. Post enucleation socket syndrome- occurs when lower eyelid is stretched downwards by the mass of whole eye prosthesis. Consequently, upper eyelid droops to deep hollow form under the superior orbital rim. Replacing the artificial eye with one of a new shape may help the appearance in the early stages, but surgery is often ultimately required.

### A note on ocular implants

An implant placed in the tissue bed facilitates construction of an ocular prosthesis thus preventing sunken appearance of the orbit. An implant that is attached to the ocular muscles move in their normal course, consequently the prosthetic eye will exhibit some degree of movement (Sorsby,1972). Also, in growing children, the restored muscle function creates tension in the orbital walls and ensures a normal pattern of orbital growth. (Stallard,1973)

Following enucleation, tenon's capsule and conjunctiva are opened by an incision at the limbus. The optic nerve and associated vessels are severed and tied to the posterior wall of the capsule. Muscles are dissected from the sclera and implant is positioned, the ocular muscle are then attached to the implant.(stallard 1973) Tenon's capsule and conjunctiva are then sutured to complete the closure. A conformer molded plastic is placed over the sutures thus reducing the edema and maintaining a socket for prosthetic eye. Fabrication of a custom prosthesis should be done 6 months post operatively.

### Materials and types of ocular implants

First material used for orbital implants was glass by Mules (1884). In recent years, inert resin polymers and silicone rubber (medical grade) have been used[10].

### Classification of implants

1) Integrated- attached to the prosthesis e.g.: hydroxyapatite implant
2) Semi integrated
3) Non integrated- e.g.: acrylic balls, glass spheres.
4) Buried- e.g.: mules, IOWA
5) Non buried / Exposed.

### Ideal properties of implants

i. Be completely buried.
ii. Simple in construction.
iii. Light weight.
iv. Be centered within muscle cone and anchored to the orbital tissues to minimize extrusion.
v. Have ocular muscles attached to it.
vi. Minimal tissue inflammation.
vii. Non resorbable.

### Conclusions

The art and science of ocular prosthesis has been refined over many decades to provide a cosmetic replacement of the enucleated or eviscerated eye. The disfigurement resulting from loss of an eye can cause significant psychological as well as social consequences.

The fabrication of a definitive ocular prosthesis should begin as soon as the socket has healed. Prosthetic rehabilitation is enhanced if an implant can be placed in the orbit to provide an attachment for the rectus muscles, which can impart motion co-ordinated with the natural eye. The goal is to return the patient to the society with a normal appearance and reasonable motility of the prosthetic eye.

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