Orbital Implants and Ocular Prostheses: A comprehensive review

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Introduction

The loss of an eye can be a very traumatic event in a person's life, not only medically, but also emotionally. For many, the face and eyes help represent who they are, and it is common for these patients to feel as if a part of them has been lost. It is the responsibility of ophthalmologists and eye care providers, as they journey with patients through the process of eye removal and artificial eye placement, to provide the best possible functional and cosmetic results. In this way, they can help patients begin to heal medically, and emotionally, as soon as possible. The following article reviews the history, surgical procedures, fabrication, and complications associated with the placement of an artificial eye.

Evolution of orbital implants and ocular prostheses

Artificial eyes have been in existence for thousands of years. Relics dating back to ancient Egyptian tombs suggest that eye replacement with precious stones, bronze, copper, and gold was common practice for the wealthy class.\textsuperscript{7,8} In the 16th century, Pare, an army surgeon of that time, used artificial eyes made of gold, silver, and later, glass. Vulcanite and celluloid were used in the 19th century, and around that time, the glass eye was improved by using sand with low iron oxide content.\textsuperscript{7}

It was not until World War I that glass eyes were used by the general population, and glass remained the most popular material used in the fabrication of artificial eyes until the Second World War. At that time, glass became very difficult to come by as Germany was the main supplier. Consequently, a material used by dentists to produce dentures, methyl methacrylate, began to be used in the manufacturing of orbital implants.

Today artificial eyes are constructed using two components. The first is the orbital implant, which is placed at the time of enucleation or evisceration and fills the anophthalmic socket.
Products currently used for the fabrication of orbital implants include silicone, hydroxyapatite, and porous polyethylene. The second component of the modern artificial eye is the ocular prosthesis, which is what makes the artificial eye appear life-like with iris color and conjunctival vessel markings. It is placed 6-8 weeks after enucleation/evisceration and can be custom-made on an individual patient basis. It is inserted anterior to the orbital implant, just behind the eyelids. Common materials used to produce ocular prostheses are glass and methyl methacrylate.

**Enucleation and Evisceration**  

Before discussing the placement and production of artificial eyes, it is necessary to discuss the indications and procedures that accompany the process. Evisceration is a surgical procedure in which the intraocular contents of the eye are removed; the sclera, Tenon’s capsule, conjunctiva, extraocular muscles, and the optic nerve are left intact. Enucleation is the surgical procedure that removes the globe from the orbital socket. As with evisceration, the conjunctiva, Tenon’s capsule, and extraocular muscles are spared, whereas the sclera and a portion of the optic nerve are not. It has long been believed that evisceration is superior to enucleation in regards to motility and cosmesis; however, modern enucleation procedures, which take care not to disrupt or imbricate the extraocular muscles, actually rival those of evisceration in the preservation of motility of the artificial eye and cosmetic outcome. In fact, enucleation allows for full volume restoration of the anophthalmic socket and may arguably provide a better cosmetic result. The complication rate for evisceration, specifically extrusion, may also be higher. One study that followed patients after enucleation and evisceration showed that evisceration had an incidence of extrusion four times than that seen with enucleation.
Indications for evisceration and enucleation are very similar and include intraocular malignancy; blind, painful eye; prevention of sympathetic ophthalmia in a blind or seeing eye; trauma not amendable surgical intervention; cosmesis; and infections not responsive to medical or surgical therapy. \(^5,7\) The decision regarding which procedure to perform is often controversial because the indications are very similar; however, there are certain instances when one is indicated over the other.

Evisceration is indicated in the setting of “active, uncontrolled endophthalmitis” because evisceration does not disturb the optic nerve. Severing the optic nerve potentiates the spread of infection, so evisceration is the procedure of choice.\(^5\) However, enucleation may be indicated if the infection has spread to the sclera because removal of the eye may be the only option for cure. Evisceration is also indicated in patients who cannot tolerate general anesthesia and in patients with bleeding disorders because it is the faster, easier procedure and damages fewer blood vessels than enucleation. Evisceration is contraindicated in the presence of intraocular malignancy because it does not allow for eradication of tumor cells that have spread to the sclera, nor does it provide adequate tissue for pathological determination of tumor metastasis.\(^7\) Enucleation is generally indicated for malignancies that are confined to the eye; and exenteration, which is the removal of the entire orbit and surrounding structures, sometimes including the eyelids, is indicated when there is extraocular spread of the tumor.\(^7\)

**Orbital implants**

Orbital implants are placed during the enucleation or evisceration procedure because, in doing so, the potential for contracture and volume deficit is reduced and the best cosmetic results are achieved.\(^1,5\) As previously mentioned, current practice employs orbital implants made of nonporous silicone, hydroxyapatite, or porous polyethylene. The intact extraocular muscles are attached either to the implant or to the wrapping material placed around the implant. The normal
innervations of the muscles move the artificial eye in coordination with the healthy eye so that some degree of normal motility is preserved.\textsuperscript{1, 7}

The nonporous, silicone implant ensures eye motility through “surface tension at the conjunctival-prosthetic interface” that is transmitted directly to the implant. Silicone implants come in sizes ranging from 14mm-20mm. Many sources agree that the largest implant possible should be used to fill the anophthalmic socket, which can usually tolerate 20 mm, in order to avoid volume loss and subsequent unfavorable cosmetic deformities.\textsuperscript{5} However, others believe that larger implants cause a higher incidence of extrusion.

The silicone implant can be placed in the orbit either unwrapped or wrapped in material such as autogenous sclera, banked sclera, autogenous fascia lata, polyglactin/polyglycolic mesh, and Gortex sheet, to name a few.\textsuperscript{1, 5} While the wrapping material helps to decrease the exposure rate of the implant in the post-surgical period, there is an increased risk of viral transmission when using donor sclera. It is also important to note that autogenous sclera should not be used in any case of suspected malignancy or infection.\textsuperscript{2, 5}

If wrapping is used, the silicone implant is placed so that the uncovered portion of the implant is facing the apex of the eye socket. The extraocular muscles are sutured in their normal anatomical positions either directly to the silicone implant or to the wrapping material. Tenon’s fascia and conjunctiva, which are still intact after enucleation or evisceration, are then placed over the implant and sutured using the same stitch used when securing the extraocular muscles. In doing so, the tissue is “pulled posteriorly onto the implant.”\textsuperscript{5}

Hydroxyapatite and polyethylene are both porous implants. The major advantage of these implants is that the porous nature of the material allows for fibrovascular ingrowth and permanent integration with orbital tissues. Theoretically, the integration of the implant into host orbital tissues should also reduce the risk of migration, extrusion, and infection in the post-surgical period.\textsuperscript{2} One
major disadvantage of hydroxyapatite is that the implant must be covered with wrapping material because direct suturing to the hydroxyapatite is not possible. The wrapping materials are similar to those used for silicone implants. Porous polyethylene, on the other hand, is advantageous because one can suture extraocular muscles directly to the implant.

A study published by Sadiq, et al. in 2007 compared hydroxyapatite and polyethylene implants on the basis of motility and post enucleation socket syndrome, which is a grading system that assesses degree of post-surgical enophthalmos, upper eyelid asymmetry, upper eyelid sulcus, and the sag of the lower eyelid. The study concluded that the implants were basically identical with regards to these parameters, and suggested that the decision regarding which product to use is determined by other factors such as surgeon experience, patient preference, cost, and availability.

Porous implants are also advantageous because they can accommodate the placement of a coupling device between the implant and the ocular prosthesis; this device is used for even greater enhancement of artificial eye motility. Hydroxyapatite implants use a round-headed peg that creates a “ball and socket joint” between the implant and prosthesis. Polyethylene implants use a similar titanium post that attaches the prosthesis to the implant. Many studies have compared the motility of non-pegged porous implants and nonporous implants, and most have concluded that there is no advantage of one over the other. However, a review done by the American Academy of Ophthalmology in 2003 of 42 studies looking at the mobility of orbital implants suggests that porous implants coupled to the ocular prosthesis show improved motility when compared to nonporous implants. This is especially true when observing large amplitude motility of the artificial eye.

Hydroxyapatite implants are surgically placed in the anophthalmic socket in similar fashion to that of silicone implants; however, there are some differences. Hydroxyapatite implant size is somewhat smaller, usually around 18-19 mm, in order to accommodate for peg placement on the
Before suturing the extraocular muscles to the implant wrap, small openings are made in the wrap at the approximate extraocular muscle attachment sites. Then channels are created into the center of the implant to facilitate vascularization, and the extraocular muscles are sutured to the openings created in the wrap. The remainder of the procedure is performed exactly as described for the silicone implant.⁵

Peg placement is a secondary operation that cannot be performed until fibrovascularization of the implant is complete. This process generally takes six to nine months, and ingrowth of the orbital tissue into the implant is confirmed with a bone scan or orbital MRI.

**Post-surgical conformers**

Ocular prostheses are usually not fabricated for 6-8 weeks following enucleation or evisceration to allow for healing of the socket. During this time, a temporary acrylic conformer is worn to keep the fornices formed and to prevent socket contracture.⁵ ⁶ Two holes are usually present in the conformer to allow for drainage of discharge from the socket, easy application of medication, and to simplify insertion of the conformer.⁶ Standard conformers are clear and do not resemble a natural eye; in addition, they are often too large or too small. There are so-called cosmetic conformers available that come in a variety of sizes, iris colors, and scleral colors. While they do not provide as good a fit or cosmetic appearance as the custom-made ocular prosthesis, they are a good temporary option. A study concerning cosmetic conformers published by Patel, et al., showed that many patients were pleased to wear a cosmetic conformer and preferred it to the clear conformer.⁶ This early cosmetic improvement seems to be important in the emotional rehabilitation of the patient following the loss of an eye.
The ocular prosthesis, as mentioned previously, is the component of the artificial eye that fits over the orbital implant and sits just behind the eyelids. Eye care professionals known as ocularists are responsible for the fabrication and fitting of ocular prostheses; they are responsible for everything regarding the production of the prosthesis, including creation of the impression, shaping, and painting the prosthesis. Ocularists also instruct the patient on how to place and care for the prosthesis, and they provide long term care for the patient.\textsuperscript{10}

Available prostheses are either stock or custom-made prostheses fabricated from either glass or methyl methacrylate.\textsuperscript{7} Generally, methyl methacrylate is the preferred product because glass is particularly subject to surface damage and deterioration and usually lasts only about 2 years.\textsuperscript{7} Methyl methacrylate is more durable, has a longer life expectancy, and has better tissue compatibility.\textsuperscript{7}

Stock, or ready-made, prostheses have their advantages, but they also have a few disadvantages. They are advantageous when time and cost are limited because they can be fabricated rapidly with materials found in any dental office.\textsuperscript{7} Additionally, they do not require an artist to complete the painting of the iris and the sclera, saving both time and money. However, most stock prosthesis only come in three sizes and three iris colors. The former is a concern because an improperly fitting prosthesis may not only distort the lid and socket, it could also create an air pocket between the prosthesis and the socket. This may provide a good medium for bacterial overgrowth.\textsuperscript{5} The latter is a concern for many patients because often times the iris color of the ready-made prosthesis is noticeably different from the color of their healthy eye, which is aesthetically displeasing.

The preferred ocular prosthesis is the custom-made prosthesis, which is fabricated using soft alginate impression material.\textsuperscript{5} The material is injected into the eye socket using a “stemmed impression tray.”\textsuperscript{5} The impression reproduces important anatomical features and is then used to
develop a semi-hard wax model. This model can be placed in the socket and modified by either adding or taking volume from the model to further enhance function and cosmetic result. With the use of a corneal-iris button, symmetry of the iris in the palpebral opening and the alignment and plane of the irises in both the artificial eye and the good eye are determined. Correct position of the iris is also ensured by measuring distance from the facial midline and pupillary light reflex in the good eye and duplicating this measurement for the prosthesis.

After the wax model is complete, a glass-stone model is cast and is then used for the fabrication of the final acrylic prosthesis. This prosthesis is given to an artist for completion of the iris, scleral, and conjunctival detail to match the patient’s healthy eye. After the painting is complete, the prosthesis is cast in clear resin, cured under heat and pressure, cooled, and then polished. The prosthesis should be tested in the patient’s eye for proper fit and aesthetic appearance, and the patient should receive instructions regarding the proper care of the prosthesis.

**Complications**

Complications following enucleation or evisceration and orbital implant placement include, but are not limited to, migration, extrusion, and exposure. As discussed previously, migration and extrusion rates are decreased when porous implants are used because of their integration with orbital tissue. Other factors that can influence the rate of migration and extrusion are proper selection of implant size and proper technique when placing the implant. Dermis fat-grafting, a procedure which takes autogenous dermis and subdermal fat from the buttocks or abdomen and places the graft in the anophthalmic socket, can also reduce the incidence of migration and extrusion through effective correction of the volume deficit in the socket. However, this fat can be unpredictably reabsorbed, causing superior sulcus deformity and eyelid retraction; or, although
quite rare, the graft can receive additional fat deposition from systemic weight gain, causing proptosis.\textsuperscript{5}

Exposure rates for porous implants have traditionally been believed to be higher than rates for nonporous implants; however, review of published studies by the American Academy of Ophthalmology in 2003 shows a great deal of variability amongst reported exposure rates for porous implants.\textsuperscript{1} Some studies report exposure rates for porous implants that are similar to those of nonporous implants, while others report significantly higher rates for porous implants.\textsuperscript{1} It seems that this variability is due to many factors including, the presence or absence of implant wrapping, the type of wrap selected, and surgical technique. Additional mechanisms proposed regarding the incidence of exposure are “excessive tension on wound edges at primary closure, chronic mechanical irritation of the rough surface of the porous implant on native tissues, and an immune or chemically mediated inflammation.”\textsuperscript{9}

Chronic exposure of nonporous implants will eventually cause extrusion, so early exposure repair is important in order to avoid revision of the implant. Porous implants are less likely to extrude with exposure because of their integration with host tissues. Small exposures may heal spontaneously, and there are many procedures available to repair large exposures and avoid removal of the porous implant.\textsuperscript{1}

**Summary**

A patient undergoing enucleation or evisceration requires special care on the part of ophthalmologists and eye care professionals. Not only are these patients dealing with a serious medical issue (anything from cancer to infection to trauma), they are also dealing with the psychological issues that accompany the loss of an eye. The main concern of most patients is the outward appearance of the eye. Proper surgical technique and proper fitting of the prosthesis help
to ensure the best cosmetic results and the fewest complications. There are additional steps that can further enhance cosmetic results for the patient, such as the use of pegged porous implants, cosmetic conformers, and dermis-fat grafting, to name a few. In addition to caring for the prosthetic eye, it is also the responsibility of the eye care team to educate the patient on how to best care for the healthy eye, as the care of the healthy eye is equally important.

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References


