Custom Orbital Prostheses for Exenterated Orbits: History, Review, and Case Studies

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ABSTRACT

Orbital exenteration remains the treatment of last resort for patients with severe eye disease.[1] The physician and patient generally consider alternatives to exenteration, the extent to which tissues should be excised, and the means by which the empty orbital cavity will be covered, masked, and camouflaged.[24] For the ocularist, an exenteration requires significant prosthetic restoration to include the eye and surrounding orbital anatomy. These are complex cases, and no two cases are alike. This article reflects the experience of 3 specialists with a combined total of more than 90 years' experience creating prosthetics, including one specialist with 25 years' experience creating personal disguise for agents of the United States Central Intelligence Agency. It is not unusual for multiple professionals such as physicians, ocularists, sculptors, and other artists to collaborate on complex restorations such as those presented here.

Introduction

Orbital exenteration is the removal of the eye and the entire orbital contents, including the eyelids, ocular muscles, and orbital fat. Due to the radical nature of this procedure and the relatively poor reconstruction alternatives, orbital exenteration is usually executed only after other therapies have either failed or been deemed inappropriate.[5,6,7]

Orbital exenteration is generally implemented to treat life-threatening neoplasms, infections (to treat severe orbital pain), or deformities. Since exenteration is severely disfiguring, it is performed only if there is a reasonable expectation that the disease or deformity will be eliminated. Consultation by medical or radiation oncologists, otolaryngologists, and hospital-based tumor boards may all be part of the patient's evaluation for metastatic disease, and these consultations may help to educate the patient on treatment options. These are never simple cases. The tissues involved in an orbital exenteration are not limited to the orbit and may include the eyelid skin, facial skin, bone, and paranasal sinuses. Figure 1 and Figure 2 show some of the structures the ocularist and other members of the reconstructive team must consider solely around the eye.

Relationships Between the Normal Eye and Orbit: A Review

Understanding the basic anatomy of the human eye is a requirement for all health care providers, and even more significant to eye care practitioners, including ocularists. Although the companion eye in monocular patients is usually within the normal range of aesthetics and function, the affected side is always distorted after exenteration.[8] In many respects, knowing and understanding the anatomy of the human eye is of paramount importance when creating orbital prostheses. This is due to the fact that almost all the orbital anatomy is removed before the prosthetic specialist begins work. The ocularist is more involved in reconstruction in cases of exenteration than in the more common cases of enucleation, in which they work with and around the remaining palpebral fissures.

While prosthetic specialists rarely work on actual eyeballs (except to cover microphthalmic and blind, phthisical eyes using scleral cover shells), this knowledge can assist in creating a natural-appearing orbital prosthesis, which will be of benefit to the patient. Cooperation and dialogue among ocularists, facial prosthetic specialists, surgeons, and patients are enhanced by the ocularist's strong background knowledge of orbital anatomy. A skilled ocularist should be familiar with the relationships between features of the healthy, normal eye in order to understand the elements to be crafted for a realistic prosthesis. Of course, all "normal" features will be considered in light of the patient's unique appearance in order to create the most natural-appearing reconstruction possible.

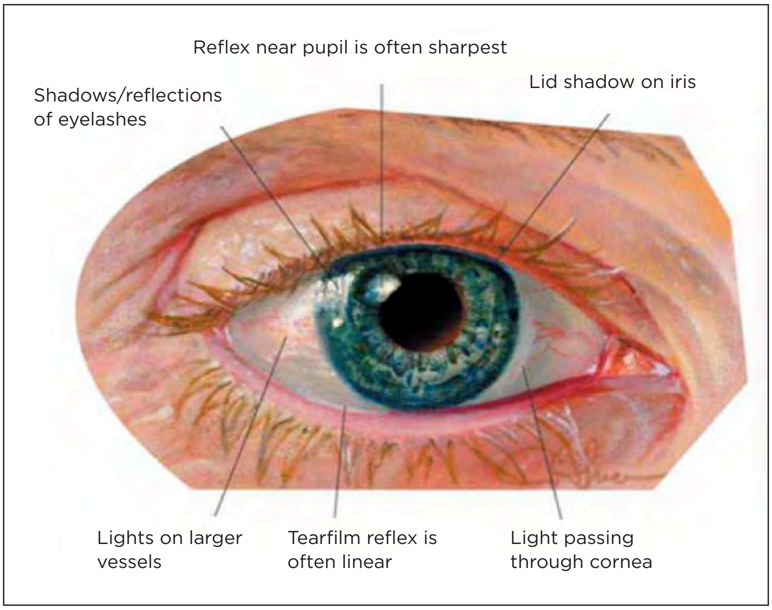

Figure 1. Key anatomy around the eye includes the proportions of the palpebral fissure. This figure also shows the typical interplay of reflected light and shadow on the eye, which is essential for the ocularist to know in order to create the most realistic facsimile of the fellow eye.

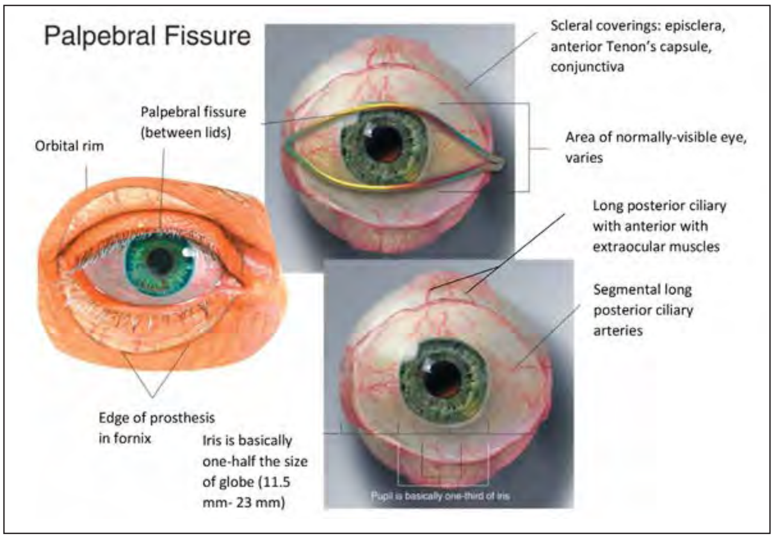

Figure 2. The palpebral fissure exposes the area of the eye that is normally visible. The size and shape of this area varies from person to person. The diameter of the iris also affects how much of the rest of the eye is visible. These proportions are essential to know in order to create natural-looking ocular (and orbital) prostheses.

The opening of the lids in primary (forward) gaze is normally somewhat asymmetrical. When the eyelids are open, the apex or highest point of the upper lid is typically slightly nasal to the center of the eye, while the lowest point of the lower lid is slightly temporal to it. The medial canthus is slightly lower than the lateral canthus. This knowledge is helpful for patients who have experienced trauma, for whom their prosthesis may become the "normal" appearing eye.

The position of an average orbit shows the anterior placement of the normal eye (Figures 1 and 2). The opening between the eyelids is called the "palpebral fissure." The amount of the sclera that is displayed, or "scleral show," varies with the horizontal laxity of the lower lid. This laxity usually increases with age. A child's eye has a generally rounder palpebral fissure than an adult's, and the canthi are often higher. The iris appears relatively large in a child's eye in comparison to the iris-to-sclera ratio in an adult eye.

From the side, approximately one-third of the eyeball, or globe, is outside the orbit at the mid-sagittal section. One can appreciate the thinness of the orbital bones, especially the floor and medial wall—known as the lamina papyracea ("sheet of paper")—covering the paranasal sinuses.

Creating the ocular prosthesis component may require modification of one's technique based on a number of obstacles determined by the cavity to be filled (see Figures 3 through 10). Standard procedures can be adapted to fit the needs of the patient and at times, the need for a quick turnaround. For example, digital iris-cornea pieces have been recently used for accuracy, speed, and convenience in working with patients on medical missions Central America, where time is limited (Figure 11).

Figure 3. This 58-year-old woman had a contracted socket OS following multiple ocular surgeries. We suggested a small orbital prosthesis covering the palpebral fissures and retained with adhesive (A) as opposed to a conventional socket-retained PMMA ocular prosthetic (B), which did not give this patient the natural appearance she desired. The patient was happy with this new, thinner prosthesis.

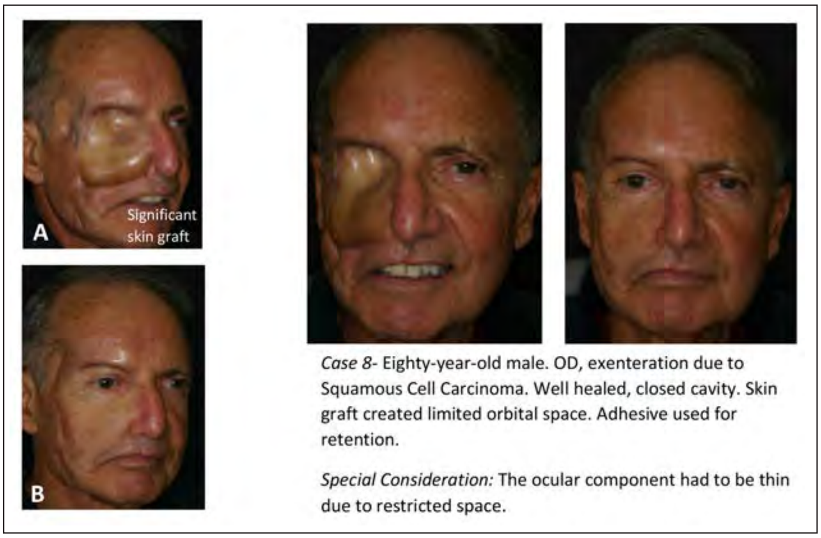

Figure 4. This 80-year-old man had exenteration to treat squamous cell carcinoma. The well-healed orbital socket provided a good foundation for the prosthesis. A skin graft (A) limited the orbital space, so the ocular component had to be thin. The end result is shown in B and at far right above.

Historical Perspective

Restoring defects resulting from facial trauma, including those occurring as a result of exenteration, through surgical reconstruction or prosthetics is a unique challenge. In the years before World War I, the use of prosthetic work for extensive loss of the orbital contents was limited. American sculptor Anna Coleman Ladd was a pioneer in the field of facial prosthetics, including orbital prostheses.[9] Ladd worked for the American Red Cross in Paris during World War I, adapting the techniques of British sculptor Francis Derwent Wood. Ladd used her artistic skills to restore the appearance of veterans' mutilated faces. Their traumatic facial injuries were more severe than general reconstructive surgeons, whose field was then in its infancy, could help.[9] Using copper and a variety of materials, Ladd and her team created masks to help conceal significant facial injuries caused by flying debris. Eyebrows and mustaches were created using real human hair. Mouth-blown glass (cryolite) human eyes were incorporated into the metal masks and secured with eyeglasses. Ladd's Studio for Portrait Masks in Paris served wounded soldiers for more than a year. When describing this skilled sculptor, one colleague described Ladd as a "[person] of great talent."[9] The end results, although not perfect, were impressive, and they highlight the skill and compassion of this pioneer in facial reconstruction (Figure 12).

The next great conflict, World War II, saw the continued evolution of reconstructive surgical techniques and an increase in creative prosthetic work. This included the use of polymethyl methacrylate (PMMA) for both ocular prostheses and the surrounding orbital anatomy (Figure 13). Today, most orbital prostheses are made of medical-grade silicone, which was developed in the 1960s.

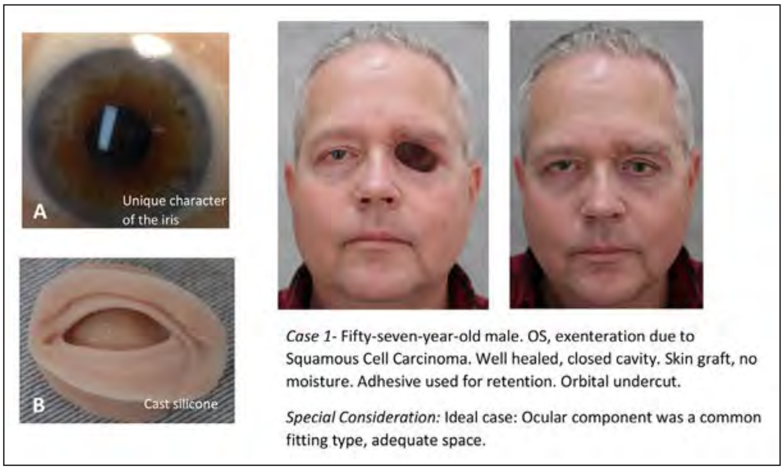

Figure 5. This 57-year-old man was the ideal candidate for an orbital prosthesis. He had recent exenteration to treat squamous cell carcinoma. The surgery was recent and the cavity was closed and well healed. He had a skin graft and no moisture issues, as well as realistic expectations. This was an ideal case, as the ocular component was a common fitting type and there was adequate space for placement. Adhesive was used for retention of this prosthesis that included an orbital undercut.

Reconstructive and Prosthetic Options for Patients with Exenterations

In many instances, exenteration surgery incorporates a reconstructive plan that aims to achieve several goals. The optimal aesthetic result is considered while remembering that most patients wish to camouflage their surgical defect with patches or oculofacial prostheses. With these goals in mind, the physician as well as the ocularist and facial prosthetic specialist will pursue solutions to disguise the exenterated orbit.

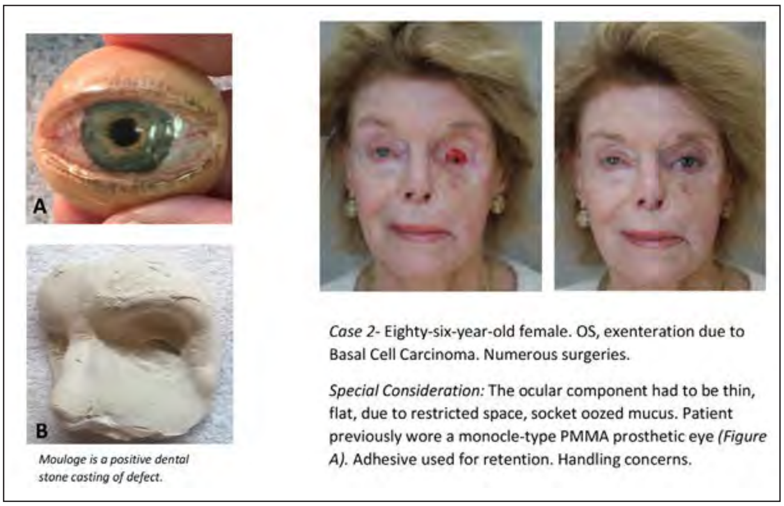

Figure 6. This 86-year-old woman had an exenteration OS to treat basal cell carcinoma. She had numerous surgeries and wore a monocle-type PMMA prosthetic eye, shown at A. Impression made moulage is shown at far left B, a positive casting of the defect using dental stone material. Challenges included making the ocular component of the new prosthesis thin and flat to fit in the restricted space available. The socket also oozed mucus. The new prosthesis used adhesive for retention, and we worked with the patient on her concerns about proper care and handling. The dramatic improvement resulted in a happy patient.

After the diseased tissue is removed and exenteration is complete, the orbit may be left to heal by granulation. After approximately 3 months, a custom orbital prosthesis can be fitted by impression and secured over the empty cavity. This straightforward and effective technique is particularly well suited to the critically ill patient because operative time is minimized.[6] Clear communication is vital among the patient, surgical team, and reconstructive team. It is not uncommon for a patient in need of reconstructive services to make an appointment for an "eye," only to learn that much more was removed than the eye alone, and the services of a facial prosthetic specialist are required as well as those of an ocularist. This situation may arise from a lack of communication or from oversimplification by the patient or medical team, or both, about the extent of surgery. Ideally, all parties will be clear about what must be reconstructed to achieve the patient's desired result.

Specific Prosthetic Options

Wearing an occlusive patch is an inexpensive and simple measure that many patients choose. The patch fits over the empty cavity to cover the defect. These patches are especially suited to the critically ill patient. The result is a rugged image that many patients, particularly men, find acceptable. Since patients are often concerned that the patch may become dislodged and expose the empty eye socket, surgical sponges, towels, or custom-made silicone moulages may be placed beneath the patch.

An orbital prosthesis the next step in restoring a patient's appearance. A standard PMMA ocular prosthesis is created to simulate the fellow eye. This is coupled to a silicone appliance that fills the orbital defect and balances the opposite side. Particularly when restoring appearance after exenteration, spectacle frames worn with a prosthesis can add stability and a more natural appearance. The shadows cast by the spectacles' stems can mask the transition zone between natural skin and a facial prosthesis, while the prosthesis itself can be attached to the spectacle frames to help hold it in the correct position and keep it in place (Figure 13). Premade digital iris-cornea pieces (DICP) are another useful tool. These can save time in crafting the prosthesis, allowing the practitioner to focus more on the surrounding orbital anatomy. They are particularly helpful when working with patients who have common iris colors and limited reimbursement options for reconstruction (Figure 11).

In some instances, the orbital prosthesis can be integrated into the orbital bone by fastening it to titanium screws inserted into the bony orbit. The advantage of this technique lies in preventing migration and displacement of the prosthesis; disadvantages are additional cost and the need for surgery. Due to these drawbacks, the authors have generally fitted orbital prostheses initially without titanium anchors to observe how the patient tolerates an orbital prosthesis held in place with liquid adhesive. These adhesives and the necessary removers can be messy, so hygiene is a consideration in using this method. The use of a permanent anchoring system is explored depending on the success of this initial approach.[10,11,12,13,14]

Figure 7. The patient in this case was a 45-year-old woman with an intact palpebral fissure OS. The socket was contracted after radiation to the orbit and enucleation to treat retinoblastoma. This restricted the space available for placement of a prosthesis, but we obtained an acceptable end result. The cavity was closed and well healed, and we used adhesive to retain the prosthesis. The ocular component had to be flat (A) due to the restricted space and vaulting eyelids.

Figure 8. This patient was a 26-year-old woman with a well-healed orbit and socket OS. The socket was contracted after radiation to the orbit and enucleation to treat retinoblastoma. The patient had previously worn a conventional PMMA ocular prosthesis (A at above left, far left). We replaced this with a more natural-appearing silicone prosthesis using adhesive and eyeglasses for distraction. Challenges included convincing the patient to use adhesive as opposed to a simple socket-retained ocular prosthesis. Other concerns were a vaulting orbit over the eyelids and moisture concerns related to the adhesive.

Categories of Prosthetic Restoration after Exenteration

To organize and aid our prosthetic service in these complicated cases, the authors created categories to summarize the various types of exenterations and subsequent prostheses that are routinely encountered. These categories encapsulate the scope of work and complexity involved, and generally mark obstacles that the patient, ocularist, and facial prosthetic specialist may encounter. These categories are sometimes helpful to use when insurance estimates are required. Photographs are useful to help set expectations when new patients present for reconstructive services. In addition, patients and families find examples comforting.

Orbital restoration categories are:

1. Eyelids intact/contracted orbit. A conventional ocular prosthesis cannot be retained due to the damaged palpebral fissures and orbital volume loss (see Figures 3, 7, and 8).
2. Entire orbital contents—including eye, eyelids, and surrounding anatomy—removed. A closed orbital cavity, with or without a posterior orbit wall graft, makes this particular situation the best for ocularists and prosthetists (Figures 5, 6, and 10).
3. Entire orbital contents have been removed and additional surrounding anatomy requires creating a larger and more complex prosthesis, usually including skin grafting (Figures 4 and 9).

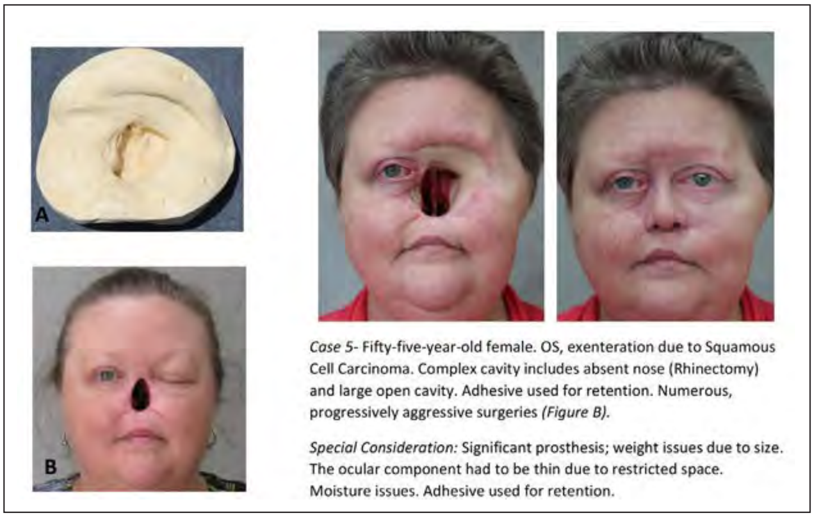

Figure 9. This 55-year-old woman had exenteration OS after numerous, progressively aggressive operations to treat squamous cell carcinoma. This reconstruction included a complex cavity due to the large opening (A) and rhinectomy (B). There were weight issues with the prosthesis due to the size required. The ocular component had to be thin due to restricted space. We used adhesive for retention. Moisture issues were a challenge, but patient motivation made this challenging prosthesis a success.

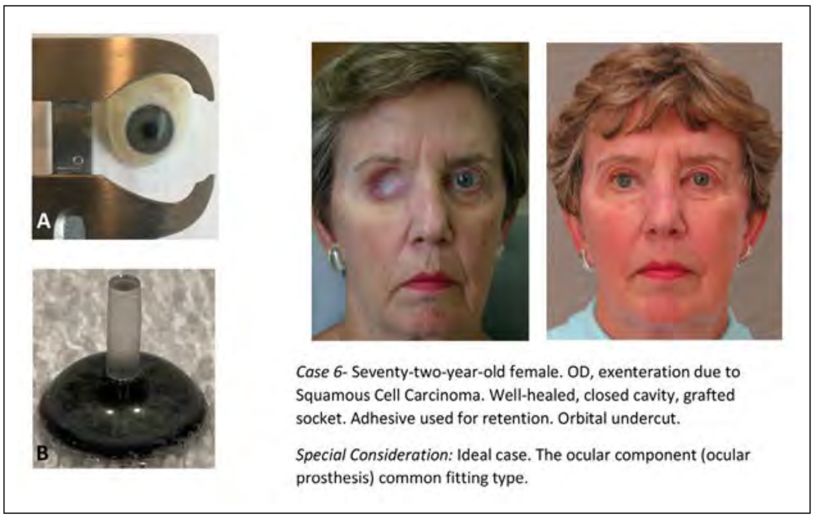

Figure 10. This 72-year-old woman had an exenteration OD for treatment of squamous cell carcinoma. There was a well-healed closed cavity. Realistic expectations and a great patient attitude helped us generate a pleasing result. We used a common prosthetic eye, adhesive for retention, and an orbital undercut. As with the patient shown in Figure 5, this was an ideal case for prosthetic fitting after exenteration.

Conclusion

Although not every patient who undergoes exenteration seeks prosthetic restoration, many do. In addition, the ocular component to the prosthesis, the central focal point, may require modification of the usual techniques of prosthetic eye fitting due to a less than ideal fitting situation. This paper shares examples of prosthetic restoration of the exenterated orbit with emphasis on the ocular prosthesis component and creates a system of categories to aid in collaborating with physicians, patients, and other prosthetic specialists.

Acknowledgments

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Special Note

One of the authors, Robert Barron, was a former Senior Master of Disguise specialist with the CIA for more than 25 years. His career with the agency saw numerous overseas assignments, as he was responsible to provide various traditional and advanced disguises to officers. Barron's second career led him from disguises to prosthetics in 1993. He performed the facial reconstructions for patients featured in this report.

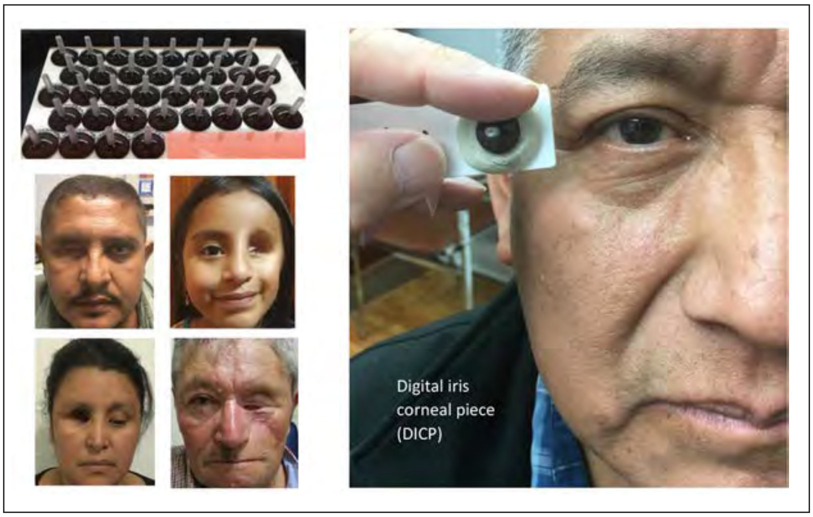

Figure 11. Digital iris-cornea pieces are used in creating ocular prosthetics in situations where time or reimbursement options are limited. They can provide a realistic match to the fellow eye. At left, examples of DCIP used in medical missions in Central America. At right, DCIP compared to the patient's fellow eye.

Figure 12. Soldiers in World War 1 had a dramatic increase in facial injuries, including orbital injuries. Sculptor Anna Coleman Ladd, shown here with a French soldier, created and painted tin and copper masks for combatants with severe facial injuries. Eyeglasses were often used to secure these prostheses. Above right, Ladd's masks were created using plaster-stone casts. Center right, some of the facial prostheses. Below right, a soldier's injury without the prosthesis and wearing the prosthesis.

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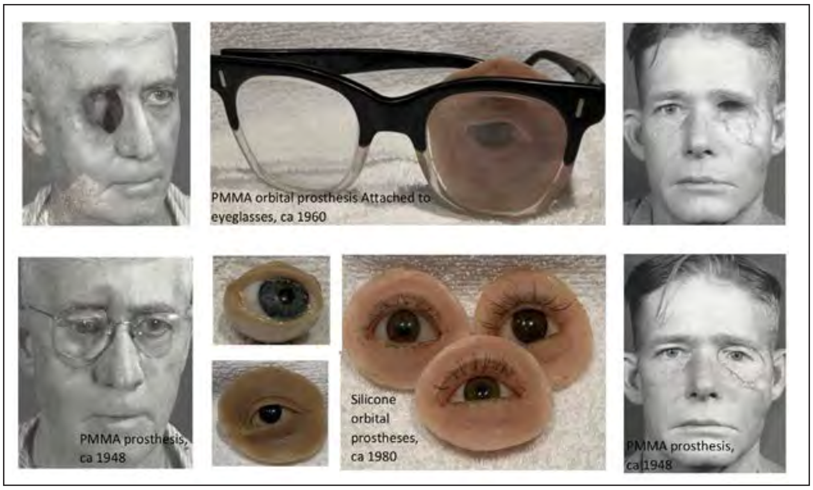

Figure 13. The material PMMA was first used in dentistry. In World War II, prosthetists began using it to create orbital prostheses. At left and right, soldiers without (above) and with (below) their PMMA orbital prostheses, ca. 1948. Top center, a PMMA orbital prosthesis attached to eyeglasses, ca. 1960. Silicone was the next material to come into use, and it is still used today. Bottom center, silicone orbital prostheses, ca. 1980.

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