Prosthetic Reconstruction of Orbital Defects

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Abstract

Orbital and craniomaxillofacial defects, in general, are best approached preoperatively by a multidisciplinary team with a clear reconstructive plan in place. Orbital defects result from a myriad of underlying diseases and injuries, and reconstruction after orbital evisceration, enucleation, or exenteration can pose a challenge to the reconstructive team. Reconstruction of orbital injuries with orbital implants and prostheses can lead to acceptable aesthetic outcomes, and the reconstructive surgeon should be familiar with current orbital implants and prostheses. Herein, the authors review terminology and classifications of orbital defects, different types of orbital implants, advantages and disadvantages of different orbital implant reconstructive options, types of orbital prostheses, and pros and cons of different prosthetic options.

Keywords

- ▶ prosthetic
- ▶ orbital implant
- ▶ orbital defects

Orbital defects can be devastating to patients not only because of functional impairment of eyesight but also because of the obvious cosmetic deformity. While eyesight cannot be repaired, there have been numerous advances over the past century and past decade to improve aesthetic rehabilitation of orbital injuries. Herein, we review the causes of orbital defects, terminology, and classification of such injuries, and review current methods of aesthetic rehabilitation focusing on orbital implants and orbital prostheses.

Defects

Causes

Orbital defects result from a myriad of underlying diseases and injuries. Treatment of malignant neoplasms and maxillofacial trauma are common reasons for orbital exenteration. Surgical management of melanomatous and nonmelanomatous skin cancers, retinoblastomas, sebaceous gland carcinomas, adenoid cystic carcinomas of the lacrimal gland, and sarcomas can leave large orbital defects, as can radiation therapy.^{1–3} Next,

severe trauma, ballistic and nonballistic in nature, can also damage the orbit,⁴ while other defects may be congenital in nature.¹ In general, orbital defects vary significantly from one to the next, and use of appropriate terminology can help reconstructive surgeons communicate and better formulate a reconstructive plan.

Terminology

Orbital exenteration refers to the complete removal of the globe, extraocular muscles, eyelashes, and at least partial removal of the eyelids, orbital fat, and periorbital. *Orbital enucleation* refers to removal of the globe (including its contents, the cornea, and the sclera) by severing the optic nerve and extraocular muscles. Orbital enucleation leaves the periorbital fat, eyelids, eyelashes, and surrounding bones of the orbit intact, and it leaves the orbital muscles intact, simply separated from the removed globe and sclera. *Orbital evisceration* is the removal of the contents of the globe (uvea), possibly including the cornea, but leaving the sclera intact and still attached to the extraocular muscles. It also leaves the extraocular muscles and optic nerve intact.¹

Orbital evisceration is more common after localized traumatic injuries to the globe in which the globe itself and functional eyesight cannot be preserved, but the sclera, extraocular muscles, and surrounding structures are uninvolved. Small, intraocular tumors are also a cause of evisceration. While orbital enucleation and exenteration can occur after extensive trauma, they result from removal of malignant tumors invading orbital structures in more than 90% of cases.⁵

An *orbital prosthesis* is a synthetic replacement of the exenterated eye which restores the orbit, eyelids, immobile eye, and periorbital. An *orbital implant* is an osseointegrated structure to support the orbital prosthesis. An *ocular implant* is a spherical synthetic replacement of the globe which can impart movement to the visible *ocular prosthesis*, the synthetic replacement of the iris, pupil, or sclera. The terms “orbital implant” and “ocular implant” are sometimes used interchangeably in the literature.

Classification

Multiple classifications systems have been described for exenteration defects. Cinar et al introduced a classification system of orbital exenteration defects to help guide reconstructive efforts.⁶ Their system separates defects into types 0 to 4, with subtypes A and B, and in general, a higher grade defect will require a more extensive reconstructive plan. Type 0 denotes a defect with completely intact bony orbital walls; these defects can be reconstructed with many methods to include free skin grafts, vascularized flaps (pedicled or free), or can be allowed to heal by secondary intention. Type 1 describes a defect in which there is a sinonasal fistula through the orbital floor and/or the medial orbital wall. Type 2 defects are characterized by cranio-orbital fistulas due to defects in the bone of the superior orbit when dura is intact. In these defects, recreation of the separation between the cranial vault and the orbit is paramount to mitigating the risk of meningitis, encephalitis, and so on. Vascularized flaps, either pedicled (such as a temporalis flap) or free (such as a radial forearm free flap), are necessary to recreate this barrier. The authors note that bony reconstruction is an option, but is not necessary; patients who do not undergo bony reconstruction will notice slight pulsations of the brain but no other differences. Type 3 defects are similar bony defects to type 2, but without intact dura. Reconstruction of type 3 defects differs from type 2 defects in that it requires an additional layer of reconstruction to remake the violated dura. This can be accomplished with a frontogaleal flap, for example, then covered by a temporalis flap for exterior reconstruction. Type 4 defects involve cranio-orbito-nasal fistulas, and the intracranial area needing reconstruction in type 4 defects can be too large for a frontogaleal flap to adequately cover. Thus, intracranial vascularized free flaps are often needed in these defects, in addition to other flaps (pedicled or free) for external reconstruction. All defects except type 0 can be further classified as subtype A, when performed in conjunction with a maxillectomy in which the palate is left intact, or subtype B, when performed with a total maxillectomy. Overall, locoregional flaps are often sufficient for reconstruction of types 1 and 2, whereas types 3 and 4 often require one or multiple vascularized free flaps.

A separate classification system was also described by Kesting in 2017.⁵ Their system separated defects into four categories, with the second category having A and B subtypes. In their system, a type 1 defect includes simple orbital exenteration with an intact bony orbit. Type 2a defects include orbital exenteration and removal of a single orbital wall. Type 2b defects include removal of more than one orbital wall. Type 3 defects describe orbital exenterations with skull base defects, and type 4 defects include extended exenterations with a penetrating orbitomaxillary defects. The authors noted that type 1 and 2a/b defects could be successfully reconstructed with locoregional flaps, whereas higher grade defects required vascularized free flap reconstruction.

Orbital Implants

Orbital implants are used when there has been loss of the globe, either through evisceration or enucleation, when the surrounding extraocular muscles and periorbital remain intact. The ideal orbital implant replaces the lost orbital volume, maximizes motility, is comfortable to wear and aesthetically pleasing.⁷ In the case of evisceration, an orbital implant is placed within the remaining scleral envelope to which the extraocular muscles remain attached, allowing natural motility. In the case of enucleation, however, the extraocular muscles must be attached to the implant to allow movement.

Historically, orbital implants have been constructed from spheres of glass, ivory, bone, or formalized cartilage, but numerous other implant materials and shapes have been developed over the last century. Today, implants are typically classified as being made of porous or nonporous materials; they can be either spherical or shaped, wrapped or unwrapped, and pegged or unpegged.

Porous implants (also called integrated implants, because they integrate with native tissues and allow ingrowth of blood vessels) include hydroxyapatite, coralline hydroxyapatite, and high-density porous polyethylene (HDPP). Nonporous, or nonintegrated, implants include polymethyl methacrylate (PMMA), acrylic, and silicone. Porous materials may reduce infection, migration, or extrusion, by allowing fibrovascular ingrowth of native tissues. Other advantages of porous implants include (1) their relatively light weight, which may minimize lower lid lag over time, and (2) their ability to be held by a post or peg, which can further minimize lower eyelid laxity and improve motility. The main disadvantage of porous implants is their increased cost, not only of the material but also the additional procedures required to place a peg. Many surgeons feel that a wrapped synthetic implant can provide comparable globe motility to an unpegged porous implant over time.⁷ A recent Cochrane review of porous and nonporous implants ultimately concluded that there is uncertainty at this time as to the true pros and cons of each of these materials.⁸

Wrapping is the process of enclosing an implant in a different material before implantation. Common materials used to wrap an implant include donor sclera, polyglactin mesh, acellular dermis, auricular muscle, and other

materials. Nonporous implant materials typically require a wrap to facilitate reattachment of the extraocular muscles. When synthetic materials such as HDPP or coralline hydroxyapatite are used, however, the extraocular muscles can be sutured directly to the implant and do not require a separate material for attachment. Using an unwrapped implant also potentially shortens operative time and morbidity from a separate procedure to obtain the wrapping material.

A peg can be surgically placed to help secure a porous orbital implant; nonporous implants cannot be pegged. In general, pegged implants incur an increased cost and an additional surgical procedure, but they can improve motility of the implant. In a recent survey of members of the American Society of Ophthalmic Plastic and Reconstructive Surgery, over 90% of surgeons responded that they prefer unpegged implants because they are cheaper, because many patients with porous implants ultimately do not elect to undergo the additional surgery required to place the peg, and because unpegged implants still impart acceptable implant motility.⁷

Complications from orbital implants, in general, are rare (<5%). The most common reported complications of unpegged implants include exposure, infection, and pyogenic granuloma, while the most common complications of pegged implants include pyogenic granuloma, exposure, and discharge.⁷

Orbital Prostheses

General Considerations

Orbital and craniomaxillofacial defects, in general, are best approached preoperatively by a multidisciplinary team with a clear reconstructive plan in place.⁹ Partial defects of the eyelids can be reconstructed with many described local, regional, and autologous free flaps, though prosthetic reconstruction can be cheaper, require fewer procedures, and lend a better final aesthetic appearance (► **Fig. 1**). Orbital exenteration defects can be approached in many ways. At a minimum, a split-thickness skin graft can be used to recreate a barrier between the outside and persistent naso-orbito-maxillary tissues, thus making for a “safe” cavity. Autologous free flaps, such as from the radial forearm, rectus abdominus, or anterolateral thigh, can provide vascularized tissue coverage of the wound bed in addition to tissue bulk to fill the cavity.¹⁰ Currently, the only tissue option for complete reconstruction of the exenterated orbit is a facial transplant, which is not a feasible option for many reasons in many patients.

When using autologous free flaps to reconstruct and exenterated orbit, surgeons should be careful not to completely fill the cavity with a very bulky flap, especially when considering further prosthetic reconstruction. It can be difficult to achieve cosmetically satisfactory prosthetic results without adequate width and depth to the reconstructed orbital

Fig. 1 Patient with deformity of her upper eyelid who wears a prosthesis held in place with adhesives.

cavity.¹¹ If a free flap completely fills or overfills the orbit, then additional procedures for flap debulking are required to allow for prosthetic wear. A large remaining socket, by contrast, can be easily filled postoperatively with a hollow prosthesis that is still light, easy to wear, and cosmetically pleasing.

Prosthetic reconstruction after orbital exenteration can provide cosmetically superior results to those achieved with traditional autologous free or regional flaps. It can also allow direct, improved surveillance in the case of malignancy, does not require a separate donor site, and requires a shorter operative time overall.⁴ Prostheses require ongoing maintenance and can be expensive, however. Further, many patients may prefer to wear an eyepatch and forego more complicated rehabilitation; reports estimate that only 11 to 21% of postexenteration patients wear a prosthesis, and of those patients, half wear the prosthesis inconsistently due to inconvenience, discomfort, poor fit, or recurrent disease.⁵ Finally, autologous tissue reconstruction may be a better option for patients at higher risk of infection, osteonecrosis, or pathologic fractures.

The orbital floor needs to be intact or reconstructed (via orbital implant or maxillary prosthesis) to support an orbital prosthesis,³ and a barrier needs to be recreated between the external world and internal mucosa, typically with a skin graft or, when greater tissue bulk or coverage is needed, autologous free vascularized tissue (→ Figs. 2, 3).

Hanasono et al proposed a reconstructive algorithm for postorbital-exenteration defects that centers around (1) the defect size, (2) whether a prosthesis is the ultimate reconstructive goal or not, and (3) whether the patient will undergo perioperative radiotherapy.¹² For smaller defects in which the patient will not require radiotherapy, skin graft coverage of the wound bed is sufficient to support a prosthesis. For patients who will undergo radiotherapy, however, vascularized tissue coverage of the wound bed is recommended either from a regional or autologous free flap to minimize the risk of wound breakdown from radiotherapy and tissue injury from a prosthesis. Patients with large defects from extended exenterations and maxillectomy will require autologous free flap reconstruction initially to provide adequate wound closure. The free flap can later be revised to support an orbital prosthesis.

Materials

Prosthetics of the early 20th century were made of vulcanized or latex rubber.⁴ Acrylic resin was introduced in the mid-20th century, and later silicone materials, which are still commonly used today in addition to methacrylates and polyurethane elastomers.^{13,14} The ideal prosthetic is aesthetically pleasing, durable, light-weight, nonirritating, retentive, and financially feasible. With advances in prosthesis material, computer modeling, and the ability to create highly

Fig. 2 Patient status-post orbital exenteration with autologous free flap reconstruction and orbital prosthesis, secured by adhesive. His appearance wearing the prosthesis is shown with and without flash photography.

Fig. 3 Patient status-post orbital exenteration with autologous free flap reconstruction and prosthesis wear. The prosthesis is secured by adhesives and is shown with and without glasses worn over it.

detailed patient-specific models, many prostheses can provide better function than autologous tissue.¹ PMMA resin is a noninvasive prosthetic material that is tolerated well by human tissue, is aesthetic, comfortable, relatively easy to make, and relatively cheap. It is more rigid than silicone prosthetics, however, and lacks translucency.¹⁵ Silicone, by contrast, is very flexible and can be stretched to translucency to allow better aesthetic blending with normal surrounding tissues.¹ All materials are subject to wear and tear over time and will need replacement after several months to years.

Osseointegrated versus Adhesive

There are implant-associated prostheses and free prostheses that are secured with adhesives (►Figs. 1–3) or to a pair of glasses.^{4,10} Prosthetics that attach to an implant typically have greater stability, less skin irritation and required care, do not need adhesives to stay in place, and can last longer than traditional prostheses; an adhesive prosthesis can be expected to last 1 to 3 years, while bone-anchored prostheses can last 3 to 5 years.^{16,17} Larger defects are typically best reconstructed with prostheses secured via osseointegrated implants, as they much more securely hold the prosthetic in place. However, bone-anchored prostheses are often expensive and uncovered by insurance plans.⁴ Bone-anchored implants can be stabilized on the orbital rim, nasal bones, and zygomatic arch, and can have a “bar-clip,” “ball-type,” or magnetic retention mechan-

isms (►Fig. 4). Problems arise with osseointegrated implants due to poor bone stock, radiated bone, and the need for more surgical procedures in the process of rehabilitation compared to adhesive-secured prostheses.¹⁸ Spectacle-retained prosthetics are the easiest to construct and the cheapest to make, but they provide the poorest aesthetic result.¹⁰

Postoperative Considerations

At least annual follow-up is necessary to evaluate the tissue bed, evaluate for recurrence in the case of neoplasm, and to polish the ocular prosthesis.⁴ Patients will need to remove and clean prostheses on a daily basis. While a prosthesis should last anywhere from 1 to 5 years, some reports suggest patients need their prostheses renewed as often as every 6 to 9 months due to changes in color, changes in the defect anatomy, and degradation of the edges of the prosthesis. Indeed, use of adhesives, routine cleaning, air pollution, and ultraviolet light exposure can all contribute to gradual degradation of color and marginal integrity of a prosthesis.¹⁵

Conclusion

Orbital and craniomaxillofacial defects, in general, are best approached preoperatively by a multidisciplinary team with a clear reconstructive plan in place. Reconstruction of orbital

Fig. 4 Patient status-post orbital exenteration with skin graft reconstruction, placement of three posts around the orbital rim, and final reconstruction with an orbital prosthesis, secured in place by the osseointegrated posts.

injuries with orbital implants and prostheses can lead to acceptable aesthetic outcomes. Orbital implants can be porous or nonporous. Porous implants often do not require wrapping and can accommodate a peg for improved motility. Nonporous implants are cheaper, overall, and still provide excellent globe motility. Orbital prostheses can be used in place of local, regional, or free flap reconstruction or in addition to other reconstructive procedures. They can be secured with adhesives or via osseointegrated posts. Typically, adhesive-secured prostheses will need to be replaced more often than post-secured prostheses, though all prosthetics will need daily maintenance by the wearer and annual touch-ups to correct regular wear-and-tear. Orbital implants and prostheses can restore a degree of cosmetic normality to patients and should be included and considered in the reconstructive algorithm of complex orbital injuries.

Conflict of Interest

None declared.

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