Digital imaging in the fabrication of ocular prostheses

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Several ocular and orbital disorders require surgical intervention that may result in ocular defects. The associated psychological effect of these defects on the patient requires immediate management and rehabilitation intervention by a team of specialists. The role of the maxillofacial prosthodontist in fabricating an ocular prosthesis with acceptable esthetics to restore facial symmetry and normal appearance for the anophthalmic patient becomes essential. This article presents a technique for fabricating ocular prostheses using the advantages of digital photography. (J Prosthet Dent 2006;95:327-30.)

The unfortunate loss or absence of an eye may be caused by a congenital defect, irreparable trauma, tumor, a painful blind eye, sympathetic ophthalmia, or the need for histologic confirmation of a suspected diagnosis.[1] Depending on the severity of the situation, the surgical management may include one of 3 approaches: evisceration, enucleation, or exenteration. Evisceration is the surgical procedure wherein the intraocular contents of the globe are removed, leaving the sclera, Tenon's capsule, conjunctiva, extraocular muscles, and optic nerve undisturbed; the cornea may be retained or excised.[2] Enucleation is the surgical removal of the globe and a portion of the optic nerve from the orbit.[2] The choice between evisceration and enucleation may be difficult, because the indications for each operation are not always clearly defined. Enucleation is often considered the treatment of choice for primary intraocular malignancies because it permits histopathologic examination of the intact globe, as well as determination of intraneural or extrascleral spread of the disease.[2] Orbital exenteration is the en bloc removal of the entire orbit, usually involving partial or total removal of the eyelids, and is performed primarily for eradication of malignant orbital tumor.[2]

The disfigurement associated with the loss of an eye can cause significant physical and emotional problems.[3] Most patients experience significant stress, due primarily to adjusting to the functional disability caused by the eye loss, and to societal reactions to the facial impairment. Replacement of the lost eye as soon as possible after healing from eye removal is necessary to promote physical and psychological healing for the patient and to improve social acceptance. A multidisciplinary management and team approach are essential in providing accurate and effective rehabilitation and follow-up care for the patient. Therefore, the combined efforts of the ophthalmologist, the plastic surgeon, and the maxillofacial prosthodontist are essential to restore the patient's quality of life.

The importance of an ocular prosthesis with acceptable esthetics and reasonable motility in restoring normal appearance in patients with anophthalmia has long been recognized. Anecdotal reports and relics from ancient civilizations indicate that the restoration of ocular defects may have existed for thousands of years. The earliest known examples of restorations date to the Fourth Dynasty (2613-2494 B.C.) in Egypt; excavation of tombs provided evidence of eye replacement by using precious stones, earthenware, enameled bronze, copper, and gold in the shrunken sockets.[4] In the 16th century, Paré fabricated an ocular prosthesis ("emblepharon") made of gold or silver.[5] Paré also used glass and porcelain for eyes, which was a great step forward and resulted in the use of the shell type of pattern rather than spheres.[6] Glass remained the most popular material until the advent of World War II, when it was difficult to obtain glass or glass eyes from Germany. Methyl methacrylate, which had already replaced vulcanite as a denture base material, seemed to be a good replacement material. A definitive technique for fabricating artificial eyes using acrylic resin was developed by the United States Naval Dental and Medical Schools and was published in 1944.[7] Unlike glass eyes, the acrylic resin eyes were solid. The material was lightweight, easy to fit and adjust, unbreakable, translucent, easily fabricated, had intrinsic and extrinsic coloring capabilities, and was inert to the socket secretions.[6] The dental-prosthetic influence in the development of this prosthesis accounts for the ocular prosthesis being fitted from an impression of the eye socket rather than by the traditional empirical method.[8]

Several techniques have been used in fitting and fabricating artificial eyes. Empirically fitting a stock eye, modifying a stock eye by making an impression of the ocular defect,[9] and the custom eye technique[10] are the most commonly used techniques. The fabrication of a custom acrylic resin eye provides more esthetic and precise results because an impression establishes the defect contours, and the iris and the sclera are custom

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Fig. 1. Digital photograph of patient's iris.

Fig. 2. Ocular button positioned on paper iris using monopoly syrup.

fabricated and painted. An impression of the anophthalmic socket is made with an ophthalmic irreversible hydrocolloid (J-603 Special Formula Alginate; Factor II Inc, Lakeside, Ariz), using a stock acrylic resin tray designed for ophthalmic impressions (Factor II). Trays are available in different sizes and have a hollow handle that facilitates the injection of the irreversible hydrocolloid into the socket through the seated tray. The impression is poured in 2 sections using dental stone, and a wax (Truwax Baseplate Wax; Dentsply Intl, York, Pa) pattern is sculpted onto the definitive cast. The wax pattern is placed into the defect and evaluated for esthetics and comfort. In addition, the iris plane and pupil point are evaluated. In the finished sculpting, the eye contours and lid configurations should resemble the natural eye of the patient, and the eyelids should close completely over the wax pattern. The iris is painted on the ocular disk using oil paints (Grumbacher Pre-Tested Artists' Oil Colors; Sanford Corp, Oak Brook, Ill) mixed into a polymethyl methacrylate painting medium (J-570-8 Monomer Non-Crosslinked; Factor II Inc). The ocular disk assembly is evaluated, and the ocular button (Factor II Inc) is attached with monopoly syrup (J-305 Monopoly Syrup; Factor II Inc). Another trial insertion with the patient is then necessary to verify the contours of the completed wax pattern and the disk assembly. The prosthesis is processed using the selected scleral acrylic resin (Factor II Inc) under compression. The acrylic resin is bench polymerized for 5 minutes, placed in a water bath at 150°F for 5 minutes, and then placed in the boiling tank at 200°F or higher for 30 minutes. After processing, the flask is cooled and the ocular prosthesis is removed from the mold. The stalk of the ocular button, flash, and irregularities are removed from the surface. The anterior scleral curvature of the prosthesis is reduced approximately 1 mm to allow for sclera characterization and for application of clear acrylic resin (Factor II Inc) to regain the contours of the finished prosthesis. Red silk fibers are used to replicate the veins, and the sclera is recoated with monopoly. The prosthesis is ready for final processing using clear acrylic resin following the previously described times and temperatures. After the eye is recovered from the flask, flash and irregularities are removed. The prosthesis is smoothed and polished with flour of pumice.

Several variations of this technique exist using different ovens, different processing times, and different methods of assembling the parts of the prosthesis.[11] This article describes the use of digital photography to simplify the process of painting the iris disk.

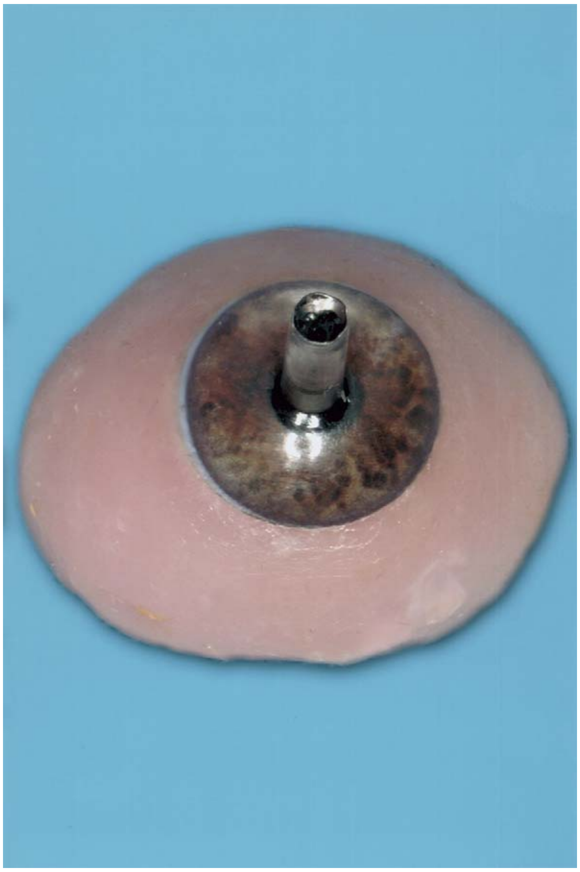

Fig. 3. Disk assembly attached to wax pattern and ready for trial insertion.

TECHNIQUE

1. Make an impression of the anophthalmic socket with a stock acrylic resin tray designed for ophthalmic impressions (Factor II Inc) using the ophthalmic irreversible hydrocolloid (J-603 Special Formula Alginate; Factor II Inc). Pour a master cast and fabricate a wax pattern using baseplate wax (Truwax Baseplate Wax; Dentsply Intl, York, Pa).
2. Evaluate the wax pattern in the patient, and evaluate and finalize the sculpting following the eye socket contours and lids configuration.
3. Make a digital photograph of the patient's iris (Fig. 1) using a digital camera (Canon EOS Digital Rebel; Canon Inc, Tokyo, Japan) with a macro lens (Canon Macro Lens EF 100 mm f/2.8 USM; Canon Inc) and a ring flash (Canon Macro Ring Lite Flash MR-14EX; Canon Inc) attached. Set the shutter speed to 125 seconds, the aperture to F 16, and the sensitivity to ISO 640.
4. Evaluate the photograph and compare it to the patient's iris. Using graphics software (Photoshop 7.0; Adobe Systems Inc, San Jose, Calif), adjust for slight differences in color, brightness, contrast, or hue, and format the image. If necessary, perform further customization and color modifications using professional quality color pencils (Prismacolor; Sanford Corp), which feature soft, thick lead. Print the final image on 20-lb white paper with brightness 87 (HP Office; Hewlett-Packard, Palo Alto, Calif) using a laser printer (HP Deskjet 950C; Hewlett-Packard) with a color-ink print cartridge (HP No. 78 Tri-color Inkjet Print Cartridge; Hewlett-Packard).
5. Cover the paper iris with 3 light coats of water-resistant spray (Workable Fixatif; Krylon, Solon, Ohio) used for artwork, and attach it to the ocular disk. Use monopoly syrup (J-305 Monopoly Syrup; Factor II Inc) to position the ocular button (Factor II Inc) on the iris, and paint around the edges of the button and the disk to achieve maximum seal (Fig. 2).
6. Attach the disk assembly to the wax pattern (Fig. 3), and evaluate it in the patient. Process the selected scleral acrylic resin at the same temperatures, using the procedure previously described for the conventional technique.
7. After characterization is added, reprocess the ocular prosthesis with clear acrylic (Factor II Inc) using the previously described temperatures. Pumice and polish the completed eye and insert it (Fig. 4).

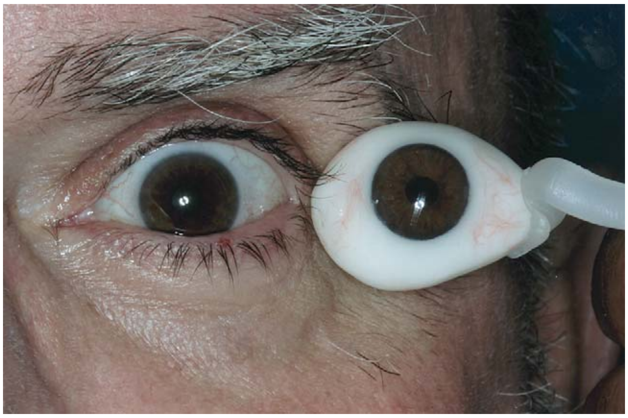

Fig. 4. Completed ocular prosthesis matching patient's iris.

DISCUSSION

Using digital imaging in the fabrication of the ocular prostheses presents several advantages compared to the conventional oil paint and monopoly iris painting technique. The digital image provides acceptable esthetic results because it closely replicates the patient's iris with minimal color adjustments and modifications. The described technique is simple, decreases treatment time, and requires minimal artistic skills, which are necessary in the iris painting technique. However, special digital photography equipment and settings, as well as computer software that allows for image adjustments, are required.

The reproducibility of results requires further investigation. Variables found include the quality of the paper used, the printer inks, and the amount of monopoly syrup added to attach the ocular button to the disk assembly. Further research is necessary to evaluate the long-term color stability and aging of these ocular prostheses.

SUMMARY

Ocular prostheses have a long history of successful use, and variations of the techniques and materials used have been introduced throughout the years. In the technique described, digital photography is used to replicate the iris of the patient, replacing the conventional oil paint and monopoly iris painting technique. Advantages such as reduced treatment time and increased simplicity make this method an alternative for fabricating ocular prostheses.

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