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DENTAL TECHNIQUE

Semiautomated fabrication of a custom orbital prosthesis with 3-dimensional printing technology

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ABSTRACT

The fabrication of orbital prostheses is complex and time-consuming. A virtual orbital prosthesis and its negative mold are presented by using a 3D printer. This method avoids damage to the soft tissue or patient discomfort and reduces the time and skill required to fabricate a custom orbital prosthesis. (J Prosthet Dent 2019;122:494-7)

Exenteration is a surgical procedure that involves removing the entire ocular and orbital contents.[1] Surgical removal of an eye is inevitable in circumstances such as irreparable trauma, malignant orbital tumors, or sympathetic ophthalmia. An orbital prosthesis is used to reconstruct the facial features of patients whose orbit has been partially or totally removed after eye surgery.[2] The conventional fabrication method uses an impression[3-5] that can deform the soft tissue and cause discomfort. Conventional fabrication methods depend on the experience of the clinician and are complex and time-consuming. Recently, 3D printing technology has been introduced in the medical field[6-10] and has been applied to the fabrication of orbital prostheses.[11] There is scope for further development.

In this report, a semiautomated, custom process was developed for fabricating orbital prostheses by using computer-aided design (CAD) and 3D printing technology. The process overcame the disadvantages of traditional orbital prosthesis manufacturing, such as the reliance on a skilled ocularist, long manufacturing times, and high costs.

TECHNIQUE

1. Scan the patient's face by using a portable scanner (cara Scan 3.2; Kulzer GmbH) to obtain 3D data of the face.
2. Determine the midplane of the face by identifying the nasion and pronasale by using a CAD software program (ZBrush 4R7; Pixologic) and automatically mirror the healthy side of the patient's face to the defect side by mirror image technology
3. Measure the distance from the midline to the medial and lateral canthus and the distance from the midline to the pupil. Complete the boundary of the orbital prosthesis manually by moving it until the mirrored model on the defect side matches the structure of the face (Fig. 1).
4. Obtain 3D data of the patient's ocular prosthesis made by the ocularist by using the same portable scanner. To facilitate assembly, increase the size of the eye prosthesis by 1% to 2% and draw the iris diameter and pupil image (Fig. 2A). Establish the proper position of the ocular prosthesis by manually moving it while measuring the distance from the horizon to the upper limit of the iris (Fig. 2B).
5. Place an interim orbital prosthesis in the facial 3D data. Manually move the position of the ocular prosthesis until both irises are symmetrical with respect to the midline on the front side and until

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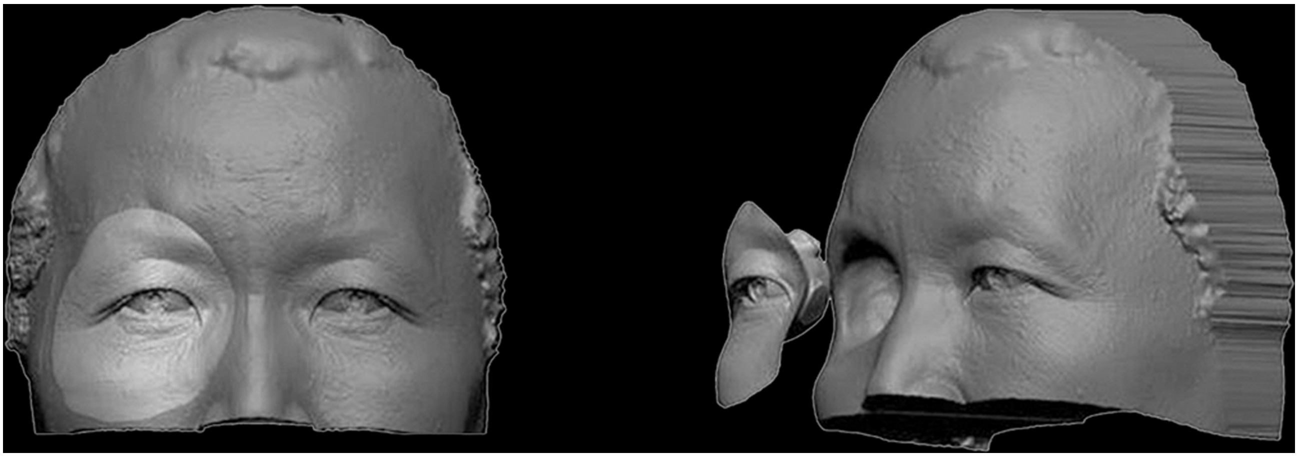

Figure 1. After mirroring healthy side to defect side based on midplane of face, boundary of virtual orbital prosthesis determined.

the distance of the degree of ocular prosthesis protrusion on the side is parallel. Make sure that the boundary of the virtual orbital prosthesis is not irregular and that the centers of both irises are aligned horizontally. Complete the virtual orbital prosthesis data by subtracting the ocular prosthesis 3D data from the virtual orbital prosthesis and save it as a standard tessellation language (STL) file (Fig. 2C).

6. Import the cylinder shape to make a negative mold. After the interim orbital prosthesis is placed on the cylinder shape, obtain the lower and upper pieces according to the flexion of the interim orbital prosthesis (Fig. 3A).
7. To prevent the material from flowing out of the mold, create a circular groove at the edge of the negative mold. Design a large hole in the middle of the upper piece for material injection and more holes on both sides to reduce the air bubbles generated when injecting the material. To connect the upper and lower pieces when assembled, attach a cube-like fixing structure to both sides of the frame (Fig. 3B, 3C).
8. Using a digital light projector (DLP) 3D printer (IM-96; Carima) with a biocompatible photopolymer resin (FotoTec DLP.A; Dreve Inc), print the lower and upper pieces of the negative mold (Fig. 4).
9. After assembling the upper and lower pieces, pour the mixture of temperature vulcanizing silicone (Multisil-Epithetik; bredent GmbH & Co KG) and intrinsic color pigments (Intrinsic coloring kit; Factor II, Inc) matching the patient's skin color through the hole in the upper piece. Remove the air bubbles that may be generated during the injection of silicone by using a deformer (Bubble Remover; SEKI Industry).
10. After the medical silicone has polymerized, remove the unwanted silicone edge of the orbital prosthesis and insert the ocular prosthesis (Fig. 5).
11. Finally, sculpt details such as wrinkles and surface textures and add extrinsic staining in the conventional way.[12]

DISCUSSION

Three-dimensional scanning and printing technology can be used to fabricate an orbital prosthesis. This technological process requires a 3D scanner and a 3D printer. The problems caused by the alginate used to create the defect-side impression in traditional manufacturing methods can be eliminated by scanning a facial shape by using a 3D scanner. To design a personalized orbital prosthesis, it is important to align the face's symmetry and orbital prosthesis boundary. Once the patient's 3D data are stored, the orbital prosthesis can be remanufactured as needed, minimizing inconvenience to the patient. The semiautomated method proposed in this report can reduce manufacturing time.

An orbital defect covered by a free flap is not ideal for wearing a prosthesis, whether produced by conventional or 3D printing manufacturing, because the prosthesis cannot be retained or attached to the defect effectively. Orbital prostheses are not indicated in patients with poor wound healing of the defect and in case of infection; this applies to both conventional and 3D printing manufacturing.

A current limitation of the process is the need to fabricate the orbital prosthesis by injecting silicone into a negative mold because few silicone-based biocompatible materials are available for 3D printing. However, 3D

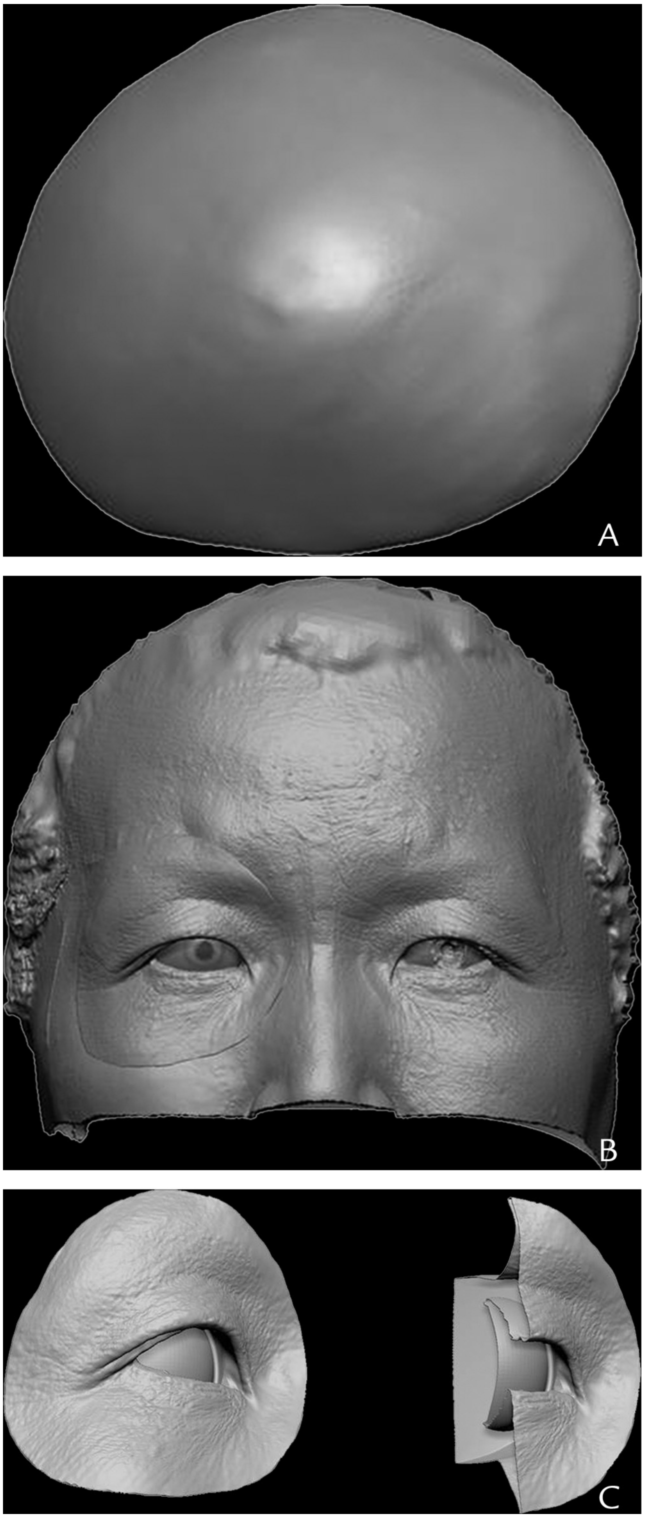

Figure 2. A, Ocular prosthesis 3D data obtained by using portable scanner. B, Centering iris symmetrically with respect to healthy side. C, Design of virtual orbital prosthesis including space where ocular prosthesis placed.

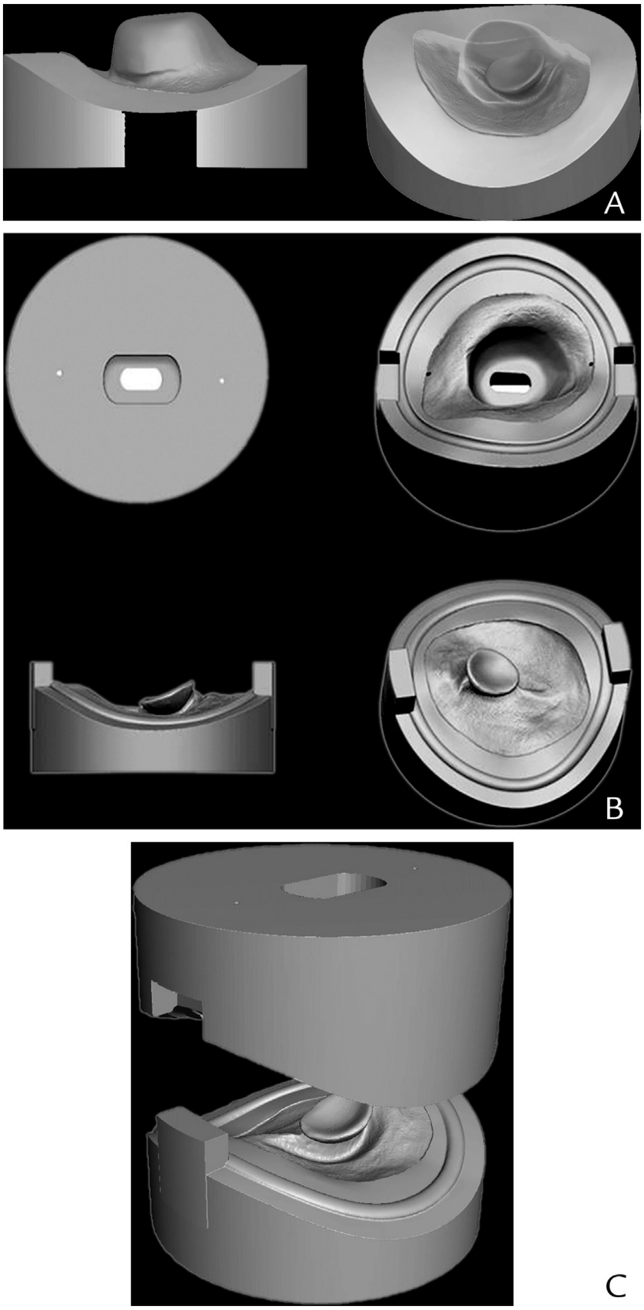

Figure 3. A, Cylinder interface designed from contour of virtual orbital prosthesis. B, Negative molds designed with silicone inlets, holes to remove bubbles, and inlets to prevent silicone overflow. C, Assembly of 2 parts of mold.

printing technology is developing rapidly, and soon, it will be possible to produce a variety of silicone orbital prostheses in various colors.

SUMMARY

A negative mold was designed and then 3D printed with a biocompatible resin. The orbital prosthesis was then fabricated by injecting biocompatible silicone material into the mold cavity. This method replaces most of the conventional process steps with a quick and precise automated process and does not damage the soft tissue or cause discomfort.

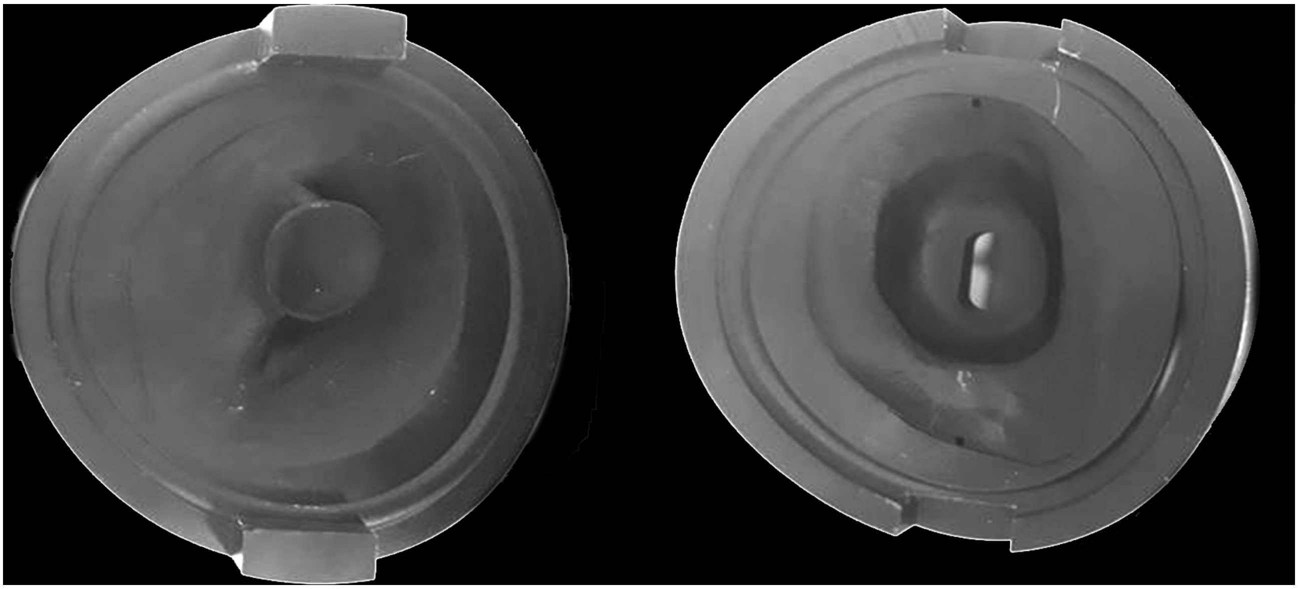

Figure 4. Negative mold of orbital prosthesis printed by using 3D printer.

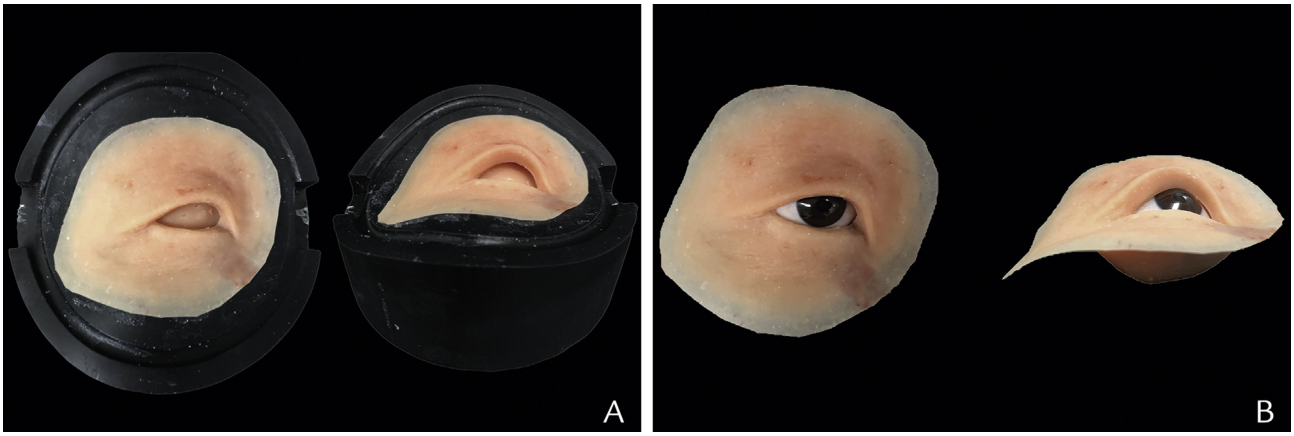

Figure 5. A, Lower piece (drag) removed from upper piece of mold (cope) and excess silicone removed. B, Orbital prosthesis with ocular prosthesis inserted.

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