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DENTAL TECHNIQUE

Combined use of a facial scanner and an intraoral scanner to acquire a digital scan for the fabrication of an orbital prosthesis

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ABSTRACT

For a patient with a unilateral orbital defect, an esthetic orbital prosthesis plays an essential role in enhancing quality of life. This technique describes the combined use of a facial scanner and an intraoral scanner to acquire the digital scan for the design and fabrication of an orbital prosthesis. The method results in an esthetic prosthesis with accurate skin texture reproduction. (J Prosthet Dent 2019;121:531-4)

Computer-aided design and computer-aided manufacturing (CAD-CAM) has been used in the fabrication of facial prostheses. The workflow for this treatment includes acquiring data on the patient anatomy, digital design, and additive manufacturing.[1] This approach offers advantages over the traditional method, as digital scanning is nonintrusive and design processes can be saved for future reproduction. This method has been used in the prosthetic rehabilitation of orbital,[2,3] nasal,[1] and auricular[4] defects.

The 3-dimensional (3D) data of patients are the foundation for the construction of facial prostheses. Facial data are typically acquired by using stereophotogrammetry, laser scanning, or computed tomography. These methods provide the gross facial topography and facilitate manual sculpture. However, the precision of detailed skin textures such as eyelids, wrinkles, and pores is limited, and sculpture of these detailed skin textures is still needed. In addition, laser light presents a hazard to the eyes and computed tomography has radiobiologic risks.[5] A more precise, safer, and more convenient way to capture 3D facial topography is needed. Intraoral scanners are used for capturing optical scans in dentistry and their accuracy is clinically satisfactory. Considering their accuracy and portability, intraoral scanners may be used to acquire detailed surface texture for facial prostheses.

This article describes the combined use of a face capture system (3dMDface System; 3dMD) and an intraoral scanner (TRIOS 2.0; 3Shape) to acquire the surface data of a patient with an orbital defect for the design and fabrication of an adhesive-retained orbital prosthesis.

TECHNIQUE

1. Acquire the facial topography by using the face capture system. Position the patient upright with the healthy eye open to acquire the facial data (Fig. 1).
2. Acquire the topography of the healthy eye by using the intraoral scanner. Use a light-proof contact lens (Realcon Color 40; Realcon) to protect the eye from

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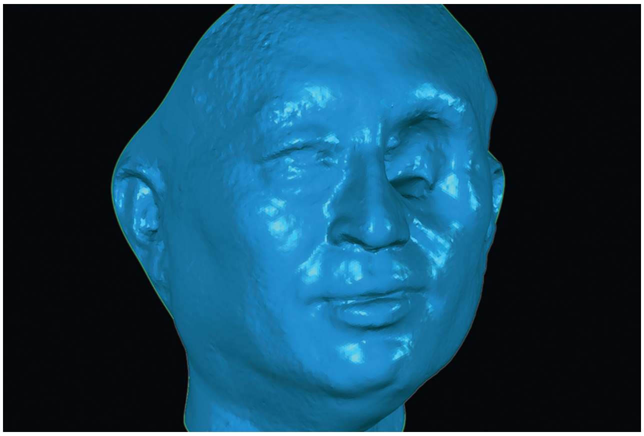

Figure 1. Three-dimensional facial image acquired with face capture system.

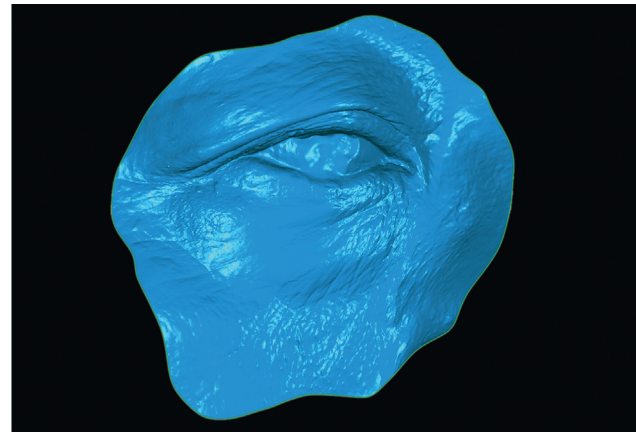

Figure 2. Three-dimensional image of healthy eye acquired with intraoral scanner.

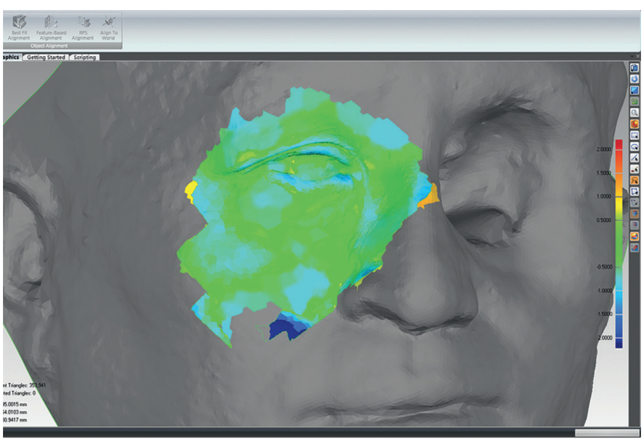

Figure 3. Matching of 2 scans.

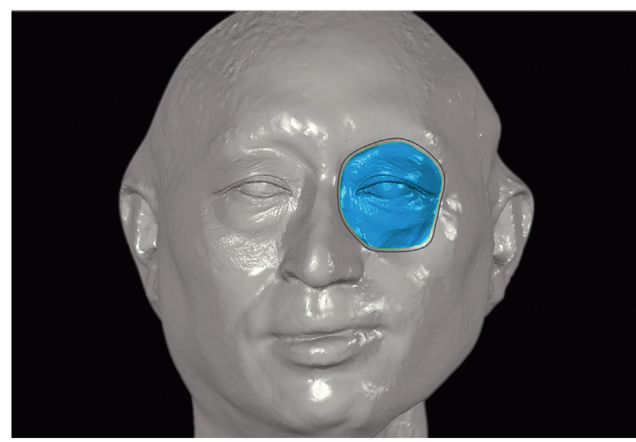

Figure 4. Mirroring healthy eye. Black circle indicates margins of prosthesis.

the light of the scanner. Gradually slide the scanner over the healthy eye and around the area (Fig. 2).

3. Match the 2 scans. Save the data as standard tessellation language (STL) files and import them into software (Geomagic Studio 2014; Geomagic Inc). Choose the optimal matching according to the color-coded deviation map. In the matching area, replace the data acquired by the facial scanner with the data acquired by the intraoral scanner (Fig. 3).
4. Locate the iris. Select a digital ocular model from a digital ocular prosthesis database.[2] Fit the ocular model in the healthy eye. Design a locating cylinder and vertically attach it on the pupil region to indicate the position of the iris.
5. Make the digital model. Separate and mirror the 3D model of the healthy eye using the facial median sagittal plane. Adjust the mirrored part to get the best symmetry with the contralateral facial morphology. Adapt the margins to the resection contour and remove the other part (Fig. 4). Fill the defect hole and deform it until the distance to the bottom of the ocular model is approximately 2 mm. Stitch the margins of the mirrored eye with the margins of the defect to make the digital model of the prosthesis.
6. Design the negative mold. Expand the margin of the prosthesis outward by 3 mm. Extrude the border forward by 20 mm and close the bottom to make the cope. There would be a hole for the locating cylinder in the pupil region to locate the ocular mold. Duplicate the expanded area and stitch it with the internal surface. Extrude the border backward by 10 mm and close the bottom to make the drag (Fig. 5). Fabricate the negative mold with a polyamide (PA2200; EOS) by using a 3D printer (EOS P500; EOS).
7. Fabricate the prosthesis. Make the silicone prosthesis with the negative mold using routine procedures (A-2000 A&B KIT; Factor II Inc) (Fig. 6). Use intrinsic and extrinsic coloration to match the appearance to that of the patient (Fig. 7). Trim the excess flash and deliver the orbital prosthesis to the patient (Fig. 8).

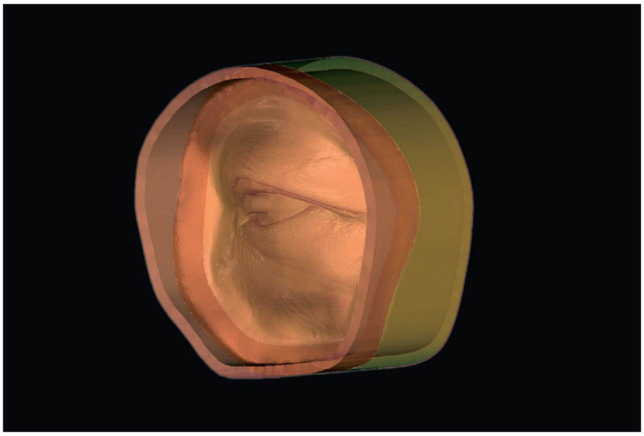

Figure 5. Two-piece digital negative mold.

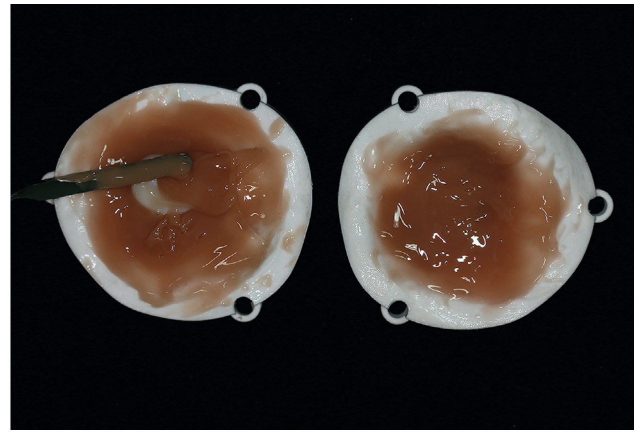

Figure 6. Placing silicone with ocular mold in negative mold.

Figure 7. Silicone prosthesis with intrinsic and extrinsic coloration. Structures of eyelid and wrinkles are reproduced.

Figure 8. Patient with definitive silicone prosthesis.

DISCUSSION

The advantage of this method is that it provides both the overall facial topography and the details of the healthy eye. The details scanned by the intraoral scanner could reach the accuracy needed to reproduce skin surface textures. In addition, the use of a 3D printer to make the negative mold could retain these structures. Moreover, additional manual sculpture is not necessary in this workflow. The present technique can be clinically applied to the restoration of a unilateral eye or auricular defect.

However, there is a difference between intraoral scanning and facial surface scanning. For intraoral scanning, the lost alignment can be regained by moving to the occlusal surface. The facial topography is flatter than teeth and thus regaining the lost alignment is difficult. Additional reference structures as fiducial points[6] could be used in the scanning.

A limitation of this technique is that a stock ocular prosthesis was used. A custom-made ocular prosthesis that duplicates the exact dimensions and position of the iris of the healthy eye for such a patient will lead to a more esthetic result. In addition, many centers have difficulties in digitally designing prostheses. User-friendly software for the design of maxillofacial prostheses should be developed to popularize this fabrication process.

SUMMARY

The present article introduces an optical scanning method for the fabrication of orbital prostheses. The 3D digital scanning was performed in 3 steps: a scan of the face by using a facial scanner, a scan of the unaffected orbit with an intraoral scanner, and matching of the 2 scans. This method along with 3D printing resulted in an excellent prosthetic outcome and saves time and labor compared with the conventional method.

REFERENCES

1. Eggbeer D, Bibb R, Evans P, Ji L. Evaluation of direct and indirect additive manufacture of maxillofacial prostheses. Proc Inst Mech Eng H 2012;226:718-28.

2. Bi Y, Wu S, Zhao Y, Bai S. A new method for fabricating orbital prosthesis with a CAD/CAM negative mold. J Prosthet Dent 2013;110:424-8.
3. Chiu M, Hong SC, Wilson G. Digital fabrication of orbital prosthesis mold using 3D photography and computer-aided design. Graefes Arch Clin Exp Ophthalmol 2017;255:425-6.
4. Bai SZ, Feng ZH, Gao R, Dong Y, Bi YP, Wu GF, et al. Development and application of a rapid rehabilitation system for reconstruction of maxillofacial soft-tissue defects related to war and traumatic injuries. Mil Med Res 2014;1:11.
5. Runte C, Dirksen D, Delere H, Thomas C, Runte B, Meyer U, et al. Optical data acquisition for computer-assisted design of facial prostheses. Int J Prosthodont 2002;15:129-32.
6. Unkovskiy A, Spintzyk S, Axmann D, Engel EM, Weber H, Huettig F. Additive manufacturing: a comparative analysis of dimensional accuracy and skin texture reproduction of auricular prostheses replicas. J Prosthodont 2019;28:e460-8.

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Noteworthy Abstracts of the Current Literature

Translational research on clinically failed zirconia implants

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Objectives. To provide fractographic analysis of clinically fractured zirconia implants recovered with their cemented crown. To calculate bending moments, corresponding stress and crack onset location on the implant's fracture surface using a mathematical model integrating spatial coordinates of the crown-implant part and occlusal loading obtained from 2D and 3D images.

Methods. 15 fractured zirconia implants parts (11 posterior and 4 anterior) with their all-ceramic crowns still cemented on it were recovered. The implants were first generations from four manufacturers (AXIS Biodental, Z-Systems, Straumann, Swiss Dental Solutions). The time-to-failure varied between 2weeks and 9years. Fractography was performed identifying the failure origin and characteristic surface crack features. From 2D and 3D digital images of the crown-implant part, spatial coordinates anchoring the crown's occlusal contacts with the implant's central axis and reference plane were integrated in a mathematical model spreadsheet. Loads of 500 N in total were selectively distributed over identified occlusal contacts from wear patterns. The resultant bending and torsion moments, corresponding shear, tensile, maximum principal stress and von Mises stress were calculated. The fracture crack onset location on the implant's fracture surface was given by an angular position with respect to an occlusal reference and compared with the location of the fracture origin identified from fractographic analysis.

Results. Implants fractured from the periphery of the smaller inner diameter between two threads at the bone-entrance level except for one implant which failed half-way within the bone. The porous coating (AXIS Biodental) and the large grit alumina sandblasting (Z-System) created surface defects directly related to the fracture origin. The model spreadsheet showed how occlusal loading with respect to the implant's central axis affects bending moments and crack onset. Dominant loads distributed on contacts with important wear pattern provided a calculated crack onset location in good agreement with the fractographic findings of the fracture origin.

Significance. Recovered broken zirconia implant parts with their restorative crowns can provide not only information regarding the failure origin using fractography but also knowledge regarding occlusal crown loading with respect to the implant's axis. The mathematical model was helpful in showing how occlusal loading affects the location of the fracture initiation site on clinical zirconia implant fracture cases.