A technique to produce a mirror-image wax pattern of an ear using rapid prototyping technology

Majd Al Mardini, DDS,[a] Carlo Ercoli, DDS,[b] and Gerald N. Graser, DDS, MS[c]
University of Rochester Eastman Dental Center, Rochester, NY

This article describes the use of computer-aided techniques to produce a wax pattern of a missing ear. A 3-dimensional (3-D) computer model of a conventional cast from a patient was obtained using an optical surface capture device (scanner). The 3-D computer model was inverted, using computer-aided design software. A physical thermoplastic (wax) pattern of the inverted 3-D cast was produced using a rapid prototyping (RP) machine. (J Prosthet Dent 2005;94:195-8.)

Several methods have been used to fabricate an auricular prosthesis when a preoperative cast is not available.[1-5] These methods include the following: (1) using the "donor technique," in which a relative or a person with ear contours that closely mimic those of the patient acts as the donor to make an ear impression[1]; (2) dividing the cast of the remaining ear into small squares to facilitate sculpting the missing ear[1]; (3) using image-editing software (Adobe PhotoShop 7; Adobe Systems Inc, San Jose, Calif) to assist in sculpting of the prosthesis[2]; (4) using a color slide[3]; (5) obtaining a mirror image of the cast of the patient's remaining ear, using transparent sheets and a copy machine to aid in the sculpting process[4]; and (6) sectioning the wax pattern of the opposite ear, using a wax saw, into 1-mm-thick slices, then reversing each section and placing it on top of the previous one to create a mirror image of the original pattern.[2] Although some of these methods are rather simplistic, matching and sculpting the symmetrical morphology of the remaining ear remains a challenge.

Computer-aided design and manufacture CAD/CAM techniques have recently been introduced in the field of maxillofacial prosthetics.[6-12] This technology may become the standard for fabricating maxillofacial prostheses.[6-8] This article describes the methodology to produce a mirror-image wax pattern of an auricular prosthesis, using a cast made from the patient's remaining ear and rapid prototyping (RP) technology.

Fig. 1. Cast of remaining ear.

TECHNIQUE

1. Make an impression of the remaining ear as follows: coat hair adjacent to the ear with petroleum jelly (Vaseline; Chesebrough-Pond's USA Co, Greenwich, Conn), place cotton in the ear canal, and inject irreversible hydrocolloid (Jeltrate Plus; Dentsply Caulk, Milford, Del) using a disposable

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[a]Resident, Division of Prosthodontics.
[b]Assistant Professor and Program Director, Division of Prosthodontics.
[c]Professor and Chair, Division of Prosthodontics.

Fig. 2. 3-D images of remaining ear and mirror image. Image at top right represents mirror image of remaining ear.

Fig. 3. Thermoplastic (wax) pattern of missing ear produced from cast of remaining ear.

syringe (Disposable impression syringes; Henry Shein, Melville, NY) in and around the ear. Place wet gauze squares on top of the impression material prior to setting of the material. Ensure that the squares are not incorporated into the material completely to allow the stone backing to engage the gauze sufficiently. After the impression material sets, add a thin mix of stone (Mountingstone; Whip Mix, Louisville, Ky) on top of the gauze to act as a backing.

2. Pour the impression with ADA Type III dental stone (Quickstone; Whip Mix) to obtain a cast (Fig. 1).
3. Obtain a 3-D computer model of the cast using a 3-D laser scanning system (GeoDigm Corp, Chanhassen, Minn), which was developed to produce a 3-D dental cast known as an ''emodel.''
4. Load the 3-D data points into the scanning system's proprietary emodel software (GeoDigm Corp).
5. Use software tools to filter points in areas that are overscanned, interconnect the remaining points to form a triangular mesh (tessellate), and invert the triangular mesh to produce a 3-D mirror image of the scanned cast (Fig. 2).

Fig. 4. Image of wax pattern and cast of remaining ear projected in front of mirror to explain concept of technique.

6. Output the triangular mesh as a stereolithography (STL) file (STL file format; 3D Systems Inc, Valencia, Calif).
7. Load the inverted STL file into an RP machine (Pattern Master RP machine; Solidscape Inc,

Merrimack, NH) to produce a thermoplastic physical model (Solidscape Inc) (Fig. 3).
8. To produce a plastic physical model (Waterclear 10110 epoxy resin for stereolithography; DSM Somos, New Castle, Del), use an RP machine, such as the SLA 250/40 (3D Systems Inc).
9. Make an impression of the epoxy resin cast using irreversible hydrocolloid (Jeltrate Plus; Dentsply Caulk), then flow wax (Baseplate Wax, NeoWax; Dentsply Intl, York, Pa) into the impression to produce the desired wax pattern.
10. Adapt the margin of the wax pattern on the recipient site and orient the pattern by using marks made with indelible markers (Dr. Thompson's sanitary color transfer applicators; Great Plains Dental Products Co Inc, Kingman, Kan) or by making a facebow transfer.[13]
11. Conventionally process the wax pattern (Fig. 4).[1]

DISCUSSION

The use of RP technology to provide a wax pattern of a missing ear was described. Data from a cast of a remaining ear were collected using a 3-D laser scanning system. The scanner used projects a laser stripe onto the surface of the cast and then processes the images of the laser stripe captured by 2 digital cameras. The cast is then translated and rotated under computer control to expose all surfaces of the cast to the cameras. This scanning process produces a cloud of over 1 million 3-D data points that describe the surface contours of the cast. These data are mirrored and then output as an STL file. STL files are usually used in transferring computer-aided design CAD models to RP technologies. The RP system was used to produce a wax pattern. This system uses a piezoelectric jet technology to produce thermoplastic objects (wax).

Optical laser scanners have been used in conjunction with a computer numerically controlled (CNC) milling machine to prepare a reversed model of a normal ear.[10] The data obtained by the scanner were used by the milling machine to create a movement of a cutter into 3 axes, enabling an ear pattern to be created from a block of expanded polyurethane. Disadvantages of this method include the loss of some information of the ear caused by light reflection from the hair when the hair was covered with a surgical cap. In addition, it was not possible for the vertically projected vertical lines of the laser beam to reach the entire undercut of the internal ear or those behind the helix. This problem was overcome in the new system described in this article (GeoDigm scanning system) by the computer-controlled translated and rotated motion, exposing all surfaces of the cast to the digital cameras.

Computed tomography (CT) imaging[11] and magnetic resonance images (MRI)[9] have been implemented with RP technology also. A disadvantage of CT is that it requires an exposure to a dose of radiation. MRI is a noninvasive alternative to CT but requires an additional step for scanning the remaining ear, increasing the cost of the treatment. Furthermore, the patient must remain motionless during the entire length of scanning.[9] The method described in this article does not require any scanning of the patient's face. It only requires making an impression of the remaining ear.

A recent article by Ciocca et al[12] described a similar technique. The method described in this paper produces a wax pattern rather than an acrylic resin pattern, thus eliminating the need to produce a wax pattern from an impression made of the acrylic resin cast. The method described in this article also uses a more advanced scanner that requires only 1 scan, eliminating the need for 8 random scans to record all of the undercut areas.

SUMMARY

This technique describes an accurate and simple method of obtaining a mirror-image wax pattern of an ear for fabrications of an auricular prosthesis using computer aided technology and rapid prototyping.

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REFERENCES

1. Beumer J, Curtis TA, Marunick MT. Maxillofacial rehabilitation, prosthodontic and surgical considerations. St. Louis: Ishiyaku EuroAmerica; 1996. p. 399-402.
2. Andres CJ, Haug SP. Facial prosthesis fabrication: technical aspects. In: Taylor TD, editor. Clinical maxillofacial prosthodontics. Chicago: Quintessence; 2000. p. 237-40.
3. Shimodaira K, Fukuda H, Kanazawa T, Funakubo T. Technique for superimposing a color slide onto a facial cast to sculpt a facial prosthesis. J Prosthet Dent 1989;62:212-3.
4. Lemon JC, Chambers MS, Wesley PJ, Martin JW. Technique for fabricating a mirror-image prosthetic ear. J Prosthet Dent 1996;75:292-3.
5. Nusinov NS, Gay WD. A method for obtaining the reverse image of an ear. J Prosthet Dent 1980;44:68-71.
6. Reitemeier B, Notni G, Heinze M, Schone C, Schmidt A, Fichtner D. Optical modeling of extraoral defects. J Prosthet Dent 2004;91:80-4.
7. Tsuji M, Noguchi N, Ihara K, Yamashita Y, Shikimori M, Goto M. Fabrication of a maxillofacial prosthesis using a computer-aided design and manufacturing system. J Prosthodont 2004;13:179-83.
8. Williams RJ, Bibb R, Rafik T. A technique for fabricating patterns for removable partial denture frameworks using digitized casts and electronic surveying. J Prosthet Dent 2004;91:85-8.
9. Coward TJ, Watson RM, Wilkinson IC. Fabrication of a wax ear by rapid-process modeling using stereolithography. Int J Prosthodont 1999; 12:20-7.
10. Coward TJ, Watson RM. Use of laser scanning and CAD/CAM systems in the fabrication of auricular prostheses. Quintessence Dent Technol 1997;20:47-54.
11. Watson RM, Coward TJ, Forman GH, Moss JP. Consideration in treatment planning for implant-supported auricular prostheses. Int J Oral Maxillofac Implants 1993;8:688-94.
12. Ciocca L, Scotti R. CAD-CAM generated ear cast by means of a laser scanner and rapid prototyping machine. J Prosthet Dent 2004;92: 591-5.
13. Tanaka Y. Face-bow for orienting ear prostheses. J Prosthet Dent 1977;37: 445-9.

Reprint requests to:
DR MAJD AL MARDINI
625 ELMWOOD AVE.
EDC, PROSTHODONTICS
ROCHESTER, NY 14620
FAX: 585-244-8772
E-MAIL: Majd_AlMardini@URMC.Rochester.edu

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Noteworthy Abstracts of the Current Literature

Immediate loading of single-tooth implants in the posterior region
Abboud M, Koeck B, Stark H, Wahl G, Paillon R. *Int J Oral Maxillofac Implants* 2005;20:61-8.

Purpose: The aim of this study was to evaluate the clinical response and safety of immediately loaded single-tooth implants placed in the posterior region of the maxilla and mandible.
Materials and Methods: Single-tooth implants were placed in healed extraction sites in 20 adult patients. Temporary prefabricated acrylic resin crowns were prepared and adjusted. The crown occlusion was adjusted to obtain minimal contacts in maximum intercuspation. After 6 weeks a ceramometal or all-ceramic crown was cemented. Radiographic and clinical examinations were made at baseline and at 3, 6, and 12 months. Cortical bone response and peri-implant mucosal responses were evaluated.
Results: The marginal bone level at the time of implant placement was preserved. The mean change in marginal bone level was 0.01 mm at 12 months. The mean Periotest value after 360 days was −4. The peri-implant mucosal adaptation to the anatomic form of the provisional crown resulted in a natural esthetic outcome, and a gain in papilla length was observed. One implant failure was recorded because of provisional luting cement impaction.
Discussion: Clinical research has shown that immediate loading is a possible treatment modality. The immediate functional loading of implants placed in this study resulted in bone adaptation to loading. A satisfactory success rate with positive tissue responses was achieved.
Conclusions: The results of this limited investigation indicated that immediate loading of unsplinted single-tooth implants in the posterior region may be a viable treatment option with an esthetic outcome.—*Reprinted with permission of Quintessence Publishing.*