Published online: 2019-09-30

Manufacturing Implant Supported Auricular Prostheses by Rapid Prototyping Techniques

Meltem Ozdemir Karatas[a]
Ebru Demet Cifter[a]
Didem Ozdemir Ozenen[b]
Ali Balik[a]
Erman Bulent Tuncer[a]

ABSTRACT

Maxillofacial prostheses are usually fabricated on the models obtained following the impression procedures. Disadvantages of conventional impression techniques used in production of facial prosthesis are deformation of soft tissues caused by impression material and disturbance of the patient due to.Additionally production of prosthesis by conventional methods takes longer time. Recently, rapid prototyping techniques have been developed for extraoral prosthesis in order to reduce these disadvantages of conventional methods. Rapid prototyping technique has the potential to simplify the procedure and decrease the laboratory work required. It eliminates the need for measurement impression procedures and preparation of wax model to be performed by prosthodontists themselves In the near future this technology will become a standard for fabricating maxillofacial prostheses. (Eur J Dent 2011;5:472-477)

Key words: Rapid prototyping; CAD/CAM; Auricular prosthesis; Extraoral implant.

INTRODUCTION

Auricular defects may be congenitally or occur secondary to trauma or surgical removal of a neoplasm. The treatments of these defects are surgical reconstructions or prosthetic treatments. Although plastic surgery is capable of restoring missing tissues it may not be the ideal choice of treatment because of the complex shape and structure. For restoration of complex organs such as ears, prosthetic restorations may be option to surgical restorations due to the aesthetical success of them.[1,2]

There are various methods for manufacturing an auricular prosthesis. These are (a) hand sculpturing method, (b) impression of a similar ear, and wax modeling with this impression and (c) rapid prototyping techniques.[3,4]

Conventional prosthetic treatment is done by taking the impression with irreversible hydrocolloid or silicone and afterwards forming the model (cast) by using hard dental stone. Wax model is prepared on this cast and final prosthesis is processed with silicone material. This method may discomfort the patient and underlying tissues may distort and cause difference between the cast and

[a] Istanbul University, Faculty of Dentistry, Department of Maxillofacial Prosthodontics, Istanbul, Turkey.
[b] Yeditepe University, Faculty of Dentistry, Department of Pedodontics, Istanbul, Turkey.

Corresponding author: Dr. Meltem Ozdemir Karatas
Istanbul Universitesi, Dishekimligi Fakultesi, Cene-Yuz Protezleri B.D.
Capa, Istanbul, Turkey.
Phone: +90 532 2552197
E-mail: meltemozd@yahoo.com

the patient's tissues. Besides, the conventional method needs more experience and more time for laboratory work.[5,6]

Achievements in computer technology in 1980's made it possible to produce 3 dimensional (3D) models in computer medium by using the images obtained by using computerized tomography, magnetic resonance imaging or laser surface scanners. These procedures have been called as computer aided design (CAD). Computer aided manufacturing (CAM) is production of this 3 dimensional (3D) model by rapid prototyping technology.[7]

Rapid prototyping (RP)

RP consists of two stages. These stages are virtual stage (modelling and simulating) and physical stage (fabrication). Virtual prototyping is formation of model by dynamic and interactive simulation. Process of forming the physical model is formation of 3D physical model by CAD. This process allows the production of geometrically complex shaped models that would be impossible to produce. These models may be used to duplicate the missing organ. Most important disadvantages of this system are requirement of equipments and high cost.[8,9]

Recently, six rapid prototyping technologies can be used to produce anatomic models: (1) Stereolithography which is a layer by layer 3-D model production system in which the model can be produced from various ultra-violet photo-polymerizing resins by laser-fusing, (2) Laminated Object Manufacturing, which creates 3-D models by laminating adhesive coated sheets of paper in which the adhesive is heat-activated by a focused laser beam, (3) Selective Laser Sintering, which selectively fuses thin layers of heat fusible powders such as polycarbonate or glass-filled composite nylon and enables the direct fabrication of wax prototypes for development of facial prostheses that can be sterilized by epoxyethane and recycled, (4) Solid Ground Curing which laser-polymerizes successive layers of resin through a stencil, (5) 3-D Ink-Jet Printing, which selectively deposits binding material through a print head to fuse a thin layer of metallic or ceramic powder to a previously fused layer and then fired in a furnace for sinterizing, and (6) Fused Deposition Modeling, which builds models by depositing layers of molten thermoplastic materials.[7,10,11]

Advantages of CAD/CAM technique are; (1) elimination of disturbance due to the impression material because there is no need to take impression, (2) possibility to form the model by avoiding deformation of the tissue due to the use of techniques that do not require contact such as CT or laser surface scanner (3) possibility to obtain more realistic looking prosthesis because the model is formed from natural tissues, (4) ability to store the models in hard disks, thus requirement of less space for storage. Prosthesis made from silicone lose characteristic properties and color by time, thus they only may be used maximum for two years. Because of this storage of models are very important.[7,12-15]

When compared to all these advantages, only disadvantage of CAD/CAM technique is high cost. Although most of the procedure is performed by the computer, expertise of clinician for application and coloring affects the success of the prosthesis.[14,15]

CASE 1

At the first case, computerized tomography of the skull of a patient who has 2 implants at auricular region was obtained in order to have the model to produce the prosthesis (Figure 1). Adhesion was maximized by soldering bars to the implants used for retention of prosthesis (Figure 2). For this patient ITI (Straumann Inc.) titanium bar and matrixes were used. Afterwards, 3D model was obtained from the data of computerized tomography by the help of a software (Mimics, Materialise Inc.). By the same software reciprocal model of the ear at intact side was taken and adapted to the defected side. Following the saving of model in STL format, output of 3D model was taken by 3D ink-jet printer (Z printer; Z Corp. Inc.). This acrylic model was transformed into wax model by conventional methods, and tried on the patient (Figure 4). No problems observed for the edge fitting for the model and then it is produced from silicone by conventional methods (Figure 5).

CASE 2

At the second case, also computerized tomography of the skull of a patient who has 2 implants at auricular region was obtained as the first case (Figure 6). There were ITI (Straumann Inc.) gold bars and matrixes in this patient (Figure 7). As

Figure 1. ITI implants and titanium parts.

Figure 2. ITI implant abutments with titanium bar and matrix.

Figure 3. 3-D model obtained by 3-D ink-jet printing.

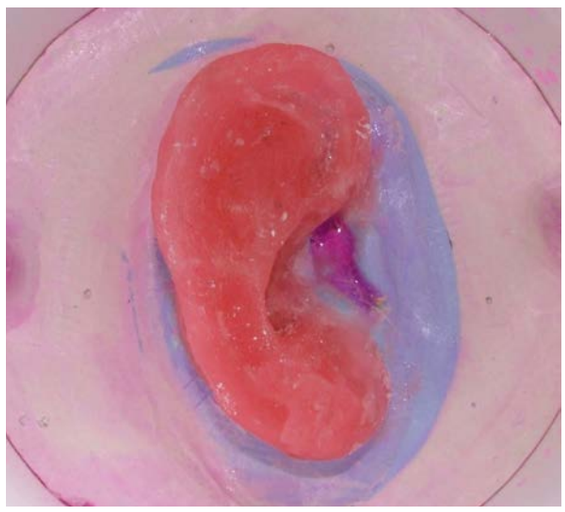

Figure 3. Wax model on mold.

Figure 5. Finished auricular prosthesis.

Figure 6. ITI implants and gold parts.

the first case, CT images are transformed into 3D model by the same software. Reciprocal image of the intact ear was used to form defected ear, it was saved in STL format and three dimensional output is obtained by stereolithography (Perfactory Standard SXGA+, Envisiontec Inc.) (Figure 8). Following the transformation of this acrylic model into wax model and tried on, silicone prosthesis is finished by conventional methods (Figures 9, 10 and 11).

DISCUSSION

Design and fabrication of auricular prosthesis by CAD/CAM techniques are advantageous because a highly skilled technician is not necessary to sculpt the ear. Procedure that allows impres-

Figure 7. ITI implant abutments with gold bar and matrix.

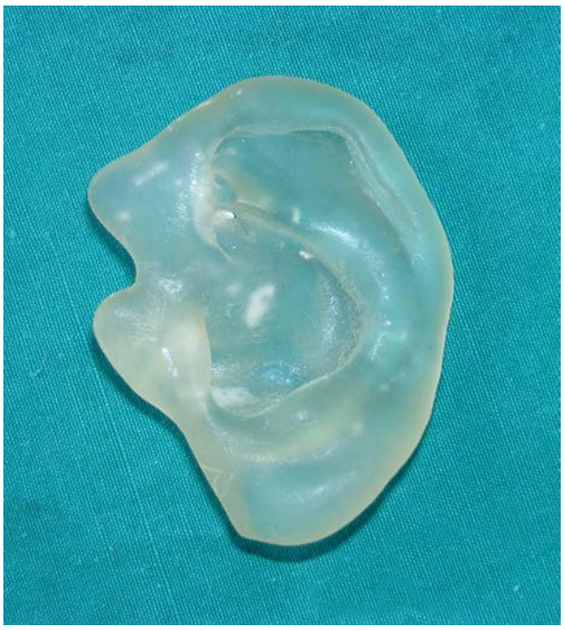

Figure 8. 3-D model obtained by stereolithography.

Figure 9. Stereolithographic model in the impression material.

Figure 10. Stereolithographic model turned into wax.

sion without contact eliminates the errors likely to occur at impression taken by conventional methods. While impression materials used for taking the impression of face, dimensions may cause deformation of the underlying tissue due to their weight, also sensorial stress may cause changes in tissues. The prosthesis produced by CAD/CAM techniques will be more realistic and will maintain good facial harmony. Despite computerized technique seems to be more complicated, finishing of prosthesis takes less time when compared to the conventional methods. Also the digital images and molds can be preserved. This feature is quite important when the need for renewal of the prosthesis for every two years due to the deformation and hardening of the silicone is considered. The only disadvantage of this method is its requirement of expensive equipments and experienced computer software operator.[4,5,14,16,17]

Although there are various rapid prototyping techniques, expensiveness of each promotes the investigators to find cheaper and that has wider field of usage.[12,14]

Besides all, this technology is insufficient for the production of maxillofacial prosthesis. Because taking the output of prosthesis directly from the silicone material is not yet possible and coloring is still a problem for clinicians.

Figure 11. Finished auricular prosthesis.

REFERENCES

1. Bulbulian AH. Facial Prosthesis. Springfield, IL: Charles C. Thomas, 1973.
2. Beumer J, Curtis TA, Marunick MT. Maxillofacial rehabilitation: prosthodontic and surgical considerations. St. Louis: Medico Dental Media Intl; 1996.
3. Lemon JC, Chambers MS, Wesley PJ, Martin JW. Technique for fabricating a mirror-image prosthetic ear. *J Prosthet Dent* 1996;75:292-293.
4. Penkner K, Santler G, Mayer W, Pierer G, Lorenzoni M. Fabricating auricular prostheses using three-dimensional soft tissue models. *J Prosthet Dent* 1999;82:482-484.
5. Chen LH, Tsutsumi S, Iizuka T. A CAD/CAM technique for fabricating facial prostheses: a preliminary report. *Int J Prosthodont* 1997;10:467-472.
6. Bibb R, Freeman P, Brown R, Sugar A, Evans P, Bocca A. An investigation of three-dimensional scanning of human body surfaces and its use in the design and manufacture of prostheses. *Proc Inst Mech Eng [H]* 2000;214:589-594.
7. McGurk M, Amis AA, Potamianos P, Goodger NM. Rapid prototyping techniques for anatomical modelling in medicine. *Ann R Coll Surg Engl* 1997;79:169-174. Review.
8. da Rosa EL, Oleskovicz CF, Aragão BN. Rapid prototyping in maxillofacial surgery and traumatology. *Braz Dent J* 2004;15:243-247. Epub 2005 Mar 18.
9. Petzold R, Zeilhofer HF, Kalender WA. Rapid protyping technology in medicine--basics and applications. *Comput Med Imaging Graph* 1999;23:277-284.
10. Gronet PM, Waskewicz GA, Richardson C. Preformed acrylic cranial implants using fused deposition modeling. *J Prosthet Dent* 2003;90:429-433.
11. Wu G, Zhou B, Bi Y, Zhao Y. Selective laser sintering technology for customized fabrication of facial prostheses. *J Prosthet Dent* 2008;100:56-60.
12. Cheah CM, Chua CK, Tan KH, Teo CK. Integration of laser surface digitizing with CAD/CAM techniques for developing facial prostheses. Part 1: Design and fabrication of prosthesis replicas. *Int J Prosthodont* 2003;16:435-441.
13. Goh JC, Ho NC, Bose K. Principles and applications of Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) technology in orthopaedics. *Ann Acad Med Singapore* 1990;19:706-713.
14. Jiao T, Zhang F, Huang X, Wang C. Design and fabrication of auricular prostheses by CAD/CAM system. *Int J Prosthodont* 2004;17:460-463.
15. Lemaire ED, Upton D, Paialunga J, Martel G, Boucher J. Clinical analysis of a CAD/CAM system for custom seating: a comparison with hand-sculpting methods. *J Rehabil Res Dev* 1996;33:311-320.

16. 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;13:179-183.
17. Nusinov NS, Gay WD. A method for obtaining the reverse image of an ear. *J Prosthet Dent* 1980;44:68-71.