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Hussein El Charkawi Proffesor
Future University in Egypt, helcharkawi@gmail.com

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Digital Fabrication of Attachments for Implant-Anchored Auricular Prosthesis: Case Report

Hussein El Charkawi[a,*]

a. Professor of Prosthodontics, Future University in Egypt

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* Corresponding author.
E-mail address:
helcharkawi@gmail.com
(Hussein El Charkawi).

ABSTRACT

This novel technique, has adopted digital technology to fabricate a customized precision attachment for a patient who has lost his attachment which anchor his implant retained auricular prosthesis. A scanner was used to acquire the ball abutment' geometry of craniofacial implant in the mastoid area. CAD/CAM technology and special software was used to fabricate a customized small PEEK precision attachment that was no longer available in the market. This attachment was picked-up by an auricular prosthesis. The retention qualities of the auricular prosthesis with this attachment was satisfactory for both the patient and the dentist. This novel approach will add to clinicians a technological tool that allow fabrication of custom-made attachment with high retention qualities that is suitable for restorative situations that require fabrication of customized small attachment and yet provide high retention. **Conclusion.** This study used CAD-CAM technology for fabrication of a small custom-made PEEK attachment that retain an implant-retained auricular prostheses. The retentive and esthetic outcome was satisfactory to the patient and dentist. It could be indicated in many restorative situations.

1. INTRODUCTION

The use of craniofacial implant-anchored auricular prosthesis for the rehabilitation of microtia or congenitally missing ear often results in superior cosmetic results with a lesser number of surgical procedures. These prostheses are usually attached to the implants via precision attachments. Despite the high success rates of implant-anchored auricular prosthesis, however, there are several inherent deficiencies within this approach, amongst which is the loss of retention due to wear of the retaining mechanism of these attachments that require replacement over time.[1–6]

2. SUBJECTS AND METHODS

A 38-year-old male patient was referred ten years ago with chief complaint of congenitally missing his left ear. He had undergone an implant surgery in the mastoid area to receive three craniofacial implants on top of which an implant-anchored auricular prosthesis was fabricated. The auricular prosthesis was attached to the implant ball abutments via precision socket attachments. The final auricular prosthesis was fabricated from silicone elastomers (Medical grade MDX 4-4210 silicone, Dow Corning, Cooperation.), then pigmented. Afterwards it is used to pick-up two flat surface steel attachment housings with nylon ring inside (Ankylos EO Extra Oral Implant System by Degusa Dental GmbH.) and delivered to the patient. The patient was satisfied with the cosmetic and retentive qualities of his prosthesis for several years.

After many years later, the patient presented again and stated that his auricular prosthesis loose and no longer retentive. On examination, it was found that the craniofacial implants were osseointegrated without any complications and the ball abutments showed no signs of wear. However, there was one lost attachment and the other one was worn off giving minimum retention to the auricular prosthesis. The decision was that the appropriate course of action since the implants were osseointegrated and the abutments were intact, is to replace only the lost attachments.

Attempts were made to contact the manufacturer of the implant and attachment (Ankylos EO Extra Oral Implant System by Degusa Dental GmbH). However, it was found that this specific production line (craniofacial implants and their attachments) was stopped several years ago and spare parts no longer exist.

In order to provide patients with new customized attachments, this study adopted a new digital technology workflow for fabrication of these attachments. Reviewing the literature, none of the previous research has documented CAD-CAM PEEK fabrication of the attachment housing itself.

Two challenges in fabrication of such a novel digital attachment were faced. The first was the design of a virtual attachment housing created by computer-aided design (CAD) that conforms to the actual geometry of the existing ball abutment and still provides acceptable retention of the prosthesis. The second was using the available current computer-aided manufacturing (CAM) techniques for fabrication such a small attachment with suitable 3D printing material.[7]

The digital workflow started with acquisition of the ball abutment geometry by an optical scanner (Medit I 500). The optical scan was obtained to capture surface topography of the ball abutment. (Fig 1).

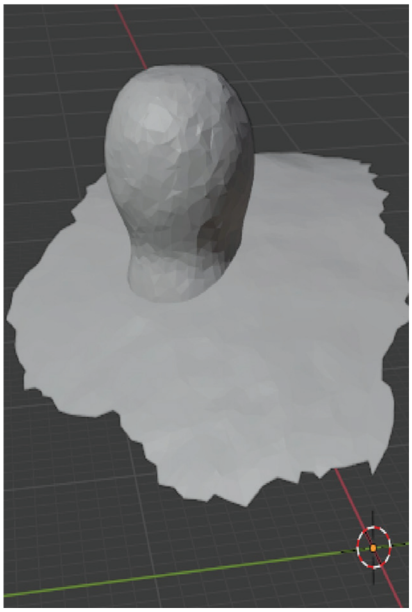

Figure (1) —Acquisition of the ball abutment geometry by an optical scanner. STL file of the ball abutment obtained from the patient's mastoid area.

Next, the STL file was exported and the housing was virtually positioned onto the abutment using a free computer-aided design (CAD) software (MeshMixer, Autodesk, Inc.). This housing had to be picked up directly with chemically-processed acrylic, which required at least 0.5 mm of space all around each housing. To achieve this, the housing was outlined, then separated from the ball to create a separate STL file. The STL housing file was given an offset of 0.35 mm to compensate for shrinkage that occur in printing of polymethylmethacrylate (PMMA). One mm of thickness and a projection of 0.5 mm thickness was added virtually, to create a mechanical undercut. A 3D printer (EPAX) was used to print a resin (PMMA) housing which was pressed into Polyetheretherketone (PEEK) housing[8–10] (Fig 2, 3).

The PEEK housing was attached to the ball abutment projecting from the mastoid area of the patient. A rubber dam was adapted on the abutment to isolate it from excess acrylic during the pick-up process. A small amount of chemically-cured acrylic resin (Acrostone Manufacturing and Import Co.) was inserted in the space created in the acrylic substructure base of the ear prosthesis and used to pick-up the PEEK attachment from the ball abutment. After complete set-up of the resin, the ear prosthesis was removed from the patient's face, cleaned, finished and delivered to the patient (Fig 4-7).

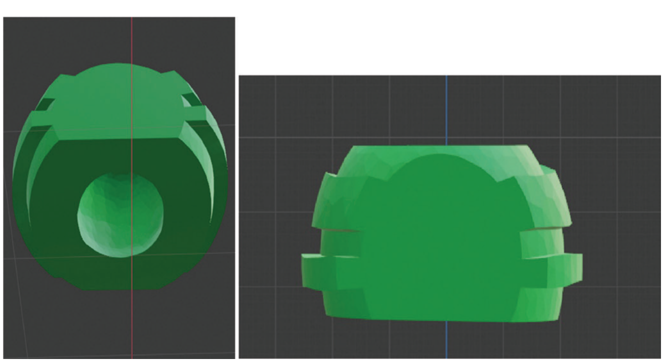

Figure (2) — STL file of the digitally designed attachment housing. A Side view and B Top view.

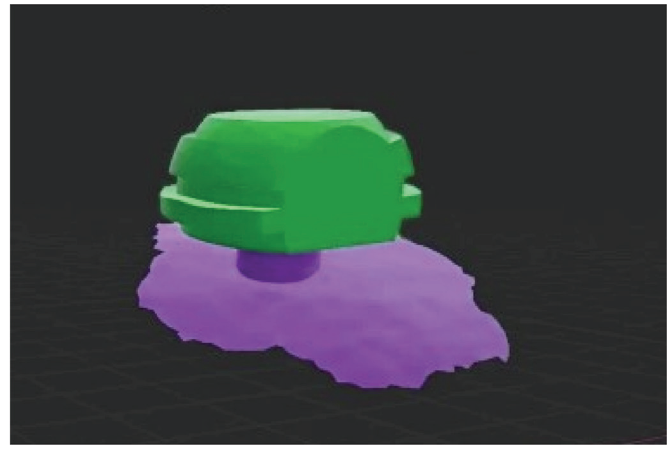

Figure (3) — The STL file of the attachment postioned on the STL file of ball abutment.

Figure (4) — The Osseo integrated craniofacial implants in the mastoid area.

Figure (5) — The CAD-CAM PEEK housing inserted on the ball abutment.

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Figure (6) — The bone-anchored auricular prosthesis attached to the ball abutment via CAD-CAM PEEK attachment housing.

Figure (7) — The final auricular prosthesis in place.

The retention of the ear prosthesis was evaluated by both the operator and the patient. The retentive outcome was satisfactory and the patient was satisfied with the improvements in his auricular prosthesis.

3. DISCUSSION

Digital technologies have enhanced prosthodontics in general, and more specifically in maxillofacial prosthetics. Digitized prosthetic rehabilitation modalities are becoming an essential tool for the maxillofacial prosthetic field.

Using digitization, various types of intraoral and extraoral maxillofacial prostheses were enhanced. Multiple digital technologies in prosthodontics were also emerged in perspective of digitization and visualization, modeling and designing, and fabrication of different implant-anchored maxillofacial prosthesis components. Despite the great progress and wide spread popularity gained by CAD / CAM technology in most dental specialties, such as fixed and removable prosthodontics, aesthetics, dental implantology and orthodontics, its development in maxillofacial prosthetics was, to date, limited and slowly progressive.[11]

None of the previous studies in the literature have dealt with digital fabrication of the attachment housing itself that attach to bone-anchored auricular prosthesis. This novel study, has adopted the digital technology to fabricate a customized attachment that is no longer available in stock due to production policies of the manufacturing company. The digital approach was carried out to save an implant-anchored silicone ear prosthesis that has been served successfully a patient with microtia for more than ten years, until he lost one of its attachment's housings in the last year.

The digital workflow starts with data acquisition, data processing (editing) and design via special software with direct or indirect manufacturing. In this study, the implant abutment ball was scanned by intraoral scanner. The design of the attachment was made by special software. Rapid prototyping, particularly additive manufacturing of resin that was pressed into PEEK, is used to obtain the final attachment 'housing'. The great advantage of most of the frequently used CAD dental software is that the different types of files (e.g., DICOM, STL, and OBJ) could be superimposed providing useful and detailed information that allowed comparison between the original software design and the final PEEK outcome product. It also, showed high accuracy.[11-13]

The advantages of 3D printing technologies comprise no waste material and the ability to manufacture complex geometry of small items; nevertheless, they have the disadvantages of being costly and time-consuming post-processing. The development of new materials and technologies will be the future progress of 3D printing in dentistry, and definitely that 3D printing will have a bright future.[14]

The 3D printing workflow has several advantages, such as having a thorough analysis and outcome (due to easy manipulation of digital 3D models), the ability of duplication of the process whenever needed, and minimizing the additional operative times. Also, the cost of this PEEK attachment is less than most ready-made attachment in the market. The 3D printing process has certain limitations, that include the need for a skilled professional with good computing skills, accurate planning is usually required, and an occasionally higher risk of infection for some medical individuals (due to surface porosity that could be unhygienic). [15-17]https://pubmed.ncbi.nlm.nih.gov/34067212/

Jazayeri et al indicated that additive manufacturing techniques with 3D design software and manufacturing abilities, in combination with recent advances in tissue bioengineering, can now have the advantages of producing biocompatible, accurate, custom tissue-engineered implants for auricular reconstruction that mimic the original ear.[18]

While used commonly in fixed prosthodontics, milling is less widely used in removable prosthodontics production. This is may be due to it is not being the most appropriate technique for RPDs since their components can have complex geometry and varying thicknesses. Milling does not provide the level of accuracy of laser sintering, as the cutting tools have specific thickness limitations that in turn compromise accuracy.[19-21]

The CAD-CAM outcome of the PEEK attachment was used to attach the silicone implant-anchored ear prosthesis to its abutment on the patient's face. The esthetic and retentive results were satisfactory for both the patient and the dentist. The technique reported in this study demonstrated the fabrication of a small custom-made CAD-CAM PEEK attachment for the retention of implant-retained auricular prostheses.[1-7, 10.]

PEEK was used in this study as an essential high-performance dental material, with many applications in dentistry. It has excellent mechanical properties, wear resistance, stability at high temperatures and good biocompatibility.[23] Several in vitro studies and clinical reports suggested that PEEK could be suitable for CAD-CAM fabricated fixed and removable dental prostheses, dental implants and abutments, implant crowns as well as for restoring the maxillofacial defects due to its favorable mechanical, chemical and physical properties.[11] Qin et al reported also, that the utilization of PEEK material as both bar attachment and framework reduce the strains induced around the abutment teeth and over the edentulous ridge. However, PEEK is characterized by being bio-inert and has a low surface energy, which causes difficulties for its potential applications in dentistry specifically in adhesiveness and implant osseointegration. Moreover, PEEK looks opaque and greyish in appearance, and thus aesthetic materials such as veneering or resin composites are used to cover [22–27]. Retention of this attachment depend mainly on friction between the attachment's inner surface and the ball abutment. However, the mechanical properties and resiliency of PEEK could be contributed to the good retentive qualities noted.

This novel attachment could be indicated when a custom made small attachment is essential, in situations when the prosthesis require high retention qualities as in minimum number of implants or in maxillofacial prosthesis.

However, further in vitro and clinical longitudinal studies are needed to evaluate performance of these attachments from all mechanical and biological aspects The effect of these materials have been previously researched[28–32] but more studies are needed. Evaluation of the retention properties and wear of this attachment immediately and after simulated long use is the subject of another research study that is under publication.

Summary: Craniofacial implants with ball abutment helps in retaining auricular prosthesis via precision attachments This clinical case report introduces a novel custom-made digitally fabricated PEEK precision attachment that could be indicated in different restorative situations when small custom-made attachment is essential. It also, could be used when high retention is required.

4. CONCLUSIONS

This study report CAD-CAM workflow for fabrication of a novel small custom-made PEEK attachment that retain an implant-retained auricular prostheses. The retentive and esthetic outcome was satisfactory to the patient and dentist.

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