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Construction of an Implant-Retained Auricular Prosthesis with the Aid of Contemporary Digital Technologies: A Clinical Report

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Microtia; auricular prosthesis; three-dimensional modeling.

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Abstract

Implant-retained auricular prostheses are a successful treatment modality for children with microtia. They involve only minor surgical intervention of implant placement and result in an esthetically pleasing outcome. Integration of digital technologies (DT) in the prosthetic reconstruction process is a new approach toward enhancing outcomes. In this report we present a case of auricular prosthetic reconstruction following two implant placements in the right mastoid region. The ear prosthesis was constructed with the aid of various DTs. A structured light laser scanner was used to digitize the nondefect patient ear. The digitized 3D ear was then manipulated in specialist software, mirrored to reflect the opposing side, and a Rapid Prototyping (RP) machine (Z-Corp) was used to manufacture the soft tissue required. This RP-mirrored ear model allows very accurate reproduction to replicate missing soft tissue. A color Spectrometer was used to accurately reproduce skin tones. The use of these technologies is now routine practice at our unit. They enhance prosthetic outcomes and esthetics, save the prosthetist's time, and are digitally stored and subsequently readily available and reproducible.

Maxillofacial prosthetics can be defined as the art and science of anatomical, functional, or cosmetic reconstruction by means of artificial substitutes of those regions in the maxilla, mandible, and face that are missing or defective because of surgical intervention, trauma, pathology, or developmental or congenital malformation.[1] Such a rehabilitation has the advantages of improving the patient's appearance, enabling early rehabilitation, shortening surgery and hospitalization time, lowering treatment cost, and allowing the patient early psychosocial reintegration.[2,3]

Craniofacial implants in maxillofacial prosthetics provide patients with predictable esthetics, durable and improved retention, and stability of their prostheses[4,5] in comparison with traditional retention methods of medical-grade skin adhesives, spectacles, and tissue undercuts. These traditional modalities are associated with difficulties related to retention reliability, stability, adverse tissue reactions, and accelerated discoloration and prosthesis deterioration, discomfort, and reduced acceptance.[3]

Microtia is defined as a congenital anomaly of the pinna (i.e., the projecting part of the ear lying outside the head).[6] It is multifactorial (i.e., teratogens, congenital) and has four grades ranging from small ear with normal anatomy (grade 1); ear with structural deficiencies (grade 2); nonrecognizable ear, also known as ear with ''peanut'' deformity (grade 3); and complete anotia (grade 4).[6] Implant-retained prosthetic auricular reconstruction for patients who lost their pinna is a more preferable option than surgical reconstruction.[6] However, such prosthetic reconstruction is entirely dependent on the skill and experience of the maxillofacial prosthetist in matching the form, surface texture, and skin tone of the prosthesis with the existing contralateral ear.[7] Such a process is challenging, time consuming for both prosthetist and patient alike, and nonreproducible. Technology now offers the opportunity to supplement these skills by capturing accurate images of the soft tissue and replicating them exactly.[3] For auricular prosthetics, several clinical reports have described laser scanning of the contralateral existing ear and rapid prototyping (RP) toward designing and construction of the defect ear.[8–10] Although such technologies enhance prosthetic ear production partially in terms of the ear shape, texture, and morphology, there is still a need to produce a prosthesis tone that blends with the tissue tone adjacent

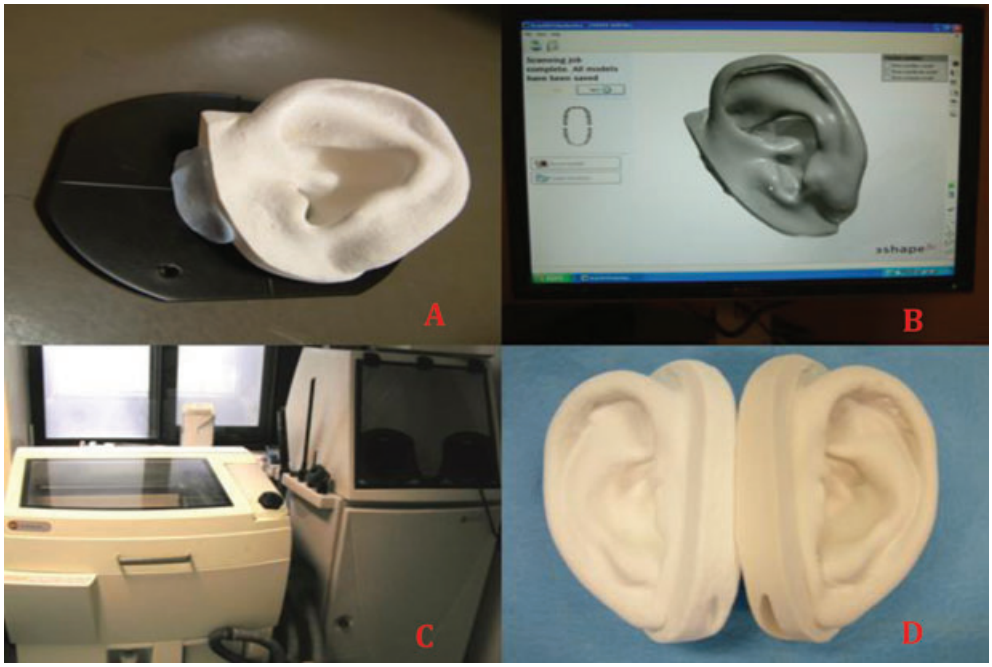

Figure 1 Patient's nondefect ear (A) virtually scanned (B) and digitized. Then it was reversed and printed out in 3D model using the in-house Z-Corp Printer (C). An image of both ears (D).

to the defect side, and looks natural under different lighting conditions. This clinical report presents the current processes of integrating advanced digital technologies (DTs) to produce predictable and reproducible outcomes in constructing and coloring ear prostheses.

Clinical report

A 10-year-old female patient was admitted to the maxillofacial department because of right ear absence due to microtia (grade 4). She proved to be a good candidate for prosthetic ear rehabilitation (good site, no history of infections, no pathology, or radiotherapy to the site). The decision was made by the Head and Neck Multi-Disciplinary Team in conjunction with her parents for implant placement for use in retaining a prosthetic ear. Two craniofacial implants (4 mm long, Vistafix Craniofacial implants, Cochlear, Surrey, UK) were placed in the mastoid region. Optimizing the position of the two implants was achieved by constructing a traditional surgical template.

Surgical template construction

Impressions of the defect ear and the contralateral nondefect ear were made using irreversible hydrocolloid material (Hydrogum, Coltene, West Sussex, UK) following conventional technique. The impressions were cast with dental stone (Crystalcal, Type IV, Gypsum, Newark, UK). Then the nondefect ear cast was scanned in a 3Shape R700 scanner (3Shape A/S, Copenhagen, Denmark), and the virtual scanned ear was mirrored using the software functions. Then, the virtually mirrored ear was printed out as a 3D model using the in-house RP Z-Corp Printer (Z Corp, Rock Hill, SC) (Fig 1).

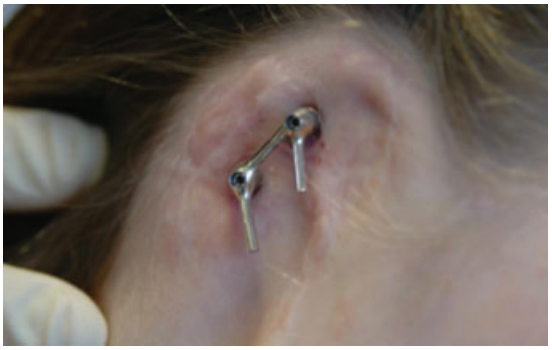

Figure 2 Bar fixed on the patient site.

The 3D model was duplicated with the irreversible hydrocolloid impression and then cast in autopolymerizing acrylic resin (Self cure, Bracon Supplier Ltd, East Sussex, UK). The acrylic resin ear was adapted over the defect site cast in the laboratory, and then the best positions for the two implants were chosen. Points were chosen beneath the antihelix, which is the thickest part of the ear (allowing enough space for the height of the bar, clips, and the retentive shell). Holes were drilled in the acrylic ear template that was then transferred to theater. The irregular surface topography of the defect ear location enabled accurate and stable positioning of the ear template during implant installation. Two implants were fixed in the mastoid bone using a two-stage technique. Twelve weeks elapsed before the prosthetic steps.

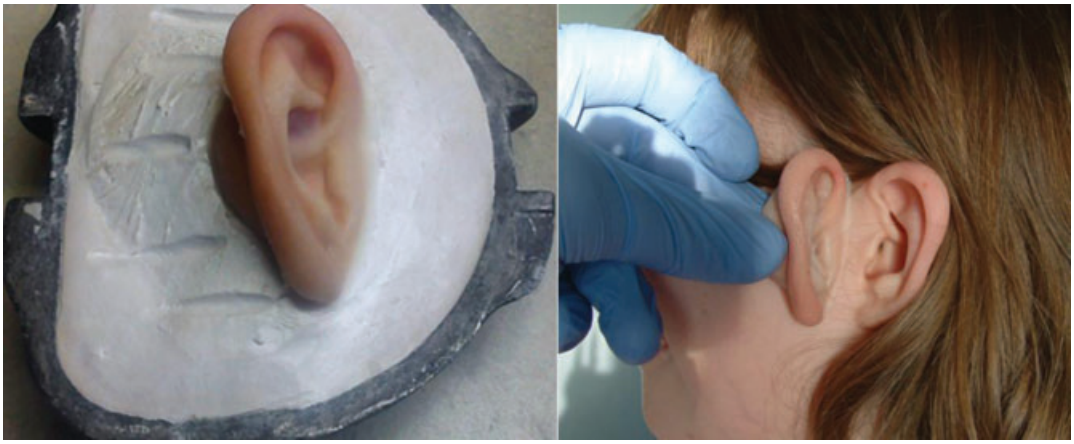

Figure 3 Finished prosthesis.

Prosthesis construction

An impression of the defect site with the two implants was made. Impression copings were fitted onto the implant abutments, and then a closed impression was performed. A heavy bodied high consistency poly(vinyl siloxane) impression material (Extrude Extra, Kerr, Orange, CA) was applied to the impression copings of the implants first. Once set, the impression was continued and completed with the irreversible hydrocolloid material. This allowed stable reproduction of implant sites and kept the impression copings in place during the removal of the impression. Lab analogs were fixed to the impression copings, and the impression was cast with the dental stone. On the cast, gold cylinders (4 mm, Cochlear) were screwed in place, and a cantilever gold bar was constructed (2 mm round bar, Cochlear), joining the implant sites, following conventional laboratory steps and tried on the patient (Fig 2).

Then, three round gold clips (Cochlear) were placed on the bar; two on the peripheries and one on the middle section. A light-cured shell was constructed using urethane dimethacrylate (UDMA) based material (Triad gel, Dentsply, Surrey, UK). The shell was finished traditionally. Another impression of the 3D model was made and cast in wax, which was then adapted over the shell. The wax ear was checked on the patient for functional fit. Final adjustments were made. Color matching of the silicone was performed digitally using a state of the art Spectromatch color system (Spectromatch, London, UK). Three facial points of color recording were chosen as the closest to the opposing nondefect ear. These were base, helix, and lobe colors. Then the wax ear was flasked conventionally. The molds were isolated and made ready for silicone application. The Spectromatch-colored silicone (M511, Cosmesil, Newport, UK) was packed into the mold and cured at 100°C for 1 hour.

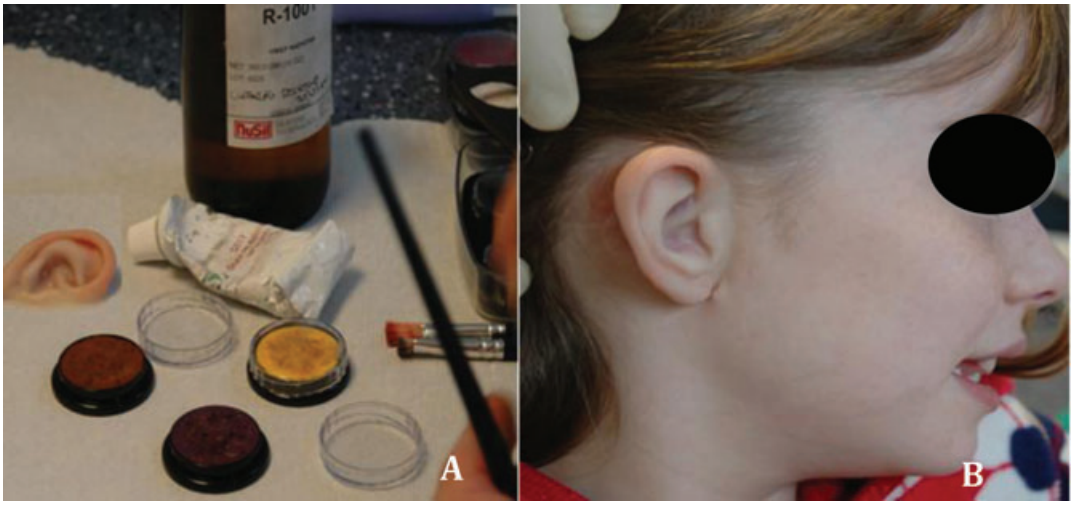

Figure 4 External characterization kit (A) used in camouflaging the ear in situ (B).

Once the silicone prosthesis cured, the flask was left to bench cool, deflasked, and finished as normal. The margins were irregularly finished, and the prosthesis was ready to try on the patient. Two prostheses were made (Fig 3). At the patient's next appointment, the silicone prostheses were tried and checked for harmony in shape and color with the opposing ear and surrounding skin. External characterization was applied to blend the margins further with the skin tone (Fig 4). The patient and family expressed satisfaction with the resultant prosthesis.

Discussion

The incidence of microtia/anotia patients is relatively small at 1:5000.[11] There has been a continuous debate between surgical and prosthetic reconstruction of microtia, with the prosthetic option being poorly represented, even misrepresented for various reasons.[12] Thorne et al showed that prosthetic reconstruction of the ear is indicated in pediatric patients with congenital deformities in cases of failed autogenous reconstruction, severe soft-tissue/skeletal hypoplasia, and/or a low or unfavorable hairline.[13] Although autogenous reconstruction presents a technical challenge to the surgeon, the prosthetic reconstruction requires lifelong attention and may be associated with late complications. On the other hand, it is agreed that surgical reconstruction of the human ear is an extremely complex procedure with various complications such as skin necrosis, and long-term significant resorption of the cartilage framework, leading to severely compromised results.[12] As a compromise, there was the notion of "because a prosthesis can always be provided, why not try to reconstruct the ear surgically first."[12] However, it gathered very little support. Regardless, both approaches have pros and cons. Selecting one should be made with both options held to an equal standard. This ideal is not reflected in reality, as in the United Kingdom, there are far more prosthetic units capable of high quality reconstruction than surgical ones. Care should be taken to discuss all options with the patient and parents before an informed decision can be made. An implant-retained prosthetic ear was the option adopted in this case for the patient and her family.

Supplying prostheses to children can present challenges. The use of adhesive retention can be problematic, as children can be very active, which can lead to loss of retention due to accidental displacement during play. Implants should always be considered the first option. Implant retention is more reliable, secure, hassle-free, and durable. Furthermore, a prosthesis retained with the clip-bar attachment system is more resistant to lateral displacement than other retention systems such as magnets, especially in the auricular region. Another important aspect is that the provision of implant-retained prostheses for children is an issue requiring careful consideration and evaluation. Children should be sufficiently mature to understand that they are undertaking a commitment to a lifetime of prosthetic treatment. Although understanding the concerns of the parents, the ultimate decision should preferably be that of the child.

This case showed that integration of advanced technologies in the data acquisition and digital design (3Shape R700 surface laser scanner), color formulation (Spectromatch Pro), and physical fabrication (Z-Corp 3D RP) of the prosthetic ear facilitated this process.[14] Specifically, the digital scanning and designing was effective in producing a perfectly mirrored shape, form, and alignment to the nondefect contralateral ear.[8–10] Skin color matching and production was made easier using the Spectromatch system. An earlier clinical case series reported using this system in color recording and reproduction of a traditionally constructed orbital prosthesis.[15] Regardless of the lighting conditions presented, the systems' silicones are nonmetameric; hence, changes in light conditions from natural to flourescent lighting have little effect on the reflective properties of the silicone colors. This in turn means the prosthesis remains well camouflaged. It also provides a reproducible recipe for the color that can be produced accurately every time a new prosthesis is required.

These technologies save time usually spent in waxing up the prosthesis and manual mixing of silicone colors. They also save physical storage space, as data is virtually stored and can be accessed anytime by any operator, making a prosthesis remake for the same patient easier without the need for the patient's physical presence. This is especially important with child patients, as they require more frequent attendance at clinic than adult patients for a remake. Finally, it is likely that data stored of scanned ears are useful in production for similar patients, especially when both ears are missing, where a complete match of both ears can be produced, saving clinical time.

Conclusion

Technology is only practical when it can be shown to improve clinical outcomes. These technologies have been flawlessly integrated into the traditional processes of prosthesis manufacture to improve outcomes for patients, especially in children, where a prosthetic is a lifelong procedure made easier with the provision of such technologies, which reduce fabrication errors and may improve patient acceptability.

References

1. Chalian VA, Phillips RW: Materials in maxillofacial prosthetics. J Biomed Mater Res 1974;8:349-363
2. Goiato MC, Pesqueira AA, Ramos da Silva C, et al: Patient satisfaction with maxillofacial prosthesis. Literature review. J Plast Reconstr Aesthet Surg 2009;62:175-180
3. Hatamleh MM, Haylock C, Watson J, et al: Maxillofacial prosthetic rehabilitation in the UK: a survey of maxillofacial prosthetists' and technologists' attitudes and opinions. Int J Oral Maxillofac Surg 2010;39:1186-1192
4. Wolfaardt J, Gehl G, Farmand M, et al: Indications and methods of care for aspects of extraoral osseointegration. Int J Oral Maxillofac Surg 2003;32:124-131
5. Schoen PJ, Raghoebar GM, van Oort RP, et al: Treatment outcome of bone-anchored craniofacial prostheses after tumor surgery. Cancer 2001;92:3045-3050
6. Hamming KK, Lund TW, Lander TA, et al: Complications and satisfaction with pediatric osseointegrated external ear prostheses. Laryngoscope 2009;119:1270-1273
7. Watson J, Cannavina G, Stokes CW, et al: A survey of the UK maxillofacial laboratory service: profiles of staff and work. Br J Oral Maxillofac Surg 2006;44:406-410

8. Turgut G, Sacak B, Kiran K, et al: Use of rapid prototyping in prosthetic auricular restoration. J Craniofac Surg 2009;20: 321-325
9. Ciocca L, Scotti R: CAD-CAM generated ear cast by means of a laser scanner and rapid prototyping machine. J Prosthet Dent 2004;92:591-595
10. Subburaj K, Nair C, Rajesh S, et al: Rapid development of auricular prosthesis using CAD and rapid prototyping technologies. Int J Oral Maxillofac Surg 2007;36: 938-943
11. Brent B: The pediatrician's role in caring for patients with congenital microtia and atresia. Pediatr Ann 1999;28: 374-383
12. Gion GG: Surgical versus prosthetic reconstruction of microtia: the case for prosthetic reconstruction. J Oral Maxillofac Surg 2006;64:1639-1654
13. Thorne CH, Brecht LE, Bradley JP, et al: Auricular reconstruction: indications for autogenous and prosthetic techniques. Plast Reconstr Surg 2001;107:1241-1252
14. Aleid W, Watson J, Sidebottom AJ, et al: Development of in-house rapid manufacturing of three-dimensional models in maxillofacial surgery. Br J Oral Maxillofac Surg 2010;48:479-481
15. Hatamleh MM, Haylock C, Hollows P, et al: Prosthetic eye rehabilitation and management of completely blind patients. Int J Prosthodont 2012;25. In press.