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Prosthetic rehabilitation of microtia using cad and rapid prototyping: A case report

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Abstract

Microtia is a major congenital anomaly of the external ear. It includes a spectrum of deformities from grossly normal but small ears to the absence of the entire external ear. Defects can be corrected by surgery but this may not be feasible due to medical or economic reasons. Reconstructive solutions are a good alternative, but rely on the artistry and availability of the anaplastologist. Maxillofacial prosthesis gains utmost significance as the process not only tries to develop acceptable esthetics but also tries to enhance the psychological comfort of the patient by restoring the defective or missing craniofacial structures. The advent of digital technology in maxillofacial prosthesis has allowed fabrication of exact anatomical models. This paper describes a case of microtia in which a semi- automated methodology consisting of computer aided designing and rapid prototyping was used for fabrication of the auricular prosthesis.

Keywords: Microtia, auricular prosthesis, semi-automated methodology, computer aided designing, rapid prototyping

Introduction

Microtia encompasses a spectrum of congenital anomalies of the auricle that range in severity from mild structural abnormalities to complete absence of the ear i.e. anotia [1]. The occurrence of microtia is of public health importance in part due to the psychosocial sequelae, including the stigma associated with malformations of the ear and the burden of undergoing multiple surgeries [2]. The creation of a silicone auricular prosthesis is an alternative to surgical reconstruction. These Prostheses provide a cost-effective and cosmetically acceptable means of camouflage for patients who decline or postpone surgical reconstruction.

The advent of digital technology in rehabilitation of maxillofacial defects facilitates the fabrication of facial prosthesis more accurately and precisely [3].

The aim of this report is to describe the rehabilitation of a patient with severe microtia using computer aided designing and rapid prototyping.

Case report

A 33 years old male patient reported to the Department of Prosthodontics with a chief complaint of congenitally missing right ear (fig-1). On examination, microtia with severity level III was noticed on the right side with complete loss of hearing ability. The left ear of the patient was also malformed with reduced hearing. The position of the tragus with respect to microtia was at a much lower level as compared to the contralateral ear. Mandibular hypoplasia was seen on the right side due to which there was deviation of chin towards the same side. The patient was diagnosed to have hemifacial microsomia [4].

Fig 1: Pre-operative view

Treatment Plan

Considering the clinical situation, economic feasibility and availability of necessary resources, it was planned to fabricate an adhesive retained auricular prosthesis using a semi- automated methodology consisting of computer aided designing and rapid prototyping. The procedure was explained to the patient and informed consent of patient was obtained.

Fabrication of prosthesis

1. Computerised tomographic images of the region from the supra orbital ridge to below the columella bilaterally were taken and slices of 1mm thickness were obtained.
2. The voxel model of the region of interest was reconstructed by stacking the CT images, considering the slice thickness, distance between the slices and their orientation using a 3D reconstruction software (Osteo3D, India).
3. An image of the left ear was extracted, inverted and its mirror image was produced (fig-2).
4. A virtual model of the required prosthesis, with the mirrored digital image, was adapted to the defective side image (fig-3). The data was processed, and was saved as a Standard Triangle Language file (STL).
5. The ear model was fabricated in a thermoplastic material (Acrylonitrile butadiene styrene) using Fused Deposition modelling 3D printing system (fig-4) [5,6].
6. A silicone putty (Flexceed, GC India Dental Pvt. Ltd.) mold was made of the 3D printed prototype (fig-5) and molten modelling wax was poured in it to achieve a trial wax pattern (fig-6).
7. The wax pattern was tried on the patient and verified with the normal ear to ensure symmetry, orientation, and visibility (fig-7).
8. Shade matching was done in several parts of contralateral ear to get exact shade and good esthetic results [7] (fig-8).
9. The fabricated wax pattern was used as a guide to fabricate the corresponding three-piece mold in type III dental stone (Gold stone, India) material (fig-9).
10. Dewaxing was done and the mold was packed using Room temperature vulcanizing silicone (MP Sai, Mumbai, India) material mixed with the right amount of intrinsic stains followed by bench curing for 36 hours under 1500psi pressure (fig-10).

11. The retrieved prosthesis was extrinsically characterized and finished (fig-11).

12. The final auricular prosthesis was retained over the defect surface using a silicone bioadhesive (Technovent pro bond adhesive, Germany) and the undercuts present in the defect (fig-12,13).

13. The patient was instructed regarding the usage of the prosthesis. Application of the adhesive every morning and removal of prosthesis while sleeping, regular cleaning of the prosthesis with soap solution and to limit the sun exposure to avoid discoloration of silicone material.

14. A follow up was done after 3 months and patient was advised for follow up every 6 months to keep a check on the wear of silicone material.

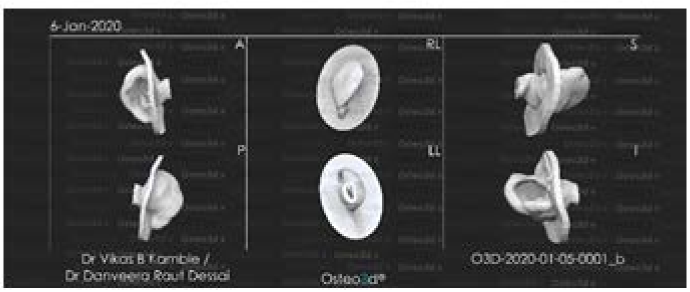

Fig. 2: Mirrored images of the contralateral ear

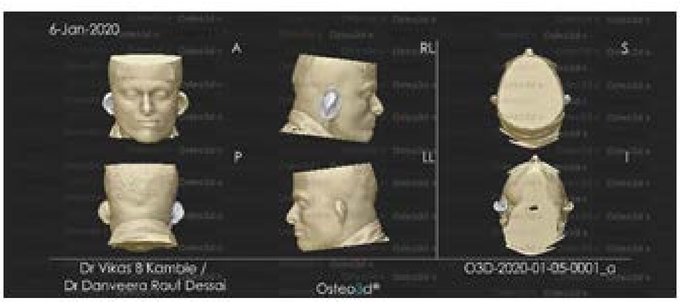

Fig. 3: Adaptation of the mirrored digital image on defective side

Fig. 4: 3D printed ear prototype

Fig. 5: Putty mold

Fig 6: Wax pattern

Fig. 7: Wax pattern try in

Fig 8: shade matching

Fig 9: three-piece mold

Fig. 10: Packing of the three-piece mold

Fig 11: Finished ear prosthesis

Fig. 12: Application of bio adhesive

Fig. 13: Post-operative front and back view

Discussion

Replacement of a missing auricle is considered to be one of the most difficult replacements in maxillofacial reconstruction. In the conventional technique of prosthesis fabrication, free hand sculpting of the wax prototype is done which depends on the accuracy of the stone cast and the artistic skills of the technician. Sykes et al. [8] reported that the free-hand-carved ear prosthesis was found to be of poorer quality with regard to shape and esthetic appeal.

In earlier case reports, the donor technique was employed. This is an easier technique. A relative/family member with ear contours that closely match with that of the patient is selected. Impression of ear is obtained and wax cast is retrieved. The wax cast is adapted and re-contoured as necessary. In this case, the donor technique was ruled out because it would not suffice aesthetically as it would be very difficult to match it with the deformed contralateral ear [9].

Nusinov and Gay [10], in 1980, described a method for obtaining the reverse image of an ear by using parallel lines transferred to casts, a vertical camara capable of producing 3-dimentional objects, and tracing paper. This technique is complex and require special and costly equipment. However, this problem can be overcome by simply making a transparent copy of the contralateral anatomic part and placing it in reverse over the working cast to assist in sculpting [11]. Another method to obtain the mirror image of the contralateral ear is, sectioning the wax pattern of the opposite ear using a wax saw into 1mm thick slices, then reversing each section and image of the original ear [12].

In today's digital era, computerised tomography/ 3D scanning system/scanning of the master model are the different imaging options that can substitute the conventional impression making procedures, which is followed by a reverse engineering process to obtain a mirror image of the contralateral ear. The final prototype of the mirrored contralateral ear is achieved either by CNC milling/ rapid prototyping [9].

Weighing the pros and cons of all the techniques this case report demonstrates how high accuracy in morphology and positioning can be achieved by finer CT scanning i.e. 1mm slice thickness, coupled with the reverse stacking approach to mirror the contralateral normal ear. The haptic CAD system eased the design to match the morphology of the deficient side, and smoothening of the final auricular prosthesis model [5]. The use of Rapid Prototyping technology enabled accurate reproduction of the designed prosthesis without requiring the sculpting skills, and was much faster than the conventional method. The properties of silicone deteriorate over time hence the preserved 3D-printed ear model will allow to fabricate the ear prosthesis multiple times without the need of any extra impression or scanning procedure.

The technique also comes with some limitations. The distortion of wax can occur during the conventional duplication process of the mold which can hamper the accuracy and esthetics of the prosthesis [13]. This procedure requires access to technologies mentioned for wider application, which is an issue for offering cost – effective solutions to a large population [5].

Conclusion

The progressive idea of bridging the gap between digital and conventional techniques used in this case report contribute to an aesthetic, well fitted, accurate and a cost-effective treatment.

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