Case Report

Microtia deformity correction with three-dimensional and two-dimensional templates: A pathway for effective ear reconstruction

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Abstract

Expression of anatomical landmarks of the ear results in the success of ear reconstruction in microtia. Ear reconstruction in India is routinely done with a two-dimensional (2D) template by tracing the contralateral ear with an X-ray sheet. There is a need of a proper template to understand the finer details of the ear reconstruction. In this report, a three-dimensional (3D) template in association with a 2D template is utilised to augment the reconstruction ability of the plastic surgeon. After computed tomography scan, an accurate 3D scan of the normal ear is obtained. Using the 3D ear model file, a negative mould of the ear 3D model is developed and fed into a 3D printer. The model is sterilised and used for reconstruction. Hyperbaric oxygen therapy is used as an adjunct for the procedure. Simultaneous utilisation of 3D and 2D templates for ear reconstruction appears to increase the ability of plastic surgeons to recreate the ear.

Keywords: Ear reconstruction, hyperbaric oxygen therapy, microtia, three-dimensional template, two-dimensional template

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Submitted: 25-Aug-2020 **Accepted:** 14-Sep-2020 **Published:** 25-Oct-2021

INTRODUCTION

Microtia is a congenital abnormality of the external ear which has an incidence of about 1.5 in 10,000–15,000 with a male predominance.[1] The deformity is bilateral in 15% of cases and commonly involves the right side.[1] Marx classification used Grades I to IV according to the severity of microtia, which ranges from the presence of all features of a normal auricle except for a smaller pinna to complete absence of the auricle and external ear canal.[2,3] Auricular reconstruction was first introduced by Tanzer in 1959.[4] The reconstruction was performed using costal cartilage as cartilage supplement. During reconstruction, a two-dimensional (2D) template with an unused X-ray film was utilised to make a template of the normal unaffected ear and the template was reversed to acquire the desired shape of cartilage reconstruction.[4] Since then, ear reconstruction for microtia in India is routinely done with 2D templates by tracing the contralateral ear with an X-ray sheet or a transparent sheet material. However, there is a need of a proper template to understand the finer details of the ear which can be effectively used for ear reconstruction. As technology advances, with 2D template as the adjunct,

Access this article online	
Quick Response Code:	Website: www.jcsr.co.in
	DOI: 10.4103/JCSR.JCSR_73_20

How to cite this article: Korambayil PM, Alappatt K, Ambookan PV. Microtia deformity correction with three-dimensional and two-dimensional templates: A pathway for effective ear reconstruction. J Clin Sci Res 2021;10:252-5.

we report the utilisation of a three-dimensional (3D) template as a guide for reconstruction of ear deformity in our institution.

In the ear reconstruction methodology, first, the patient undergoes computed tomography (CT) of the normal ear. This is done to get an accurate 3D scan of the normal ear. The advantage of using a CT scan is for precise millimetre thin cuts, which translate into more error-free and detailed 3D scan. The CT DICOM data files are imported into Horos TM DICOM software and the CT data are analysed. The 3D model of the ear is segmented. And then, the 3D model is exported as an *.Standard Tessellation Language file. The resulting 3D ear model is mirrored using Meshmixer 3.3 software. Using the 3D ear model file, a negative mould of the ear 3D model is developed using Blender v2.7 3D Modelling software. Then, the 3D files are imported into the Slicer Software Ultimaker™ Cura v3.6, and a G-code 3D printer file is generated. The G-Code file is fed into the 3D Printer Creality CR-10 3D. And, the printer prints the 3D ear model and the negative mould. The polymer used to print is polylactic acid and is biodegradable. The model is sterilised using ethylene oxide and is used during the procedure as a template for ear reconstruction from bone grafts (Figure 1).

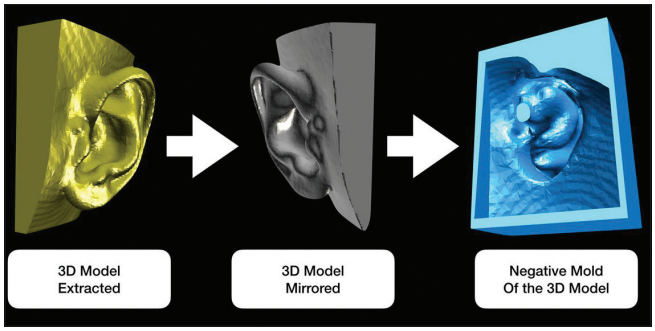

Figure 1: Pre-operative analysis with computed tomography scan for three-dimensional imaging and three-dimensional printing for ear template from the normal side

CASE REPORT

A 9-year-old male child reported to the plastic surgery outpatient department with congenital absence of the right ear. An initial assessment of clinical grades of microtia and degree of hearing loss as well as severity of middle ear abnormalities were done. The patient had Grade 3 deformity of the right external ear (Figure 2). The 6th, 7th, 8th and 9th costal cartilages were harvested from the ipsilateral side of the chest, leaving the posterior layer of the perichondrium (Figure 3). After harvesting the costal cartilage, the breach in the pleural cavity was checked. Then, the donor area was closed primarily after placing a suction drain. Two-dimensional templates were formed for each layer of reconstruction of the ear cartilage (Figure 4). A three-dimensional template was also utilised to compare the layers of reconstruction and finer definitions of the ear reconstruction with costal cartilage (Figure 5). 4-0 polypropylene suture materials were used to secure the layers of cartilage reconstruction. The completed framework was placed inside the carefully created subcutaneous auricular pocket with a suction drain (Figure 6). With Stage 2, auricular framework elevation was done with temporal fascia and skin grafting at the post-auricular region (Figure 7). Post-operatively, six sessions of hyperbaric oxygen therapy were administered. There were no complications following staged surgeries and the post-operative periods were uneventful.

Figure 2: Microtia Grade 3 deformity of the right external ear

Figure 3: The 6th, 7th, 8th and 9th costal cartilages were harvested from the ipsilateral side of the chest

Figure 4: Multiple two-dimensional templates for each layer of reconstruction of the ear cartilage

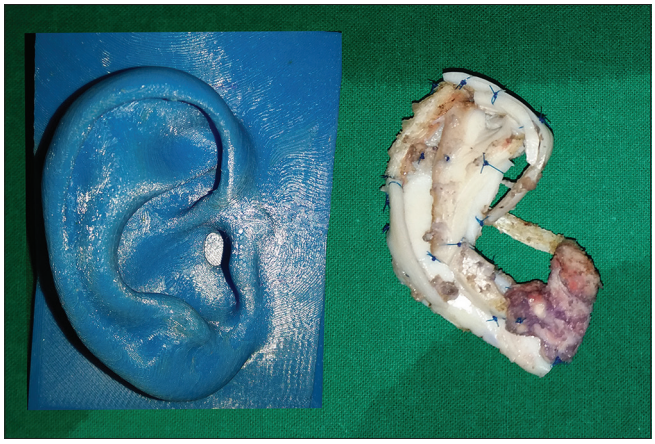

Figure 5: Three-dimensional template for finer definitions of the ear reconstruction

Figure 6: Completed framework placed inside the subcutaneous auricular pocket with a suction drain

Figure 7: Stage II – Auricular framework elevation

DISCUSSION

Congenital abnormality of the external ear is a relatively common condition which requires a complete intraoperative understanding for replicating the form of the contralateral normal ear. Every technique and technology required for understanding the finer details of the ear should be utilised to reproduce an aesthetically pleasing ear structure. There was constant improvement in the efforts of reconstruction by various surgeons in the history of ear reconstruction. Tanzer started reconstruction with autologous costal cartilage in 1959 and thereafter the contribution of Brent, Nagata, Firmin and Marchac was significant for the current understanding of ear reconstruction from single layered to Three-layered reconstruction of the ear.[5] Even though auricular reconstruction with 2D templates provides sufficient replication of normal ear, finer details in terms of shape of the concha and triangular fossa were made out with difficulty. Intraoperative comparison of the normal ear was also difficult due to the operative position of the patient. Visual evaluation and memory of the surgeon lead to subjective evaluation rather than the objective assessment of the ear to be reconstructed.[6]

As 3D imaging and printing technology evolved in craniofacial surgery, 3D templates for ear reconstruction were first used in 1993.[6] The 3D printing technology for auricular reconstruction during an assembly of framework has been used thereafter.[7] Fan *et al*.[6] used a 3D template including whole of the face to precisely understand the spatial relationship of the auricle, eye and nasal tip. However, creation of a 3D template of the whole face may increase in expense of the procedure and a long way to the Indian population. We utilised 3D printing technology to get guidance for auricular reconstruction.

As there is a requirement of three-layered creation of an auricular framework, we made multiple 2D templates separately for the base plate, helical rim, antihelix and conchal projections (Figure 4). The approach of ear reconstruction with both 2D and 3D templates will give additional evaluation for the surgeon for effective reconstruction. Complete negation of 2D templates for 3D templates is still not possible, as 2D templates have their own comfort in segmental analysis of multilayered cartilage reconstruction.[6]

Hyperbaric oxygen therapy is used as an adjunct for surgical procedures. Six sessions of hyperbaric oxygen therapy are given post-operatively, with 2.4 atmospheric pressure. Hyperbaric oxygen helps in the survival of cartilage graft and skin flaps created for cartilage pockets.[8] In conclusion, simultaneous utilisation of 3D and 2D templates for ear reconstruction helps to increase the ability of plastic surgeons to recreate the ear. Receptivity to the technological advances provides plastic surgeons, an objective platform for a scientific approach.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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