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Tengku Noor Daimah Tengku Din, Nafij Jamayet, Zainul Ahmad Rajion, Norhayati Luddin, Johari Yap Abdullah, Abdul Manaf Abdullah, and Suzana Yahya



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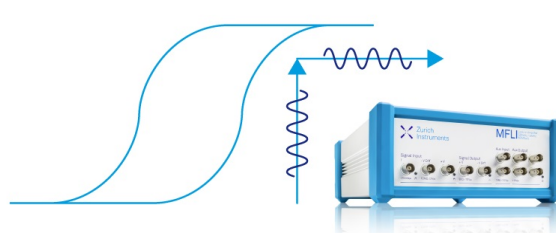
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Design and Fabrication of Facial Prostheses for Cancer Patient Applying Computer Aided Method and Manufacturing (CAD/CAM)

Tengku Noor Daimah Tengku Din¹, Nafij Jamayet¹, Zainul Ahmad Rajion^{2, a},
Norhayati Luddin¹, Johari Yap Abdullah¹, Abdul Manaf Abdullah¹ and
Suzana Yahya¹

¹School of Dental Sciences, USM Health Campus, Kelantan, Malaysia

²College of Dentistry King Saud Bin Abdulaziz University for Health Sciences, Riyadh, Kingdom of Saudi Arabia

^aCorresponding author: zar5057@gmail.com

Abstract. Facial defects are either congenital or caused by trauma or cancer where most of them affect the person appearance. The emotional pressure and low self-esteem are problems commonly related to patient with facial defect. To overcome this problem, silicone prosthesis was designed to cover the defect part. This study describes the techniques in designing and fabrication for facial prosthesis applying computer aided method and manufacturing (CAD/CAM). The steps of fabricating the facial prosthesis were based on a patient case. The patient was diagnosed for Gorlin Gotz syndrome and came to Hospital Universiti Sains Malaysia (HUSM) for prosthesis. The 3D image of the patient was reconstructed from CT data using MIMICS software. Based on the 3D image, the intercanthal and zygomatic measurements of the patient were compared with available data in the database to find the suitable nose shape. The normal nose shape for the patient was retrieved from the nasal digital library. Mirror imaging technique was used to mirror the facial part. The final design of facial prosthesis including eye, nose and cheek was superimposed to see the result virtually. After the final design was confirmed, the mould design was created. The mould of nasal prosthesis was printed using Objet 3D printer. Silicone casting was done using the 3D print mould. The final prosthesis produced from the computer aided method was acceptable to be used for facial rehabilitation to provide better quality of life.

INTRODUCTION

Facial defects may create emotional feeling and physiological effect to certain affected patients resulting in an unpleasant and low self-confidence due to their appearance to socialize with other people which affect routine daily life [1]. Facial defects involving nose and ear are usually congenital or caused by trauma or cancer [2]. Various options exist for rehabilitations of this defect where reconstructive surgery or prosthetic treatment being commonly advocated [3] [4]. In reconstructive surgery another body parts of the patient is commonly utilized while in prosthetic treatment, an artificial device is used to replace the missing part. It depends on the area of defect. The manual method of prosthesis fabrication is time consuming which requires many steps before delivering to patients. The application of Computer Aided Design and Manufacturing (CAD/CAM) in prosthesis fabrication proved to save time in producing the prosthesis. This article describes the CAD/CAM application to produce the facial prosthesis.

CLINICAL REPORT

A 50 years old male was referred to the Maxillofacial Prosthodontics of School of Dental Sciences for a maxillofacial prosthesis. The patient presented with severe defect on his face including the eye, cheek, and nose. He was diagnosed with Gorlin Gotz (GG) syndrome. The syndrome is also known as nevoid basal cell carcinoma syndrome (NBCCS) with common presentation such as multiple basal cell skin cancers and jaw cysts. This syndrome is genetically

inherited from the parents [5]. Besides that, exposure to the sun and radiation could also cause cancer [6]. The patient had previously been restored with nasal prosthesis 4 years ago. However, a new prosthesis is needed since the defect was getting larger. Therefore, a new prosthesis that covers the eye, nose, and cheek is produced by using CAD/CAM.

Method

The patient went for a CT scan to obtain the latest facial morphology. The CT data shows the affected soft tissue where the right and left part are different in shape (Figure 1). Based on the CT scan performed on 2011, 2015 and 2016 the size of the defect was getting bigger (Figure 2). The CT data was retrieved from the Radiology Department, Hospital Universiti Sains Malaysia (HUSM) and saved in Digital Imaging and Communication in Medical (DICOM) format. The CT data was imported into medical imaging software, MIMICS (Materialise, Leuven, Belgium) for three-dimensional (3D) reconstruction. The stacks of two-dimensional (2D) images from the CT data were converted into a 3D image.

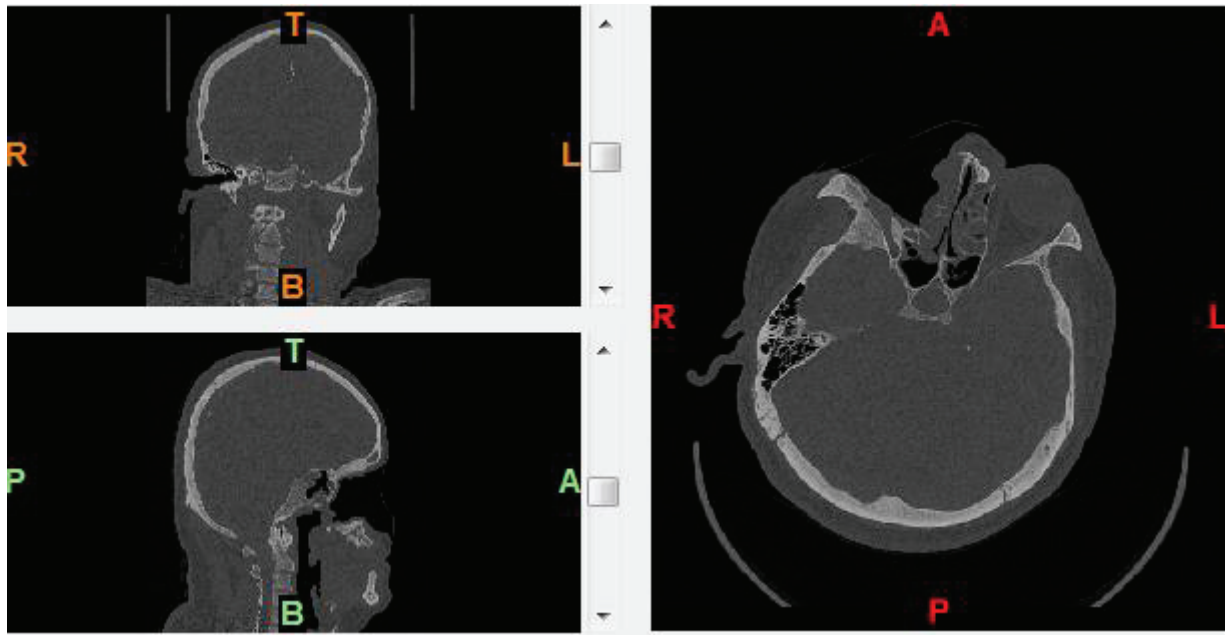


Figure 1: CT data of latest facial morphology of the patient.

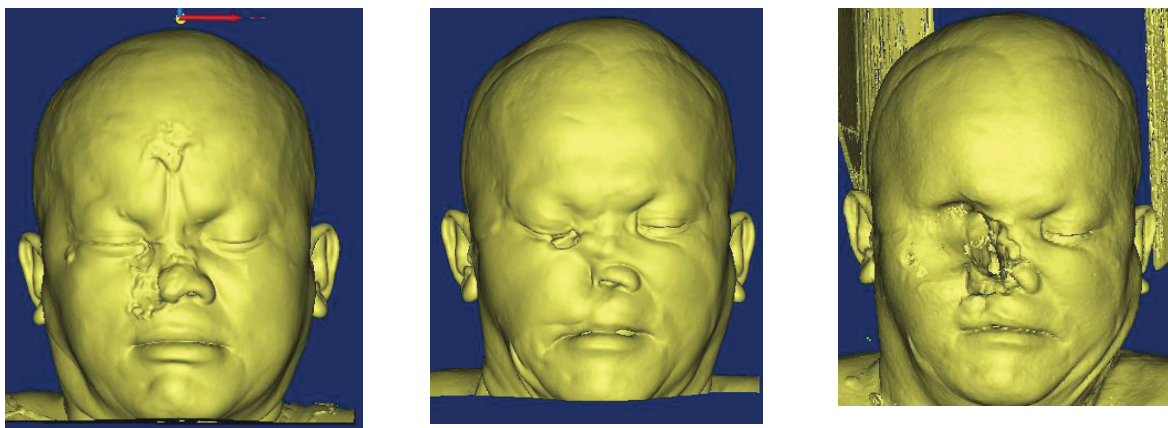


Figure 2: The 3D image of the patient on 2011, 2015 and 2016.

The 3D image was saved in Standard Tessellation Language (STL) format and transferred into Geomagic software for further processing. In Geomagic software, the 3D image of the head was aligned on the sagittal plane. The head needed to be positioned straight to ensure no interference affecting the next steps of the design process (Figure 2).

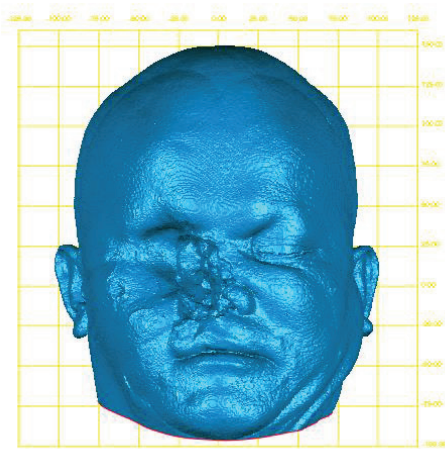


Figure 2: The head was positioned straight and aligned on the sagittal plane

On the sagittal plane, half of the head covering the defect area (right side) was removed and the left side was preserved (the normal part). The healthy part was mirrored and merged with the original data (Figure 3). After mirroring the normal part of the face to cover the defect part, the face appear normal but the defect on the nose needed further processing. The next step was the superimposition of the nose. The digital nose sample was taken from the nasal digital library. The selection was based on the rule of fifth and rule of third. In this case, the nose width was based on the intercanthal distance. The nose length was based on the mid facial length.

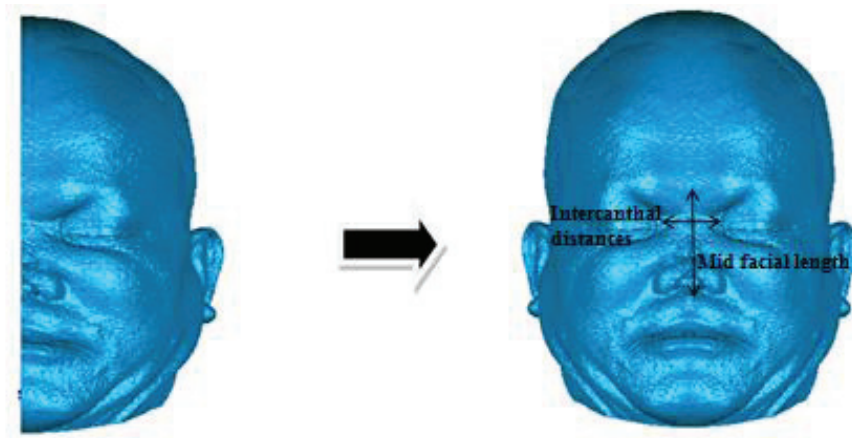


Figure 3: Mirror image of the healthy part.

After the nose sample was chosen from the database, it was loaded into the software. The nose sample was superimposed on the face (Figure 4). It was aligned to cover the defect part. The virtual outcome of the nose sample matched with the face.



Figure 4: Nose sample was superimposed on the 3D image of the face.

The highlighted blue part represented the defect area (Figure 5). The blue part was extracted for the sequential editing process. Smoothing was done to ensure the smooth surface of the prosthesis.

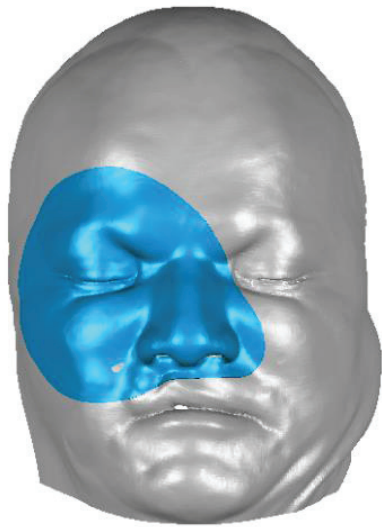


Figure 5: The blue part shows the defect area.

Next, the mould was designed. Two part moulds were created which was made up of core and cavity mould (Figure 6). The important criterion of a mould includes an inlet for material injection, a runner for excessive material and the parting surface of the core and cavity part. The mould was printed using acrylonitrile butadiene styrene (ABS). The printing process for both parts took about 6 to 7 hours to complete, using MakerBot Replicator 2X

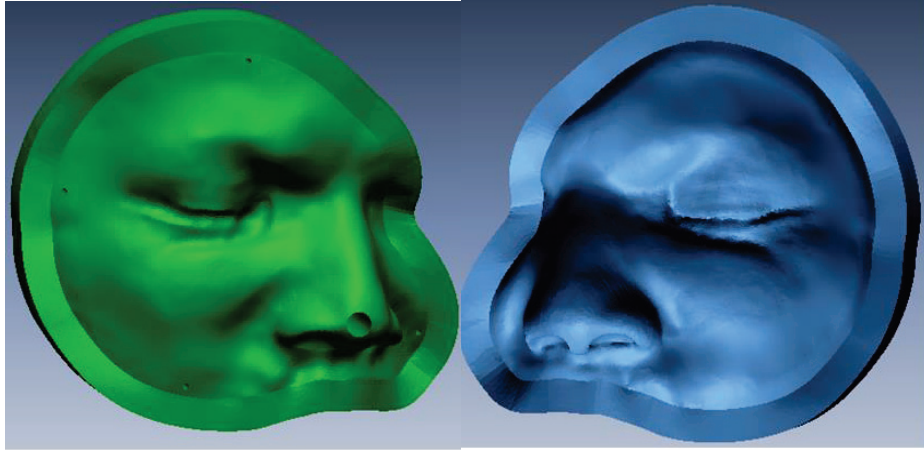


Figure 6: Two-part moulds of the prosthesis.

In this case, the silicone was not directly poured into the mould because the eye part needs further adjustment. Therefore, the wax was poured into the printed mould for duplication process. Then the wax was used to produce the stone mould. The stone mould was produced using the hydrocolloid material. After the mould was completed, the eye prosthesis was placed in the final mould. Silicone casting was produced using the final mould. A room temperature vulcanizing prosthetic silicone material was used to fabricate the prosthesis. Silicone mix was prepared and packed into the mould. Then, it was pressed and left for curing at least for three days.

Lastly, the silicone maxillofacial prosthesis was fitted into the patient (Figure 7). Extrinsic colouring was applied during the appointment day to match the colour of the skin and prosthesis. Eyelash and moustache were attached to the prosthesis. The prosthesis fitted perfectly on the face despite the needs for colour adjustment. Adhesive can be used for better retention.



Figure 7: Patient with the maxillofacial prosthesis.

DISCUSSION

Prosthetic treatment is advocated when surgical reconstruction is not possible to cover the defect part. Large surgical defects require a large amount of skin and flap to replace the skin around the defect area. The surgery also involves complex procedures. Therefore, another solution is to use prosthesis to replace the skin. The conventional method for producing the prosthesis involves many steps. The method of prosthesis fabrication utilizing CAD/CAM proved that it is not harmful to patient, time saving and the quality was good. The CAD/CAM was applied in the fabrication of nasal, auricular, orbital and also maxillofacial prosthesis [7] [8] [9]. The available CT data helps in taking the facial impression digitally. This prevents the clinician from taking manual impression which caused discomfort to the patient and soft tissue distortion. Laser scanner can also be used to obtain the digital facial impression [10][11][12]. During the scanning procedure, patient has to avoid from moving because it will affect the data capturing. Besides that, manual carving and sculpting of the wax model can be eliminated [13]. Carving process would normally take the most time spent for the manual prosthesis fabrication. This is due to the high skill and experience needed for modelling the wax [14]. By using CAD/CAM, the required part can be extracted from the CT data with the help of medical imaging software. The part produced from the software is usually accurate in shape and size. The mould was designed using the software and later printed using 3D printer. However, for this case, the printed mould cannot be used for silicone casting because it needs some adjustment for the eye part, but it can still be used as a model for duplication process. Therefore, the processing time to fabricate the mould was reduced. The adhesive can be used to seal the margin around the prosthesis. This technique provide benefit in eliminating a few complicated steps during procedures, thus, it saves time and non-invasive to the patient.

CONCLUSION

The application of CAD/CAM could facilitate the prosthesis fabrication. A few of the manual steps can be replaced with computerized method which reduces the time taken for prosthesis fabrication and does not rely on the skill of the technician. The involvement of the patient can also be reduced. The defect present on the patient face was able to be restored with the prosthesis. With the aid of the prosthesis, the patient can comfortably communicate and socialize with other people. Thus far, the prosthesis fabricated using CAD/CAM is satisfactory

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