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NASOFACIAL MORPHOMETRIC ANALYSIS FOR NASAL RECONSTRUCTION

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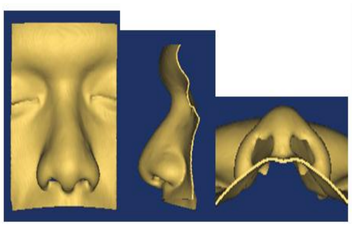
Graphical abstract



Abstract

The advances of computer aided design with powerful additive manufacturing techniques have been applied to produce the nasal prostheses. Basically, nasal reconstruction using manual technique was time consuming. The objective of this study is to measure the naso-facial parameters and to model the nasal prostheses from the CT data. The CT data were obtained from the Radiology Department in Hospital Universiti Sains Malaysia (HUSM) Kubang Kerian. Total of 30 normal healthy subjects were included to measure nasal and facial distances. The measurement of the predetermined landmarks on the nose and face were done on the 3D images using medical imaging software. Then, the virtual nose models were segmented from the entire face. Based on the measurements, the mean for the most of parameters were higher in males compared to females. The p values for most of the parameters were also significantly different. The result showed that there was sexual dimorphism in males and females for nasal characteristics. From this study, it can be concluded that this method give more advantages over the conventional methods in terms of prosthesis fabrication time and nose shape accuracy.

Keywords: Nasal reconstruction, computed tomography, nasal anthropometry, 3D image

1.0 INTRODUCTION

Nasal reconstruction is essential for patients with nose defects because of congenital, trauma or tumour. The process of nasal reconstruction is a complicated and challenging task to surgeons. Generally, there are two ways of nasal reconstruction either through reconstructive surgery or prosthetic rehabilitation. As for surgical, the surgeons used flap and skin graft techniques in order to restore the normal look of nose [1]. The used of prostheses was also applicable for nose rehabilitation by using the retention methods such as eyeglasses and implants.

The conventional method to produce the facial prostheses was by using the impression and sculpting which depends on the skill of the technician [2]. Furthermore, this method actually caused uncomfortable feeling to the patient due to material impression, time consuming and also disturbance of soft tissue contour [3]. To overcome this deficiency, computer aided technique could be utilized in facilitating the design and fabrication of the nose prostheses. Application of computer aided design and manufacturing (CAD/CAM) could reduce the time and also cut the steps in producing the prostheses [4]. Based on previous study, the total time taken for impression taking, production of stone replica, pattern design and mould production were about 10 hours. By using the CAD/CAM the time taken can be reduce up to 50% which just include the virtually design and to produce the mould [5]. The use of digital library of nose also can help the surgeon in choosing the suitable nose shape to be fitted to the patient based on the gender.

By using the CAD/CAM program, the design of the prostheses was faster which could reduce the steps compared to conventional method such as the impression and wax sculpting process. For nasal prosthesis, there were some techniques used by the researches to produce the nose model. The previous study by Ciocca (2010) used digital nose to match with the patient`s face. The digital nose was formed from the stone cast that had been digitized using the laser scanner. In this study, the utilization of computer software was used to generate the nose model from the CT data.

2.0 MATERIALS AND METHODS

In this study, 50 CT data of patients who undergone routine head scan were retrieved from the PACS server in the Radiology Department, Hospital USM (HUSM), Kubang Kerian, Kelantan. To ensure the accuracy of measurements, only normal patients were included. The patients with fractures, swellings, or malformations that affected the features of facial were excluded to avoid any inconsistencies of measurement. After the exclusion, 30 CT data were included consists of 15 females and 15 males. The age ranges were from 18 to 40 and 41 to 70 years old. These age ranges were categorized because there are differences between gender and age to be considered [6]. As for females, at the age of 18 the bones already stop growing while for male it is been stated on 20 years old.

2.1 Processing Of CT Data To 3D Image

The first step in processing the nasal prosthesis was converting the CT data into 3D image. CT data are stack of images in axial, forming the 3D images. The CT data collected was in Digital Imaging and Communications in Medicine (DICOM) file format. Then, the CT data was imported to medical imaging software known as Mimics Research 17.0 (Materialise NV, Leuven, Belgium) for further process. Mimics software uses 2D cross sectional images such as from computed tomography (CT) scan and magnetic resonance imaging (MRI) to construct 3D models, which can then be directly linked to rapid prototyping, CAD, surgical simulation and advanced engineering analysis.

Next, the CT data were converted to a mask by using thresholding technique. Thresholding values consists a few selections as it depends on what we are interested to be working on. It used default value of Hounsfield units based on bone, tissue, or skin surface. For this study, the soft tissue and skin surface was used for thresholding to form the 3D image. The 3D images of facial were generated by using the soft tissues which is the default values from 306 to 847.

2.2 Measuring Facial And Nasal Parameters 3D Images

One of the objectives in this study was to measure the distance between landmarks on nose and face. There were some landmarks that have been identified to be measured that related to nasal prosthesis as in figure 1. By using the measurement tools in Mimics software, the distances between landmarks could be measured automatically. In CT data, the bone was coloured in white, while, for soft tissue is grey. So it easy to define between these two objects.

Refer to figure 2, the measurement of distance between the predetermined landmarks of external nose includes: nasal height (nasion – subnasale), nasal length (nasion – nasal tip), nasal base width, nasal tip protusion and nasal tip projection while, the facial measurement consists of upper facial height (glabella – subnasale) and facial width (left zygomatic – right zygomatic) [7].

To measure the length between landmarks on nose and face, 3D images is suitable in viewing all those landmarks by rotating in any position to define the actual landmark points.

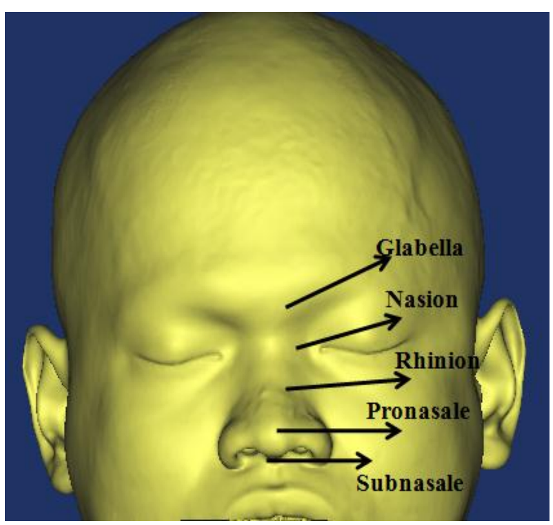


Figure 1 The predetermined landmarks on facial and nasal on 3D image

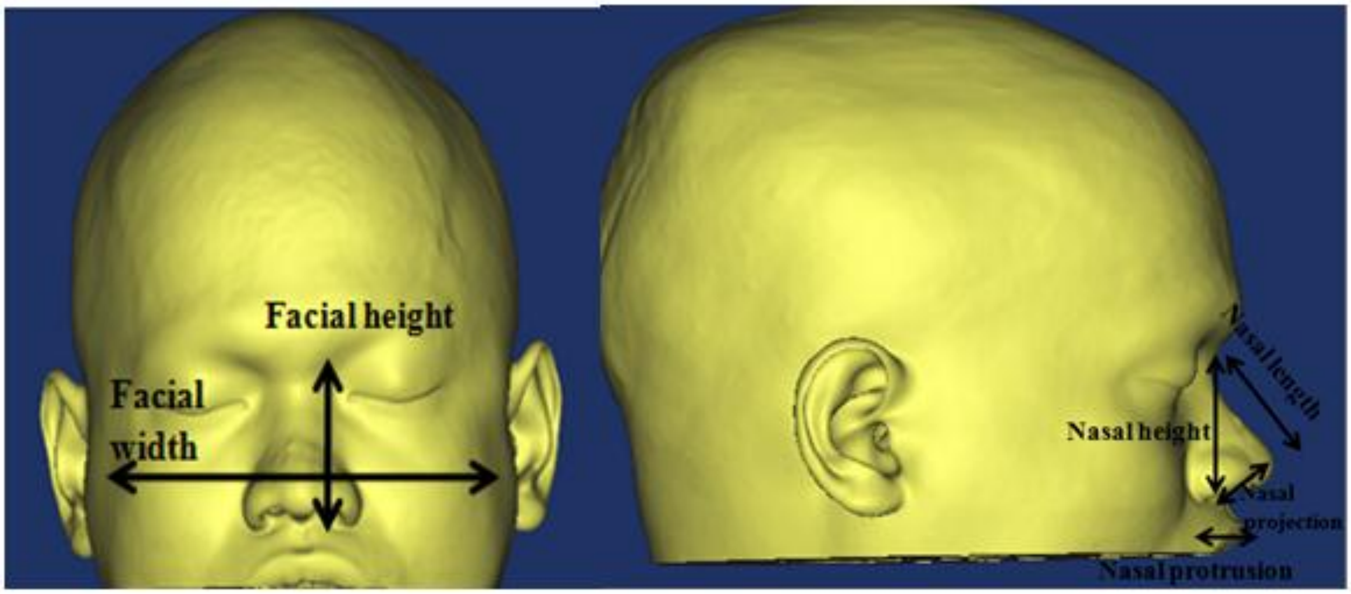


Figure 2 The distance between landmarks for facial and nasal parameters on 3D image

2.3 Segmentation On Nasal Part From 2D Mask

Thresholding values of skin tissue (adult) were used to segment only the interested region of the nose part. The selected Hounsfield values of the skin surface were from 306 to 847. After selecting the thresholding value that covers only the surface part, the "crop mask" tool was used to segment between those parts and the cropped part that was selected in the bounding box. Then, "calculate 3D"tool was used to transform to 3D images. The nose model was then formed automatically. Refer to figure 3, the view of the 3D model of nose.

2.4 Final Editing Using 3-Matic Software

The final step from the Mimics software was a 3D image of nose part. Sometimes, the Mimics software was unable to edit any defect on the image. By having this 3- Matic software, it was helpful in editing the file from Mimics that was converted to stereolithography (STL) format. The 3-Matic software able to fill holes which caused by the contrast during the scanning procedure. This software was also used to smoothen and cutting the nose based on the curve created.

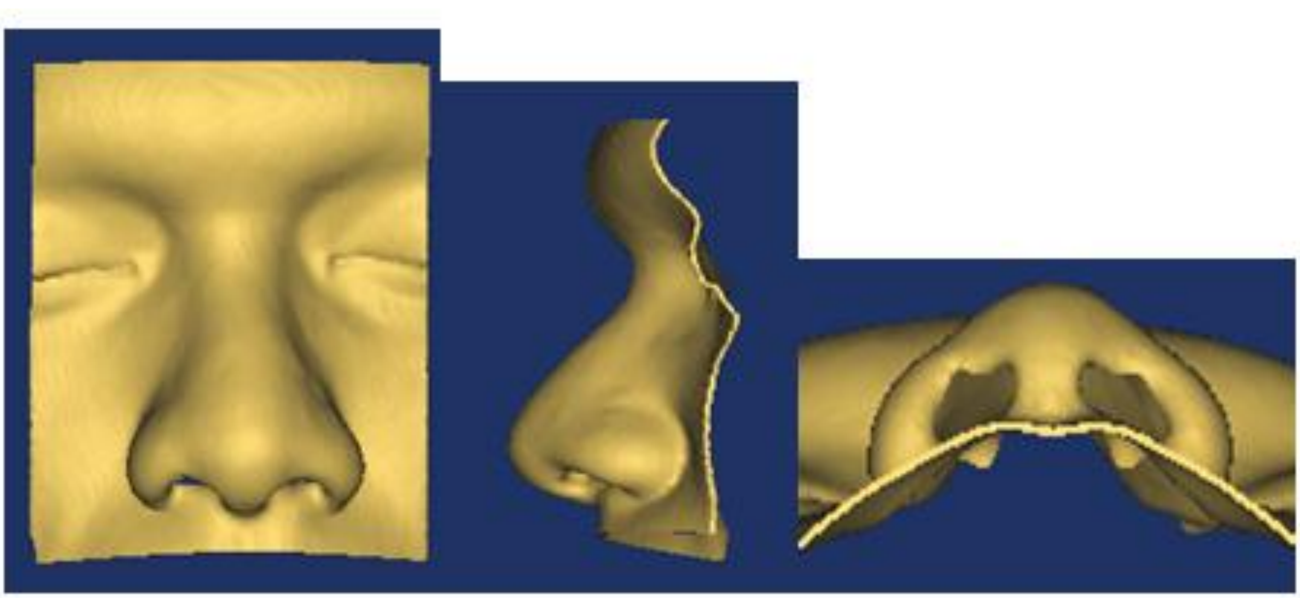


Figure 3 The frontal, lateral and basal view of 3D nose model generated from CT data

3.0 RESULTS AND DISCUSSION

The IBM SPSS Statistics version 22 was used for statistical analysis. The independent t test was used to compare the means of parameters between males and females. Table 1 shows the mean and the p value of the parameters.

Refer to Table 1, the mean values for all nasal and facial parameter were higher in males compared to females. There are some of the parameters between males and females such as nasal height, nasal length, nasal width, nasal protrusion and facial width that are significantly different where ($p<0.05$). The others parameters were difference in means but not significantly different. The mean nasal height for males were 49.75 (3.93) while females 46.45 (3.93) respectively. The nasal length for both males and females were 40.46 (3.10) and 37.35 (3.93) respectively. The nasal widths for males were 42.71 (3.49) and 39.84 (3.90) for females. The nasal protrusions were 21.62 (1.89) and 19.64 (2.17) for males and females respectively. The nasal projection for male is 19.88 (2.40) and 18.10 (2.90) for female. As for the upper facial height and facial width, the values for males were 64.81 (4.09) and 131.26 (7.83) while female is 63.19 (4.29) and 123.33 (8.40) respectively.

The development of CT scans as one the imaging modality had the advantages in nasal reconstruction. As instance in Malaysia, the nasal reconstructions still use the conventional method to model the nose. The measurement taken on the 3D images was used as a reference for choosing the suitable nose measurements to design the specific nose model for patients that come for treatments.

The measurement recorded shows that the all nasal and facial parameters were higher in males than female. Gender found to be significant in some parameters. The studied done by Mar (2015) in Malaysia showed that the parameters in males were significant compared to females. Thus, the nasal characteristics were related to the person's race, gender and other facial features [9].

This study also had some limitations. Commonly, other researchers used full head parts to analyse the data. For this study, it was difficult to collect full head part of CT data. So, the CT data that cover the predetermined landmarks were considered. In study, only the upper facial heights were measured instead of total facial height. The upper facial heights were covers from glabella till subnasale. Most of the CT data were covers from head until the upper vermilion.

Table 1 The mean and standard deviation of nasal and facial parameters for males and females.

Naso-facial parameters	Male Mean (SD)	Female Mean (SD)	p-value
Nasal height	49.75 (3.93)	46.45 (3.93)	0.012
Nasal length	40.46 (3.10)	37.35 (3.93)	0.301
Nasal width	42.71 (3.49)	39.84 (3.90)	0.077
Nasal protrusion	21.62 (1.89)	19.64 (2.17)	0.013
Nasal projection	19.88 (2.40)	18.10 (2.90)	0.043
Upper facial height	64.81 (4.09)	63.19 (4.29)	0.023
Facial width	131.26 (7.83)	123.33 (8.40)	0.024

4.0 CONCLUSION

The availability of nose anthropometry from the CT data and the virtual nose model as a reference to produce the nose prosthesis was an advantage in nasal reconstruction for Malaysia populations. In addition, the information about the normal dimensions of the nose and face would also helpful as guidance to the clinicians. In conclusion, the advance of CAD/CAM with the availability of nasal and facial measurements as well as nose model from CT data and could simplify the nasal prosthesis manufacturing thus immediately recover the defective part of the patients for better quality of life.

Acknowledgement

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