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PARAMETRIC MODELLING OF MALAYSIAN TEETH TEMPLATE USING COMPUTER AIDED DESIGN

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ABSTRACT

This study explored a new method and process of design denture using CAD technology to develop a template of a complete denture. Computer aided design were used as a tool of the design process. Occlusion curve was set up as variable as to follow patient size. The maxilla and mandible teeth arrangement were treated as a template of Malaysian user. The accuracy of design is the main aspect of concern that match the patients' data so that the outcome product would be suitable with maximum comfort for the patient. The product of design template will be matched with the conventional method to compare the tolerance between both. The new design template helps to reduce the time consumption of conventional carving method. The final output of 3D geometry teeth templates design will represent the patient details.

Keywords: CAD, denture, modelling.

INTRODUCTION

Denture is used to replace the damage, lost or removed tooth for human. There are few types of denture which have been classified as removable complete denture or sometime called as full denture, partial denture and over denture. The complete denture is used for people missing all teeth and the partial denture over denture both are adaptations of the basic process in the removable complete denture. Report from Malaysia Ministry of Health, Malaysia have 3 million denture users and among the highest in Asia. Where, about 58 percent is the elderly more than 50 years (Kementerian Kesihatan Malaysia, 2003). Currently, the elderly population those aged 60 and above has increased due to a longer life expectancy, the quality of life and better medical facilities (Ibrahim, 2011). Following that, it shows the denture demand has increased from year to year. However, the problem occurs currently when the demands of consumers and the services provided by the dental clinic are quite slow due to lack of skilled staff in Malaysia. This is because the existing conventional techniques of denture process that used in the current dental clinic require a relatively long period of time to complete each denture. Therefore, the improvement of denture design process was selected in this study to solve several problems observed in the conventional denture process. The generation of 3D surface parametric model of the new customized complete denture for new design template. Many efforts have been carried out to improve the denture process, including the development of a new CAD system for denture design (Sun *et al*., 2009) and integration of CAD/CAM and CNC for denture tooth fabrication (de Boer *et al*., 2011). Development of dental technology currently is not only grow specialized in denture production, but it was spread to the whole of dentistry field. Several dental treatment and implant surgery guide as digitally. There were highly sophisticated methods that ability to save time and work space to make a diagnosis on patients (Gao, 2014). In fabrication, there was also a development in rapid manufacturing for implant framework directly using selective laser melting (SLM) by Gideon (Gideon and Schindel, 2003). Although progress has already been reported elsewhere in the literature concerning the design and fabrication, significant gaps in the technology still existed in the implementation in Ministry of Health Malaysia.

Denture design

Background

This study describes a 3D optimization of product design, focusing on denture design of removable complete denture. The materials, tools and method were an important aspect to be reviewed in designing process of the denture design. Computer aided design (CAD) systems are usually known for their fast, interactive response and graphic display (Ibrahim, 1991). Thus, by understanding the function and application of the CAD system in designing products or models was crucial in order to achieve the objective of the study. Finding the best-suited tool were most important

Removable complete denture

Removable complete denture is a dental prosthesis which replaces the entire dentition and associated structures of the maxilla and mandible. A complete denture functions to restore aesthetics, mastication and speech. For aesthetic reason, the complete denture should restore the lost facial contours, vertical dimension and so on. While, a complete denture should have a good balanced occlusion in order to enhance the stability of the denture for functionally (Mastication). Then the phonetics are one of the most important functions of a complete denture is to restore the speech of the patient (Veeraiyan *et al*., 2009).

a) Complete Denture **b) Removable Partial Denture** **c) Implant Denture**

Figure-1. Types of denture (Deadwood, 2008).

Occlusal and teeth arrangement principles

Occlusal and teeth arrangement principles are very important in the preparation of denture setup. On occlusal principles, it depends on anterior guidance which refers to the dynamic relationship of the lower anterior teeth against the lingual contours of the maxillary anterior teeth in accentric, long centric and their protrusive, lateroprotrusive and lateral excursions. Together with the centric relation and vertical dimensions, anterior guidance must be regarded as the most important in reconstructing the stomatognathic system (Jambhekar *et al.*, 2009).

Maxilla tooth position and arrangement

Figure-2 shows the position of maxilla anterior teeth was identified by following the principle of teeth arrangement. There were demonstrated to define the maxilla anterior teeth location. The central incisor tooth viewed from the anterior presented the long axis was slightly inclined to the labial of the lateral view. Then the edge of the incisal contacted to the horizontal plane. The horizontal planes for all maxilla teeth are similar to the occlusion plane. While, the lateral incisor from the anterior view presented the long axis was inclined towards the middle line of the mouth, and the labial tilt is more than central incisor teeth when it's viewed from the lateral. The incisor edge is 2 mm higher from the horizontal plane. The canine tooth presented the long axis was parallel to the vertical axis if viewed from the anterior and lateral view (Rahn *et al*., 2009). The cusps are in contact with the horizontal plane.

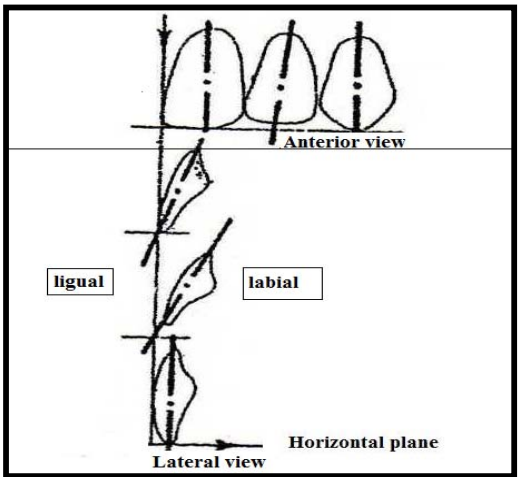


Figure-2. Relationship between maxilla anterior teeth with horizontal and vertical axis (Rahn *et al*., 2009).

Figure-3 shows the maxilla posterior of teeth principle arrangement. The first premolar teeth demonstrated from anterior and lateral view which the long axis is parallel to the vertical axis. The ligual cusp is 0.5 mm higher from horizontal plane and buccal cusp contacted to the horizontal plane. Then, the second premolar presents the teeth viewed from anterior and lateral, and the long axis was parallel to the vertical axis. However, the both buccal and ligual cusps were contacted to the horizontal plane. Furthermore, the first molar teeth presented the long axis was inclined to buccal if viewed from anterior and slightly inclined to distal if the view from lateral. It is only their mesio ligual cusp contacted to the horizontal plane and disto buccal cusp is 0.5 mm or more higher from horizontal plane. While, the second molar presented the long axis is more inclined to buccal if viewed from anterior and more inclined to distal if a view from the lateral compared to first molar teeth. Then the four cusps are not in contact to the horizontal plane, although the mesio ligual cusp nearly to the plane(Rahn *et al.*, 2009)

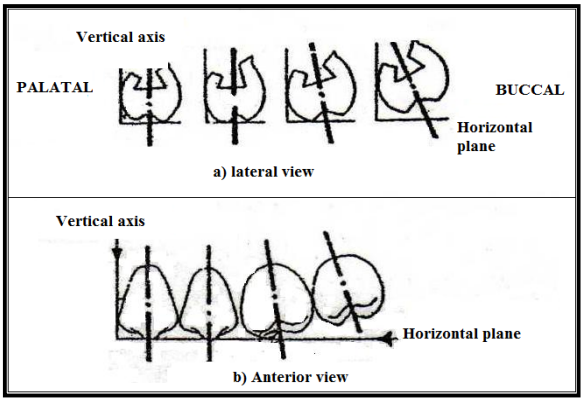


Figure-3. Relationship between posterior teeth with horizontal and vertical axes in a) lateral view, b) anterior view c) anterior view (Rahn *et al.*, 2009)

Mandible teeth position arrangement

Proximal views of the mandible anterior teeth indicate average Anteroposterior tendencies to a horizontal plane as shown in Figure-4 Mandible anterior teeth are an integral part of the aesthetics and phonetics for complete dentures. Crowding and/or irregularity in the position of the lower anterior teeth generally mirrored conditions that exist in the upper arch. However, lower anterior teeth are usually more crowded and irregular than upper anterior teeth with a similar condition. (Morrow *et al*., 1969). The mandible anterior reference lines had been established by referring on the proximal view and the mandible teeth position manual.

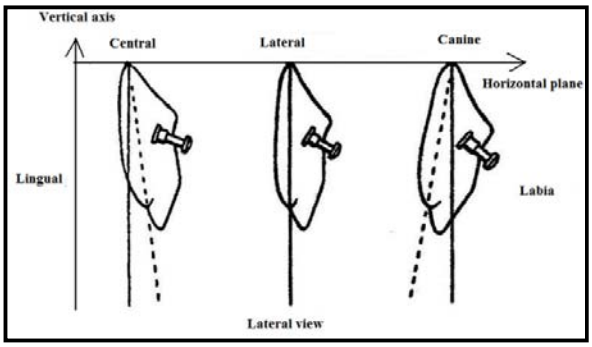


Figure-4. Proximal view of lower anterior showing average anteroposterior inclinations to horizontal plane (Morrow *et al*., 1969).

In order to consider the arrangement of the mandible anterior teeth, the front view of the lower anterior teeth shows they have been arranged in an average horizontal alignment of their incisal edges as shown in Figure-5. The long axes of the central incisors are perpendicular to the plane. The long axes of the lateral incisors incline slightly distally at the neck. The long axes of the canines incline still distally at the neck (Morrow *et al*., 1969).

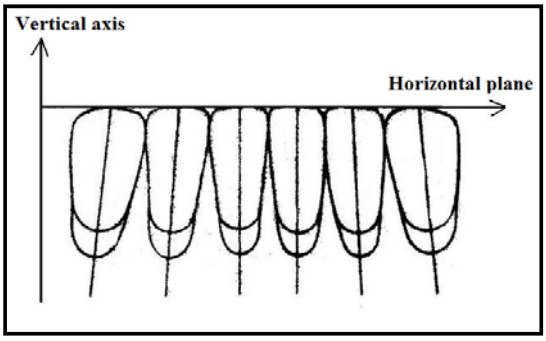


Figure-5. Mandible anterior teeth arrangement consideration (Morrow *et al.*, 1969).

Overbit and overjet position

The horizontal plane used for aligning the mandible anterior teeth may be above the actual occlusion plane. A distance about 2mm of teeth usually described as the vertical overlap or overbite. The vertical and horizontal plane and overlaps in the vertical plane are also called overbit while in a horizontal plane called overjet (Morrow *et al*., 1969) as shown in Figure-6.

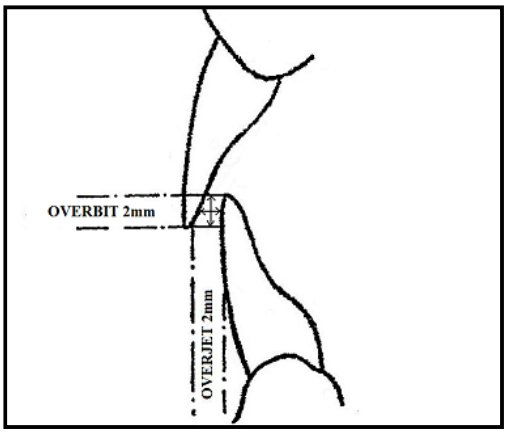


Figure-6. Overbit and overjet (Morrow *et al.*, 1969).

Contact point on chewing surface

Figure-7 shows a plan view on upper and lower jaws that showing the deposition of the contact point on chewing surface of the teeth (Moenckmeyer, 2003). The contact points are very important to determine the produced dentures will function efficiently to users.

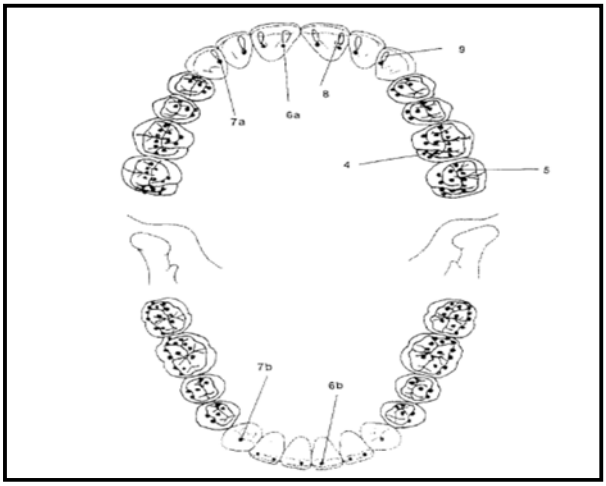


Figure-7. Contact point on chewing surface of teeth (Moenckmeyer, 2003).

Design consideration

The main software used in CAD step was Solidwork 2013, (Dassault System). It could be applied to the designs that have many complicated 3D objects. The object designed can be displayed in 3D, moved, and rotated along any axis. The software provides abundant tools for designing 3D profile, line/curve and surface.

Variation of occlusion size analyzed to obtain occlusion curve where it is the main parameter used for tooth assembly. Impression samples of maxilla and mandible edentulous denture have been recorded by digitizing the occlusion point using 3D imaging process.

From the data collected, ten points of occlusion point were selected to be the standard measurement for the dental technician to mark the point of occlusion curve and

thus generated by other software and be the main parameter of occlusion.

With CAD software used, templates of smile library of tooth arrangement based on the theory of teeth arranged. The occlusal plane will semi- automatically defined and the curve for setting up teeth will be overlap from main occlusion curve.

STEP OF DESIGN DESCRIPTION

The design procedure should be taken into consideration as to make it as simple as possible. The step taken is to ensure the method will not collide with each other.

Creating main occlusion curve

Ten positions selected were identified from molars, premolars, canine and central incisor based on the patients anatomy. The data obtained will be used to produce imaginary occlusal plane on the main assembly on the cad software as Figure-8.

Creating parameters for each tooth

By using spline feature, an imaginary curve produced for teeth arrangement in the assembly. Teeth CAD model were obtained from scanning and made as the template for this study. The free curve line was the base for the teeth mate when assembled with the main curve, the spline will fit with the main curve.

Each teeth coordinate system orientation was setup so as to make it accordance to the assembly. The cusp end edge of the teeth surface was set as the origin of the coordinate system. The coordinate system was defined so as to make sure it follows the height of contours.

Mating of the arrangements

Each mating for each component was arranged accordingly to avoid overlapping between mating, using path mate the teeth fixed along the spline curve following the coordinate system. Limitation on the conventional software limits the freedom of design method we can apply. A perpendicular construction line was setup using 3D sketch method to be the reference line for mate angle as Figure-9b. This design was set for ten degrees of slope from vertical axis based on anterior teeth theory as on Figure-9a.

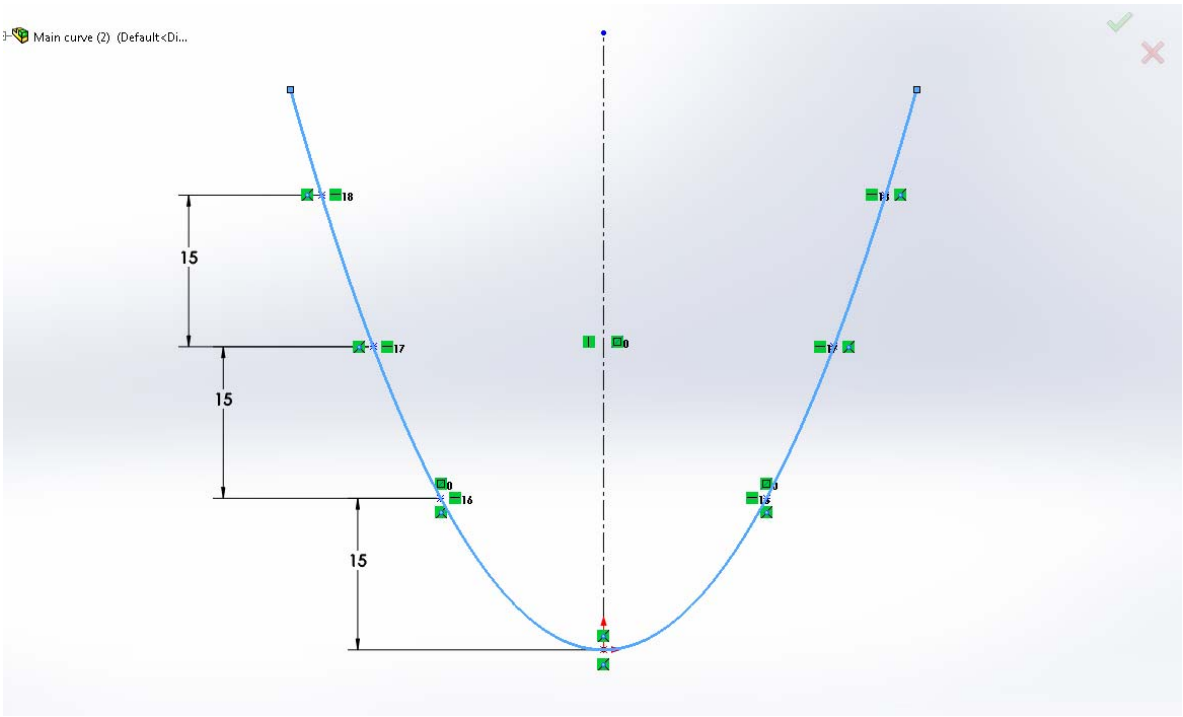
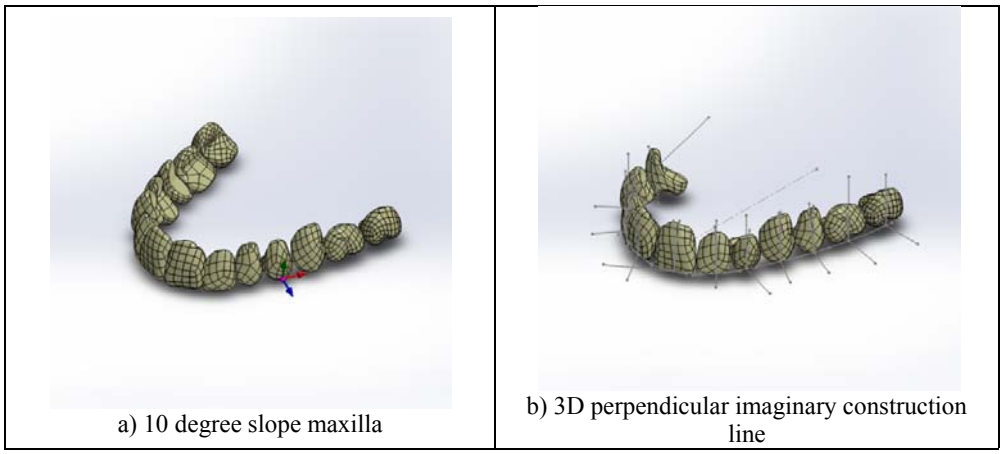


Figure-8. Main curve of imaginary occlusion curve.



a) 10 degree slope maxilla

b) 3D perpendicular imaginary construction line

Figure-9. Maxilla teeth arrangement.

CAD TEETH TEMPLATE

The development of the teeth template is still in progress thus a lot of study still have to be taken into consideration. The most suitable point of selection for each patient to be specified to meet the patient best comfortable. This study is possible with the existing conventional software used.

By far the template done were the variation of 5° degree and 10° degree from the vertical axis of maxilla anterior teeth. Based on the advised of the expert in dentistry few considerations will be taken to ensure suitable arrangement of teeth before final template be set as library.

CONCLUSIONS

The design process taken in this study still in develops and few verification still have to be taken in consideration to improvise the method.

The new design template should have the library data suited to apply to Malaysian user. The teeth assembly produced according to practices of the dental procedure. The restriction due to conventional cad software limits the potential of the design template produced.

The future design development has to be explored in order to maximize the existing software potential thus outcome suited with the objective of this study.

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