Preliminary Study of Dental Model Rebuilding Base on Reverse Engineering Technology

Qingyong Lu[1, a], Shan Zhong[1, 2, b, *]

[1]School of Mechanical and Control Engineering, Guilin University of Technology, Guilin Guangxi 541006, China

[2]School of Mechanical and Control Engineering, Wuzhou University, Wuzhou Guangxi 543002, China

[a]1187136197@qq.com, [b]1356152731@qq.com

*Corresponding author

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Abstract: In this paper, the dental digital design is studied by combining software and experiment. Based on reverse engineering technology, this paper uses 3D scanner to collect point cloud data of tooth model, and explores the characteristic line and surface of denture surface. The design process of denture was explored and the missing tooth model was reconstructed. Compared with clinical crowns, this paper mainly explores a digital oral design method.

1. Introduction

Reverse engineering (RE) can play a promising role in reducing the product development time. Reverse engineering of physical objects is to extract information from objects that can be used for specific purposes, such as replication or redesign. The process of reverse engineering is to restore the geometric information of a physical object from its size measurement [1].

The defects of the teeth and dentition are a common and frequent disease, which can be repaired with fixed dentures. With the advent and spread of RE, computer-aided design and computer assisted manufacturing (CAD/CAM) , for fixed restorations during the 1980s, it was only a matter of time before this technology was applied to removable prosthodontics, and researchers began to solve the challenges involved with CAD/CAM dentures [2-6].

In the 1970s, Duret et al [7-8] first introduced the technology of Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) into dentistry and invented the commercially available Sopha system in 1983. Subsequently various systems represented by Sopha, Rekow, CEREC, Denti CAD and Procera appeared. Typical dental restoration systems abroad include the German Cerec system and the Procera system. In China, Lv Peijun's research group do a lot of study and application about advanced manufacturing technology (CAD/CAM/RP) and related materials in dental repair [5-6]. All CAD/CAM systems have three functional components: 1) digital tools/scanners that convert geometry into digital data that can be processed by a computer; 2) device systems integrate CAD software for processing scanned data; 3) manufacturing techniques, utilization the data set transforms it into the desired product

The traditional process requires experienced prosthodontists or general dentists, skilled dental technicians, and numerous office visits, which takes substantial time. The use of RE and CAD/CAM technology to make dentures can greatly shorten the treatment time, which make the work more efficiency and maintenance quality compared with traditional process. It has a profound impact on the theory and practice of dental restoration.

The purpose of this study was to introduce a method base on RE and CAD to design denture crown.

2. Tooth Model Construction Process Based on Reverse Engineering Technology

In this study, the point cloud data of dental model was obtained by scanning the plaster model. The dental plaster model of the patient was obtained through precise impression, filling and tooth preparation by the stomatologist and technician. The edentulous CAD model is the data basis for the design of crown fixed bridge.

CAD model and clear abutment margin is the key factor for the success or failure of the prosthesis design. As shown in Figure 1, 3D Scanner was used to scan the tooth mold, to obtain the point cloud data, and Geomagic software was used for the preprocessing of point cloud data, which was then converted to STL format and saved for CAD design.

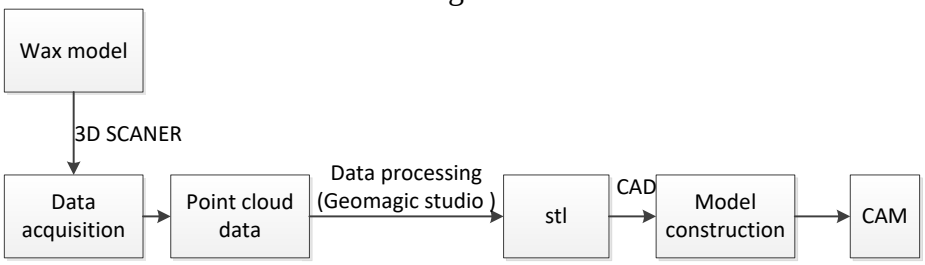

Figure 1. The process of the denture prosthesis' design

2.1 Data acquisition and pre-processing

2.1.1 Data acquisition

This research acquire the data of the teeth model from the three dimensional scanning device (Heraeus Kuler). The process is shown in Fig.2

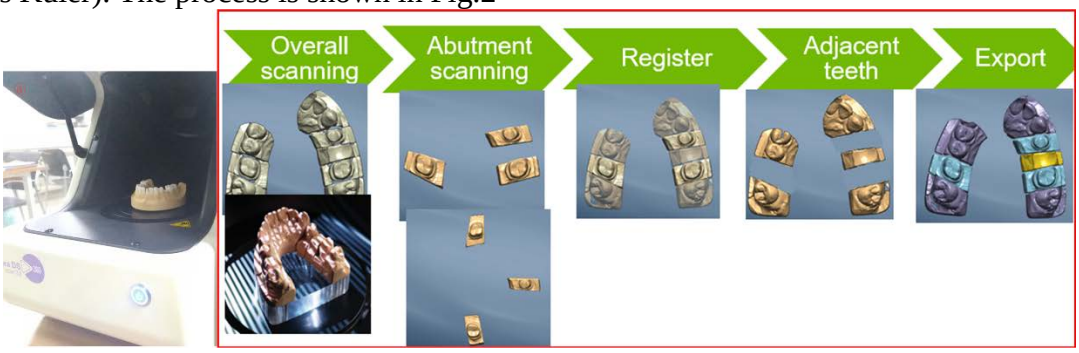

Figure 2. Data acquisition process

2.1.2 Data pre-processing

After scanning, the model data of each shell is stored in the computer as point cloud of multiple angles. So to remove noise data and redundant data, it is necessary to use Geomagic Studio to pre-process as follows: (a)Delete noise points; (b) Feature matching ;(c) Automatic Flatten;(d) Data Fusion.

2.1.3 Tooth Model Construction and Design

After the data pre-processing, the teeth model is transferred into STL (Stereo Lithography) format. The it is imported to CAD softer to construct and design the denture crown. The process is shown in Fig.3

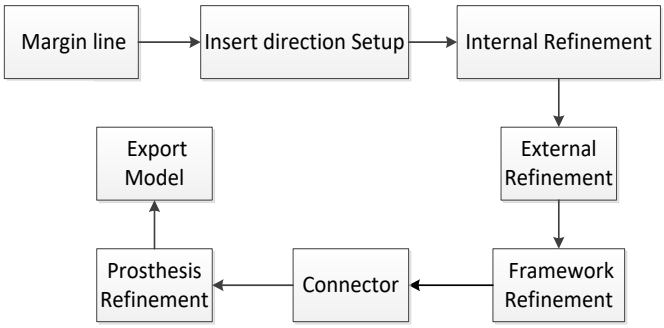

Figure 3. Modeling Steps for denture Crowns and Bridges

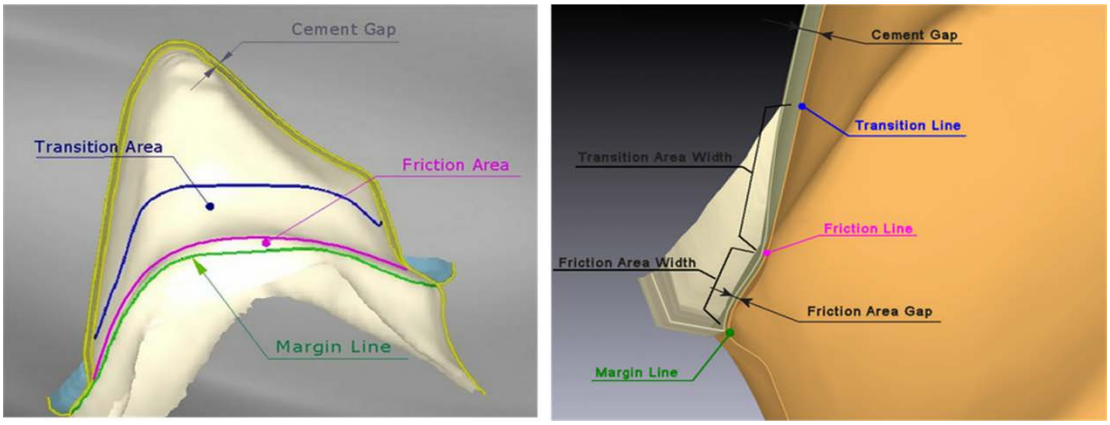

Figure 4. Tooth Properties

(1) Margin Line Setup

In this Step the DentalCAD shows the Margin Line calculated on the Stump in green, and the boundary of the variable offset transition area, the Transition line, in blue(Fig. 5).

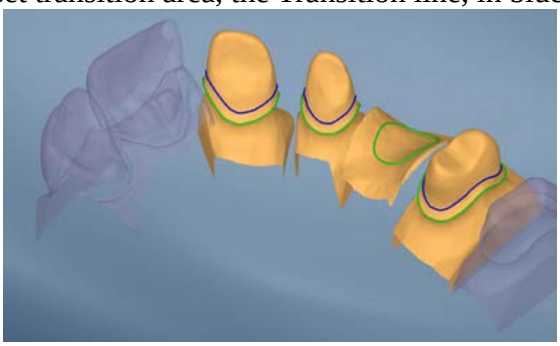

Figure 5. Margin Line

(2) Insertion Direction Setup

In this step, the occlusal direction and Stumps or Bridges insert direction is set up.Fig.6 a shows for each Stump the Insert Direction. Green arrows are used for the active Stumps or Bridges, red one for all the others. What's more, the Undercuts area, Margin Line Protection area and Outside Margin Line area is signed so as to design correctly and fit for biomechanics? As is shown in Fig.6 b, the stump surfaces are also colored and follow the below color code: 1) Brown: Undercuts area. Undercuts are identified against an Insertion Direction which minimizes them. A Quality indicator will be shown, as a visual meter of the surface percentage resulting as undercut against the selected direction; 2) Blue: Margin Line Protection area, this is the area of the Stump where the projection falls outside the Margin Line. In some situation the compensation of the Margin line Protection can separate the Internal Shape surface and the Margin ring from the Stump? In Fig. 7 an example where it is shown, in an exaggerated way, the phenomenon; 3) Red: Outside Margin Line area

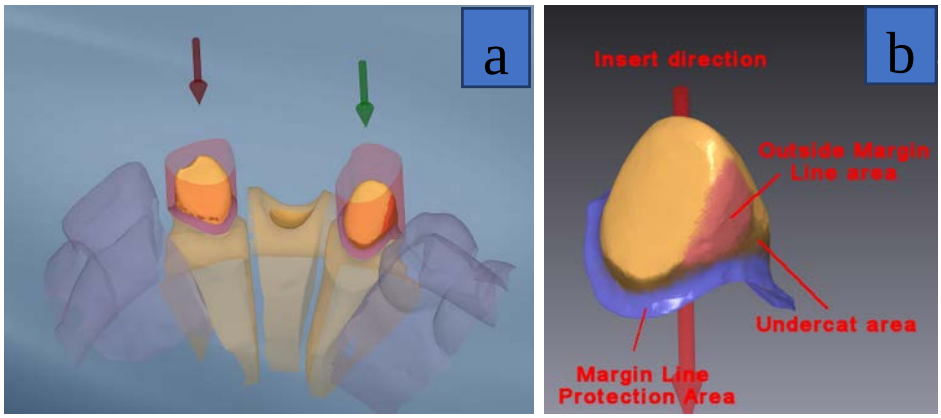

Figure 6. Insertion Direction Setup

(3) Internal Shape

This step shows the surface resulting from the application of the offset with the parameters described in the previous section. Margin Ring and Internal shape are created at the same time. The SCULPT SHAPE is an advanced way to modify the morphologic shape of a mesh dynamically.

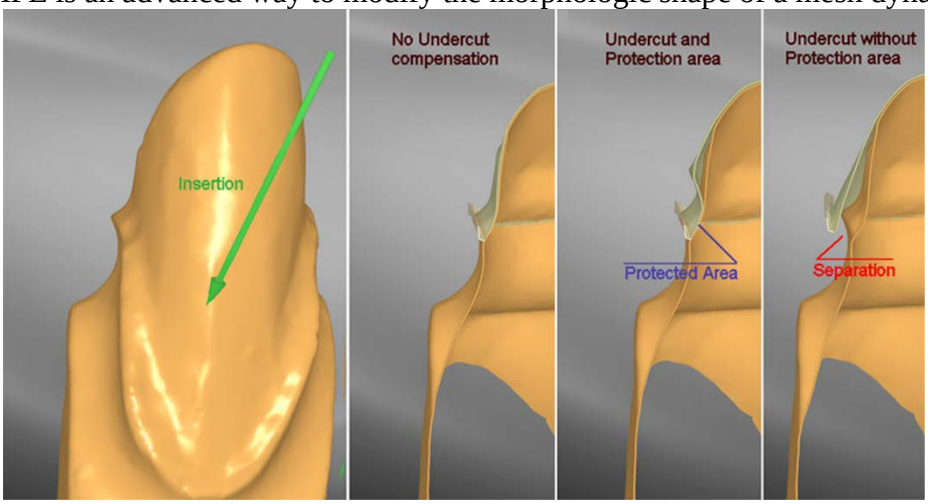

Figure 7. Some situation of Margin Line Protection area

(4) External Shape

In this step DentalCAD gets anatomic shapes from library and places them on arc jaw. In order to verify the right anatomic position DentalCAD shows the Reference Coping, in red color. The reference coping is a shape representing the minimum thickness of the prosthesis. No intersection between External Shape and Reference Coping should be tolerate, just as shown in Fig.8.

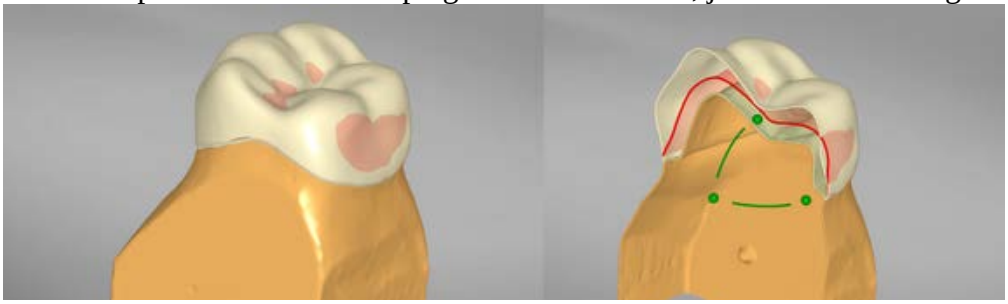

Figure 8. The right anatomic position of denture

(5) Framework Shape

The inner crown was added/reduced and smoothed with free-form tools, so that the wall thickness of the inner crown was uniform and the surface was smooth. The result of Framework Shape can be seen in Fig.10.

(6) Setup Connectors and Prosthesis Refinement

The Connector surface is always created between two adjacent Framework teeth. In this Step the connectors surface are created and sewed to the teeth Framework, the result is shown in Fig.9

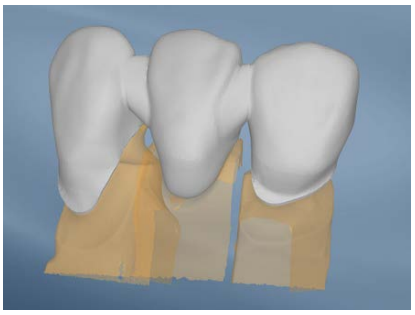

Figure 9. Connectors and Prosthesis Refinement

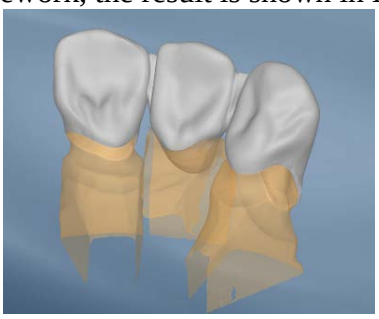

Figure 10. The construction teeth model

(7) Export

The final model can be seen in Fig.10

3. Conclusion

Compared with the traditional labor-intensive process in dental laboratory, computer analysis of the data obtained from laser-scan; provide the accurate individualized data which was used to design a custom-fit via CAD. In addition, the CAD process can save much time and improve quality control in the dental laboratory.

The digital restoration technique represented by three-dimensional scanning and three-dimensional (3D) printing has improved the digital workflow of restorative treatment and compensates for the shortages of the manual techniques, but there are still many limitations in the application of complete dentures[9,10]. At present, a few computer aided design and computer aided manufacture (CAD/CAM) complete denture systems have been developed both domestically and abroad, and these system are mainly focused on the digital design and manufacture of denture, and are seldom used for the recording of impression and jaw relation [11].

In this study, the theory and method of computer aided design of fixed crown bridge are explored, and a complete design route of Crown Bridge is formed. A surface model that meets the requirements of CAD/CAM system is obtained. The denture with artificial teeth performs well on the clinical applicability and is easy to popularize and apply. In a word, this new method has the possibility to reduce inter-operator variability, and increase speed and economy over traditional handcrafting method.

Acknowledgments

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References

[1] Zhang Lei, Wang Heng, Xu Hai Li. Application of the Reverse Engineering to 3D Reconstruction on a Denture. Advanced Materials Research, 2012, 490-495: 2032-2036.

[2] J. Bryan McLaughlin DMD, MPH, Van Ramos Jr. DDS, Douglas P. Dickinson PhD. Comparison of Fit of Dentures Fabricated by Traditional Techniques versus CAD/CAM Technology. Journal of Prosthodontics, 2019, 28 (4).

[3] Goodacre CJ, Garbacea A, Naylor WP, et al: CAD/CAM fabricated complete dentures: concepts and clinical methods of obtaining required morphological data. J Prosthet Dent 2012;107:34-46

[4] Parsell D. Effect of camera angulation on adaptation of CAD/CAM restorations. J. Esthet. Dent. 2000, 12.

[5] Peijun Lü, Li Y, Wang Y, et al. The research and development of CAD-CAM system in restorative dentistry. Zhonghua kou qiang yi xue za zhi = Zhonghua kouqiang yixue zazhi = Chinese journal of stomatology, 2002, 37 (5): 367-70; discussion 370.

[6] Wang L, Tang Y, Dong J, et al. Denture feature modeling and processing by reverse engineering technology — A case study [C] // International Conference on Mechatronic Sciences. IEEE, 2014.

[7] Duret F. CAD/CAM in dentistry. J Amer Dent Assoc, 1988, 117 (7): 715-720

[8] Hotta Y, Miyazaki T. CAD/CAM systems available for the fabrication of crown and bridge restorations. Australian Dental Journal, 2011, 56 (s1): 97-106.

[9] Lin, W., Zandinejad, A., Metz, M., Predictable Restorative Work Flow for Computer-Aided Design/Computer-Aided Manufacture–Fabricated Ceramic Veneers Utilizing a Virtual Smile Design Principle. Operative Dentistry, 40 (4), 357–363. doi: 10.2341/13-295-s

[10] Shereef Shahen, Gennaro Carrino, Rossella Carrino, Palatal volume and area assessment on digital casts generated from cone-beam computed tomography scans. The Angle Orthodontist 2018 88: 4, 397-402

[11] Kawai, Yasuhiko, Muarakami, Hiroshi, and Feine, Jocelyne S. "Do traditional techniques produce better conventional complete dentures than simplified techniques? A 10-year follow-up of a randomized clinical trial." Journal of Dentistry 74 (2018): 30-36.