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The accuracy assessment of dental traditional and digital impression methods

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Abstract

Objectives: This study aimed to evaluate the accuracy and availability of different scanning technologies, including the conventional impression, oral, and CBCT methods. **Materials and Methods:** An artificial model was used as the basic model. The basic model was scanned to obtain the standard model. The basic model was subjected to CBCT scanning, intraoral scanning, and traditional impression five times, respectively. Finally, the obtained scanned STL file information was compared with the standard model and analysed for accuracy differences. **Results:** The overall error of the CBCT method was 0.67 mm ± 0.13 mm, the general error of the traditional impression method was 0.62 mm ± 0.15 mm, and the overall error of the digital oral scan was 0.86 mm ± 0.32 mm, the precision of the conventional impression method is higher than others. **Conclusions:** The accuracy of dental impression information through digital and traditional scanning techniques. Clinical Relevance Traditional impression methods have higher accuracy than digital oral scanning and CBCT methods, but all three can be used for denture restoration.

Keywords: CBCT scanning ▪ oral scan ▪ traditional impression ▪ accuracy

Introduction

In clinical statistics, the global market value of dental prosthetics has been over €10 billion and continues to grow according to the demand for superior aesthetic restoration [1-3]. However, to obtain a prosthetics restoration, the dental impression is a crucial step [4-10]. Traditionally, prosthetic restorations are made on stone casting based on the conventional impression. Although the traditional impression has a good result in prosthetic restoration, some risks generally exist. The quality of the impression procedure heavily relied on the dentist's experience and quickly involved stone casting and prosthetics restoration fabrication. Besides, the stone casting might change material properties due to the storage environment, affecting the prosthetics restoration fabrication [11]. Digital technology has been increasingly used in dental treatment [11-13]. The dentist can accurately evaluate the symptoms through digital technology and shorten the treatment time. For the ideal impression information, digital image scanning technology is developed. The desktop scanner (indirect impression), using a 3D laser or a white light, is considered a standard procedure and widely used in clinical applications to digitize the oral structure [13-15]. The desktop scanner digitally records oral information and reduces the property of material variation of stone casting. The CAM machine can virtually design and manufacture the prosthetics restoration through the three-Dimensional (3D) data from stone casting. Nonetheless, desktop scanners are primarily used in the dental laboratory and rarely in the dental clinic [15,16]. The intraoral scanner (direct impression) has been increasingly used to obtain digital impression information quickly and conveniently [7,17].

The dentist can intuitively operate the intraoral scanner to get information about the oral circumstance. Compared to the desktop scanner, the intraoral scanner does not need stone casting and can be performed in the clinic office anytime. In addition, the image quality of the intraoral scanner has been obviously improved and reduced the scattering problems due to the human tissue fluid by optical design. However, there are still some limitations in the operation of the intraoral scanner, such as significant deviations at the distal ends with full-arch scan, long chair-time operating for scanning, and high price for use [18].

Cone Beam Computed Tomography (CBCT) has recently been commonly used for dental treatment applications because of its high image quality. The dentist understands the oral structure through different CBCT image slices and uses the CBCT images to render the 3D virtual model for spatial diagnostic judgment. The impression model could be accurately formed from the actual stone model by setting suitable triangular mesh. The CBCT also supplies a similar way to desktop and oral scanners for oral model obtaining and is increasingly used in clinical

applications [19,20].

Investigating the different scanning technologies for accurate impressions is a pertinent concern in clinical practice. However, the related system investigations between other scanning technologies for the accuracy evaluation still need to be improved. Thus, this study aimed to evaluate the accuracy and availability of different scanning technologies, including the conventional impression method, oral scan method, and CBCT method.

Material and methods

An artificial edentulous dental mandible model was used as the basic model. A desk scanner digitally converted the primary model into a standard model. The model was then subjected to CBCT scanning, intraoral scanning, and traditional impression five times, respectively. Finally, the obtained scanned STL file information was compared with the standard model and analyzed for accuracy differences.

▪ CBCT scanning

The primary dental model was taken using the Cone Beam 3D Imaging System (TCT, Kaohsiung, Taiwan). The parameters of CBCT scanning were set at 120 kV, 10 mA, and a voxel size of 0.2 mm. The CBCT image data were imported into the MIRDC Dental software (Metal Industry Research Centre, Kaohsiung, Taiwan) for implant planning. The MIRDC Dental software can display 2D images, interrelate a 3D reconstruction model from the CBCT images, and contain an implant library that enables dentists to plan surgery preoperatively. The HU number was set as 1500 to construct the 3D information of the primary dental model and input it as an STL file (**FIGURE 1**).

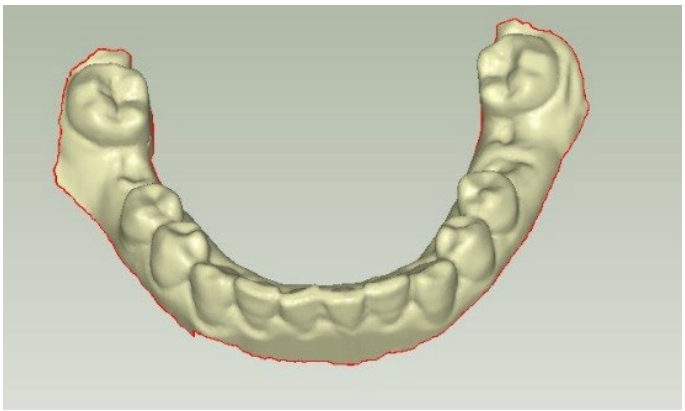

FIGURE 1. The dental model from CBCT.

▪ Convention impression method

The dental model was duplicated by the traditional impression method. The primary process was the following:

- The basic model was to make an impression with precision impression materials.
- and then turn the model procedure, the impression material is filled with plaster.
- Wait for the plaster material to harden, and then separate the tooth model.
- Repeat the above process of turning over the mold to make five sets.
- Use the extraoral desktop scanner IScan L1 dental scanner (IScan L1, Imetric 3D SA, Courtenay, Switzerland) scans the plaster model and obtains its scanning information STL file (**FIGURE 2**).

FIGURE 2. The dental model from the traditional method.

▪ Oral scanning method

The digital model was obtained by digital oral scanner method; the primary operation process is the clinical technician directly scans the dental model with the intraoral scanner, repeat the above scanning process for five groups and obtain the scanning information STL file (**FIGURE 3**).

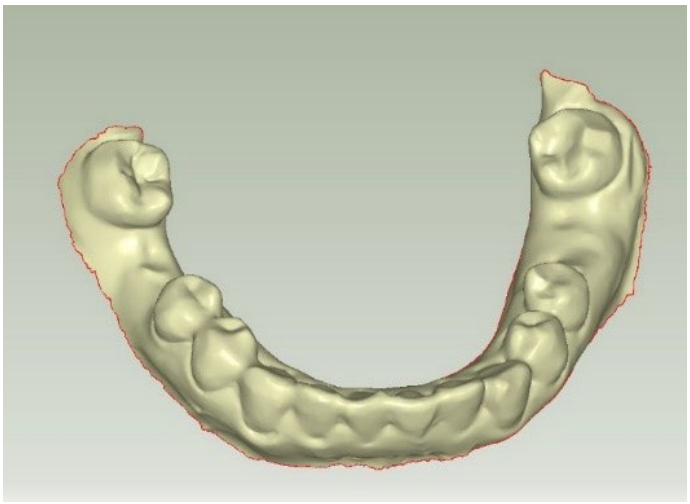

FIGURE 3. The model from the oral scanner.

▪ Data analysis

The accuracy comparison was evaluated in the accuracy calculation module of MIRDC dental software, which can read STL scanning information and perform shape superposition according to the model's mesh characteristics. The STL file of the standard model was compared with the scanning model obtained from CBCT, traditional impression, and oral scanner through the rough positioning and acceptable positioning

procedures (Best fit alignment), and finally, the error of the overall model calculation (**FIGURE 4**).

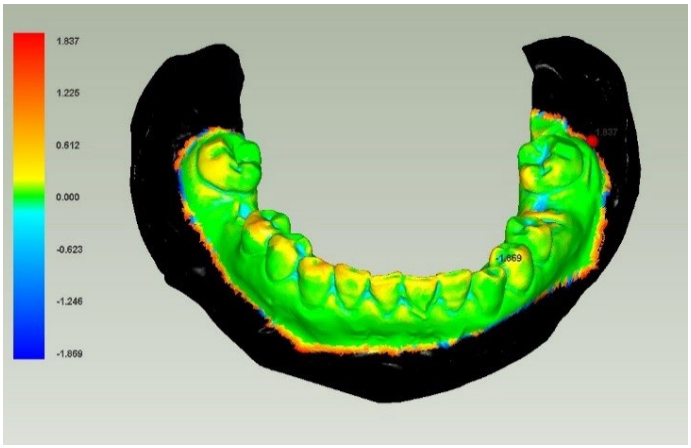

FIGURE 4. The accuracy assessment by MIRDC software

Results

The characteristics of the CBCT, traditional, and digital dental model information in this study are compared with the standard model. According to the analysis of MIRDC dental software, the overall error of the CBCT method was 0.67 mm ± 0.13 mm, the overall error of the traditional impression method was 0.62 mm ± 0.15 mm, and the overall error of the digital oral scan was 0.86 mm ± 0.32 mm. The precision of the conventional impression method is higher than the others.

Conclusion

This study compares the accuracy of dental impression information through different digital and traditional scanning techniques. Traditional impression methods have higher accuracy than digital oral scanning and CBCT methods, but all three can be used for denture restoration.

Digital scanning technology has been paid more and more attention to in the dental treatment process. From the results of this study, the traditional impression method has high accuracy. It can be found that the dental mold can be accurately reprinted through precision impression materials. Precision impression materials are commonly used in the production of dentures, and the cost is also low. Although the CBCT scanning method has a certain degree of accuracy, it still has HU value-setting restrictions during operation. Different HU value settings may lead to other 3D models, which are more direct than the traditional impression method. Reflect on the actual situation of the oral cavity. However, because the intraoral scanning method can reduce the production of impression materials and plaster models, it has been gradually used in dental impression-taking in recent years, and its accuracy has been continuously improved. In this study, the error of intraoral scanning is 0.86 mm, slightly lower than the traditional impression method, but some parts can still be explored.

- Environmental error: since the digital scanning method used in this study is to scan directly with the basic model of the scanner needle, since the model is placed in a general external environment, compared with desktop scanning in a closed scanning environment, it may be affected by external factors. The light interference produces scanning errors.
- Scanning process error: In this case, the scanner needs to manually scan the tongue and buccal side of each part of the dentition. The computer will continuously reorganize the model information, which may affect the scanning accuracy due to the operation process.

Disclosure of potential conflicts of Interest

▪ Funding

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▪ Conflict of interest

The authors declare no conflict of Interest. This article contains no study with human participants or animals performed.

▪ Author contributions

C-C Tseng contributed to the conception and design of the study. Y.Y. Cheng wrote the first draft of the manuscript. Both noted the sections of the manuscript and organized the database. All authors have read and agreed to the published version of the manuscript.

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