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TRUENESS OF DIFFERENT SCANNING METHODS FOR ACQUIRED MAXILLARY DEFECT: AN INVITRO STUDY

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ABSTRACT

Purpose: This study investigates the trueness of three different intraoral scanning methods using intraoral scanner for acquired maxillary defect compared to extraoral scanning method using desktop scanner.

Materials and Methods: A cast of an acquired maxillary defect was duplicated to ten casts (n=30), each duplicated cast was scanned using desktop scanner as a reference data, then each cast was scanned using intraoral scanner performed by three different scanning methods as measured data. The STL (Standard Tessellation Language) file of the desktop scanning method is compared to the STL (Standard Tessellation Language) files of the three methods of the intraoral scanning technique using Medit Link v4.4 surface matching software program. The deviation of the three methods was recorded and statistically analysed through one-way ANOVA and Tukey as post-hoc tests, where $\alpha = 0.05$.

Results: The second scanning method showed significantly lower deviation (113.7±9.9μm) when compared to the first and third scanning method (143 ±21.6 μm, 139.4±26.2 μm) respectively, (P<.05). However, there was no statistically significant different between the first and the third scanning method (p = .91870).

Conclusions: It is recommended to use the second scanning method because it had the least deviation when compared to the other methods.

KEYWORDS: Intraoral scanning, Maxillary defects, Scanning methods, Medit Link software.

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INTRODUCTION

Maxillofacial defects represent challenging cases for the dentists. Prosthetic treatment of maxillofacial defects requires high skills and experience to overcome the obstacles that may face the operator, such as limited mouth opening, scar contraction and radiotherapy. These obstacles will impair the step of taking conventional impression, in addition to the risk of aspiration of the impression material. However, conventional dental impressions are still widely used. [1–3]

CAD/CAM technology has been introduced in the dental field since 1990s [4], Many studies[5–8] applied this technology to the prosthodontics fields. However, applying this technology in prosthetic rehabilitation of maxillofacial defects was difficult because of the complex structures of the maxillary defect and the accessibility as well. **Brucoli et al** [9] stated that the digital technology for the manufacturing of maxillary obturator prosthesis was promising to overcome the disadvantages of the conventional techniques.

Accurate reproduction of oral and dental tissues is required to produce an adapted prosthesis that is achieved either by taking accurate impressions and cast manufacturing or using digital technology. Many disadvantages of the conventional technique arise from the dimensional stability of the impression material and pouring of a cast. Recently digital technology helped to eliminate some of these disadvantages, also it was stated that digital scanning techniques ensured an accurate image production as well as the conventional silicone impression. [1,10,11]

According to the ISO standards, Accuracy is defined as trueness and precision. Trueness refers to the deviation between a measured value and the actual or reference value, while precision represents the ability to repeat the exact measurements every time of scanning. [12]

Accuracy is affected by many factors such as the scanning techniques and the scanner type whether it is an intraoral scanner or desktop scanner .[13] Image capturing involves stitching of images together till forming a 3D image, since that the intraoral scanner head is usually small, thus errors can happen during stitching of images together unlike desktop scanner. [14,15]

Intraoral scanning accuracy is affected by several factors, such as the model of the scanner machine, the scan field and the method of scanning. However, for the edentulous and full arch cases need an enhancement of the intraoral scanning accuracy to match the accuracy of the conventional impression techniques. [5,16–18]

This study aims to evaluate the trueness of three different intraoral scanning methods for acquired maxillary defect in relation to extraoral scanning method using desktop scanner. The null hypothesis was that no significant differences would be found between the three intraoral scanning methods.

MATERIAL AND METHODS

The Research and Ethics Committee of the Faculty of Dentistry, Ainshams University, reviewed and approved this research project protocol with project approval number FDASU-Rec ER042402.

A cast of an acquired maxillary defect was used and duplicated to ten casts (n=30) to standardize the same defect size and defect position, each duplicated cast was scanned using desktop scanner (MEDIT T500, Seoul, Korea) as a reference data and saved as an STL file , then each duplicated cast was scanned using intraoral scanner (MEDIT i600, Seoul, Korea) performed by three different methods as measured data and saved as an STL file. To standardize the use of the intraoral scanner for in vitro applications, the cast was securely fixed in a phantom head at a specific angle to ensure consistent positioning across all scans. The distance between the tip of the scanner and the cast was around 10mm away from each other. The scanner was calibrated before each session following the manufacturer's

recommendations to maintain accuracy. To ensure precision, each cast was scanned three times, and the scans were compared to confirm consistency in capturing the cast's details. The whole scanning procedures were done with a single operator.

The first scanning method: The scan started at the most left posterior area of the edentulous ridge, then up to the central incisors area and extended to reach the remaining dentition in bucco-lingual direction until reaching the most right posterior area, proceeding to buccal then palatal surface of the remaining dentition, then scanning the palatal area in a zigzag pathway. The scan duration with an average 125 seconds. (Fig. 1)

The second scanning method:_The scan started at the anterior remaining dentition in bucco-lingual direction, then the buccal aspect of the remaining dentition proceeding to the palatal area in a zigzag pathway. The scan duration with an average 95seconds. (Fig. 1)

The third scanning method: The scan started at the most left posterior edentulous area in a zigzag pathway passing through the palatal area, then scanning of the remaining dentition in bucco-lingual direction. The scan duration with an average 89 seconds. (Fig. 1)

Trueness evaluation:

The STL file of the desktop and intraoral scanning methods were imported to the Medit Link v4.4 surface matching software. The STL file of the desktop scanning is used as reference data and the STL files of the intraoral scanning methods were used as target data. Each intraoral scanning method was compared to the reference data. These files were superimposed together manually by selecting three matching points then "best fit alignment" option was chosen. The deviation is presented as color map and numerical values by using "deviation display mode" The numerical values represented as RMS (Root Mean Square). (Figure 2-4)

The deviation of the three methods was recorded and statistically analysed through one-way ANOVA and Tukey as post-hoc tests, where $\alpha = 0.05$. The sample size was calculated by G*Power software for windows version 3.1.9.4 according to a previous study [13], minimum sample size of was 6 casts calculated to have 80% power, $\alpha = 0.05$, $1\text{-}\beta = 0.8$. The sample size was increased to 10 casts per group. (n=30)

RESULTS

The deviation of the three scanning methods is represented in table 1. The second scanning method showed significantly lower deviation when compared to the first and third scanning method ($P<.05$). However, there was no statistically significant different between the first and the third scanning method ($p = .91870$). (Figure 5)

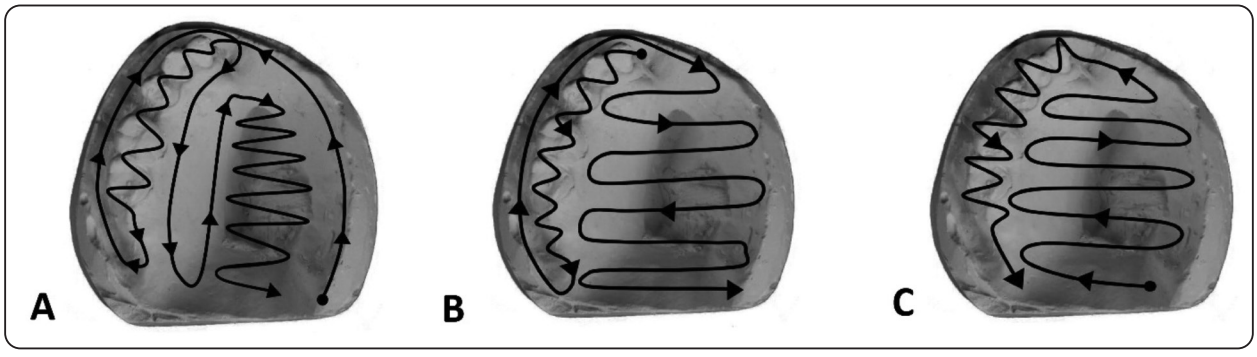

Fig. (1) The three scanning methods of an acquired maxillary defect cast. A) the first scanning method, B) the second scanning method, C) the third scanning method.

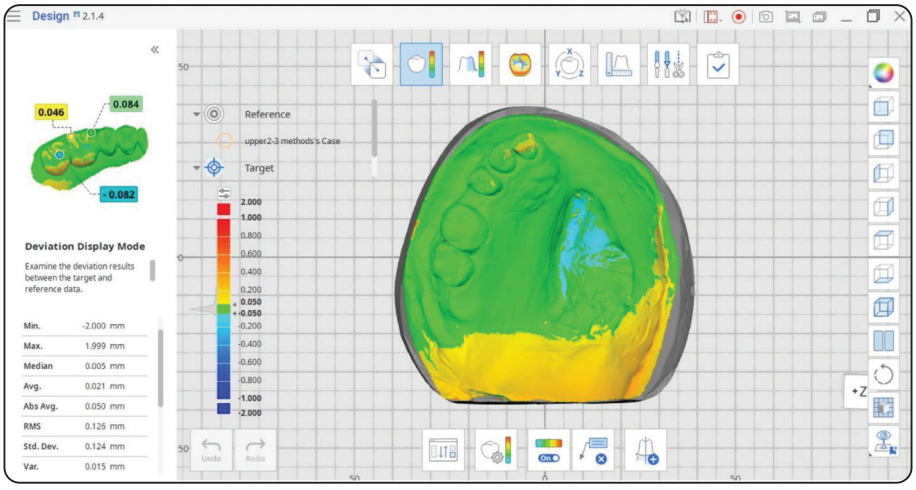

Fig. (2) Deviation report of "Best fit alignment" in Medit Link v4.4 software program for the first scanning method

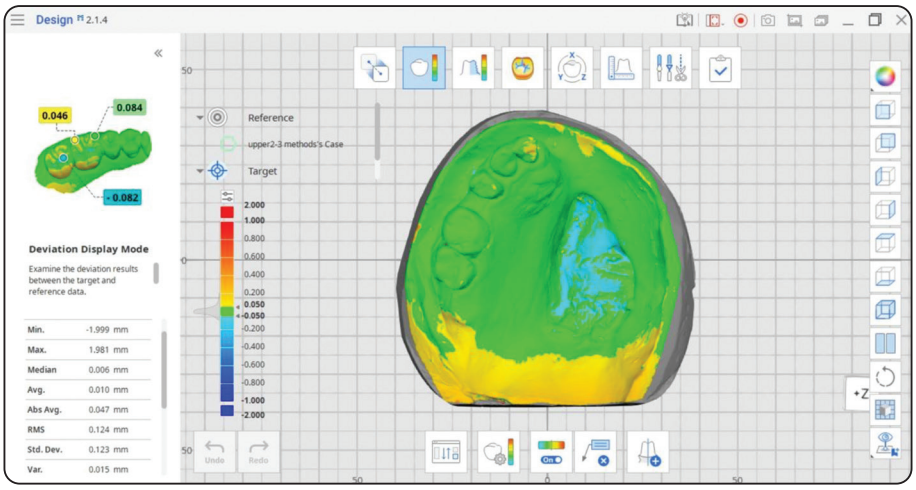

Fig. (3) Deviation report of "Best fit alignment" in Medit Link v4.4 software program for the second scanning method

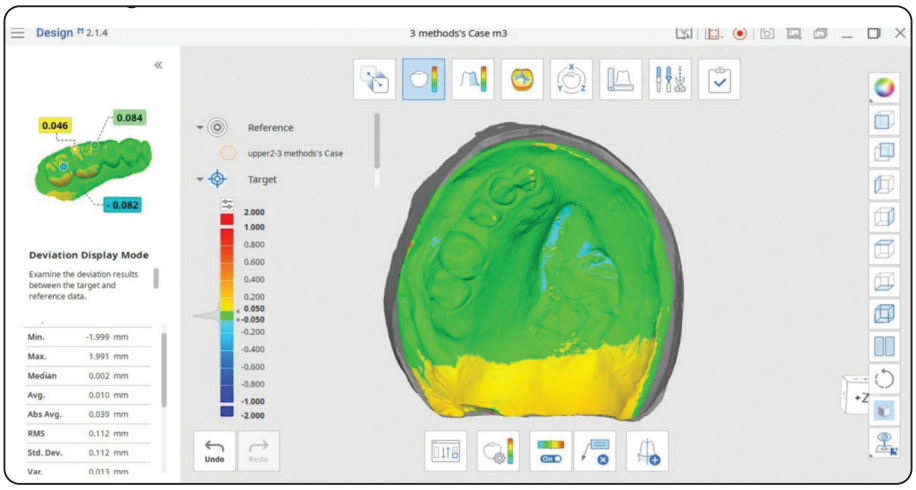

Fig. (4) Deviation report of "Best fit alignment" in Medit Link v4.4 software program for the second scanning method

TABLE (1) Trueness of the three different methods represented as RMS values in micrometer

	The first scanning method	The second scanning method	The third scanning method
RMS deviation value	143 ± 21.6[a]	113.7 ± 9.9[b]	139.4 ± 26.2[a]

Different superscript indicates statistically significant difference (p<0.05)

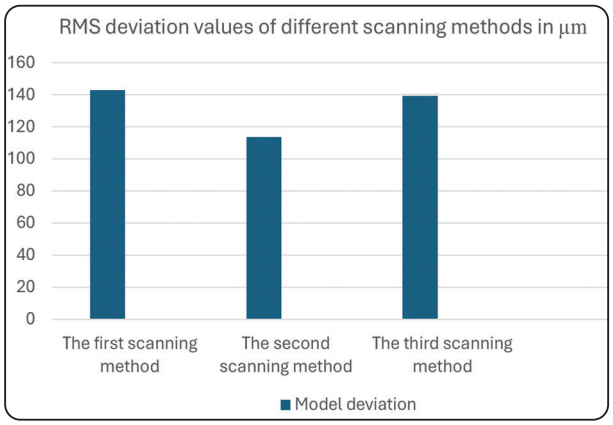

Fig. (5) RMS deviation values of different scanning methods in μm.

DISCUSSION

It is important to know the trueness of the digital impression and the best pathway to record an accurate anatomy of the patient and capture the details and the depth of the surgical defect with the least duration to construct an accurate prosthesis. [19]

The intraoral scanning technique depends on capturing an intraoral image through linear stitching of images, this can affect the accuracy of the image being produced because of some stitching errors. However, desktop scanners has no linear stitching difficulty because of the wide exposure, so it is used to be a reference guide when comparing accuracy of different intraoral scanners. [20–23] In this study, the scanners and surface matching software program developed by Medit were used to ensure process standardization and accuracy. The use of desktop scanner Medit T500 is because of the scanning accuracy that is less than 0.007mm[24], this will lead to an accurate model production that can be used as a reference data. Medit i600 intraoral scanner is used in this study since it captures images with high precision according to manufacturer instructions. [25]

The null hypothesis was rejected since the second scanning pathway showed significantly lower deviation when compared to the other two methods. The deviation of the three methods had a range from 143 to 113 μm and that was clinically acceptable range for deviation.[26]

Brucoli et al[9] stated that maxillary obturator can be efficiently manufactured using digital technology through solving many problems of the conventional techniques including the laboratory work, difficulties of taking the conventional impression specially when encountering undercut in the defect areas. **Cao et al** [30] stated that intraoral scanning can be used in cases of partially edentulous patients with maxillary defects and can produce similar results when compared to the conventional impression techniques.

Little information is found regarding maxillofacial digital impression accuracy. However, much research studied the trueness of different impression techniques related to the fixed partial denture, and full arch restorations. It was reported that for a smaller area as sextants, the scanning pathway didn't affect the trueness, but the scanning pathway affected the trueness when scanning larger segments as scanning complete arch. [27,28] Trueness is affected by the scanning duration, since the longer the duration, the more errors it can be. This may explain why the first scanning method was with more deviation compared to the others. However, it is not necessary that the scanning method with the

least duration will have lesser deviation, because it might be inaccurate for some areas that need to be recorded in a longer pathway. This explains why the third scanning despite having the lesser duration it didn't have the least deviation, since it didn't capture the buccal side in one direction as the other methods, but it captured each tooth with the corresponding buccal area.

Several research was made as an attempt to capture the defect depth. one of the studies[29] stated that it was very difficult to scan the deep defects of the palate unlike the non-defected side. Capturing the undercuts in the defect area can be very challenging and can affect the trueness of the scanning.

The primary limitation of this study is that it was conducted in vitro using dental casts, not in an intraoral environment. Consequently, this study did not present clinical variables such as saliva, blood, and soft tissue movements, which could impact the trueness of intraoral scans. While depth perception is a critical factor for accurate vivo scanning due to the complex 3D environment of the mouth, it is not relevant in an in vitro setting using static dental casts. However, we recognize that other important factors, such as reflective surfaces and undercuts, can affect the accuracy of scans even in vitro. Reflective surfaces can interfere with light-based scanning systems, leading to potential distortions, and undercuts may limit the scanner's ability to capture detailed and accurate data. Future research should explore these variables further in both in vitro and in vivo conditions using different brands of intraoral scanners to evaluate their influence on scan trueness comprehensively.

CONCLUSION

It is recommended to use the second scanning method because it had the least deviation when compared to the other methods.

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