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A COMPARATIVE INVITRO STUDY ON THE TRUENESS OF DIGITAL IMPRESSIONS IN DIFFERENT SIZES OF ACQUIRED MAXILLARY DEFECTS

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ABSTRACT

Aim of the study: Digital impressions captured by intraoral scanners (IOS) are increasingly used in dentistry. However, research on their accuracy for maxillary defects is limited. This study aimed to assess the trueness of digital impressions of various maxillary defect sizes captured by an IOS compared to a desktop scanner**.**

Methods: Three groups of models with different maxillary defects were created: Group I (midline defect), group II (unilateral defect), and group III (posterior defect). Reference models were digitized using a desktop scanner, and six digital impressions were captured with the IOS for every group (n=18). The impressions were evaluated using Medit Link software program regarding the trueness of the entire model and the defected area as well. One-way ANOVA and Tukey post hoc tests were used for statistical analysis.

Results: Group I exhibited the highest model and defect deviation with mean (0.094 ± 0.007 and 0.088 ± 0.008 mm), followed by group II with mean (0.084 ± 0.0032 and 0.054 ± 0.0046 mm). Group III showed the lowest deviation with (0.050 ± 0.0079 and 0.009 ± 0.0019 mm). Significant differences were found among all groups ($p < .05$).

Conclusions: This study concluded that increasing the size of maxillary defects negatively impacts the accuracy of the intraoral scanning.

KEYWORDS: Acquired defects, Dental impression, Accuracy.

INTRODUCTION

Maxillary tumors can contribute to substantial depletion of both hard and soft tissues, resulting in development of maxillary defects and subsequent decline in the overall quality of life for affected individuals. Consequently, the approach of treating maxillary defects should prioritize the mitigation of potential complications while preserving and

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enhancing the quality of life for patients. The creation of a maxillary obturator emerges as a viable solution to address these challenges, with documented reports indicating that patients exhibit improved satisfaction levels through the incorporation of a maxillary obturator in their treatment plans.[1,2]

The key to success in maxillofacial cases is the meticulous performance of impression-making. This process plays a vital role in the production of a prosthesis characterized by optimal fit, thereby preventing any undue stress on the adjacent musculature and tissues[3]. For partially edentulous patients with maxillary defects, conventional dental impressions, either rubber or alginate impression material remain prevalent in clinical applications due to their satisfactory accuracy and feasibility. Nevertheless, challenges arise for these patients, as they may encounter difficulties in mouth opening due to scar contracture or temporomandibular joint disease. These factors can adversely affect the precision and feasibility of conventional dental impressions.[4,5]

Palatal defects, deficiency of palatal tissues, and communication between the oral and nasal cavities may lead to entry of the impression materials into the nasopharynx, resulting in discomfort and pain for the patients. Consequently, the process of making dental impressions becomes a challenge for prosthodontists while dealing with these patients having maxillary defects.[6]

Digital innovation led to the application of digital impressions in dental practice, which offers several advantages such as real-time imaging, reduced material requirements, and enhanced cost-effectiveness.[7,8] In general, digital dental impressions can be obtained through two main techniques, the first one involves utilizing an extraoral laboratory scanner to scan conventional impressions. The other technique uses an intraoral scanner for direct intraoral scanning to digitally capture the anatomy of the oral cavity. [9,10] Data obtained through intraoral scanning has comparable and enhanced accuracy compared to conventional methods regarding single crowns and partial fixed prostheses.[11,12] Nevertheless, studies have reported that extraoral scanners tend to have better accuracy than intraoral scanning.[13]

Accuracy plays a critical role in evaluating the effectiveness of IOS in capturing dental impressions for acquired palatal defects. Accuracy consists of trueness and precision; trueness is the deviation of the scanned object from its real geometry, while precision is the deviation between repeated scans .[14,15] Scarce studies have investigated the application of intraoral scanners in capturing digital impressions for partially edentulous patients with acquired defects.[6,16]

This study aimed to assess the trueness of digital impressions of different models and varying sizes of maxillary defects captured by an IOS compared to a desktop scanner. The null hypothesis stated that there is no significant difference in the trueness of digital impressions of different models and maxillary defects captured by an intraoral scanner (IOS) compared to a desktop scanner.

MATERIAL AND METHODS

Power analysis was conducted to ensure sufficient power for testing the null hypothesis that there was no difference in the accuracy of intraoral scanning across different groups of acquired maxillary defects. The sample size was calculated using G*Power software for Windows (version 3.1.9.4) based on a previous study.[17] A sample size of six models per group (n=18) was determined to provide 80% power, with α=0.05 and 1-β=0.8.

The study involved three groups, each representing a partially edentulous model with varying sizes of acquired maxillary defects (dental stone type IV; Kromotypo 4). Group I included a model with an acquired maxillary defect crossing the midline (Defect 1). Group II involved a unilateral

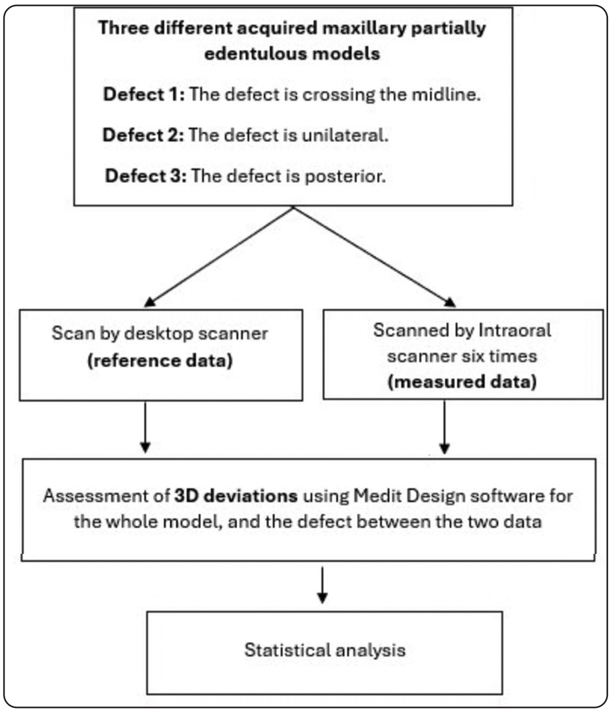

Fig. (1) Flowchart of the study procedure.

acquired maxillary defect (Defect 2), and group III represented a posteriorly acquired maxillary defect (Defect 3). A detailed flowchart of the study procedure is presented in Figure 1.

The models were scanned by a desktop optical scanner (MEDIT T500; MEDIT Corp.). The precision of the scanner was verified by repeating three scans for the reference model and superimposing them. Afterward, the scanned models were imported into the Standard Tessellation Language (STL) file format as reference models I, II, and III according to the model scanned. [18]

The models were installed on a phantom head before scanning. Each IOS underwent calibration following the manufacturer's guidelines. The scan pattern was also made according to the manufacturer's instructions. An IOS (Medit i600; MEDIT Corp.) was used, starting at the leftmost posterior area of the defect, extending buccolingually along the dentition to the rightmost posterior, followed by buccal and palatal scanning of the entire dentition. The palatal area was recorded in a zigzag pattern. Each model was scanned six times to generate six STL files for each group. The scanning methodology was performed by the same experienced right-handed prosthodontist at the same parameters each time: the same room under the same temperature (22 °C), relative humidity (60%), and the same light level. The distance between the IOS tip and the scanned model was 10 mm each time.[17] Afterward, the scans were saved in an STL file format in the digital library of program software as measured in models I, II, and III according to the scanned model.

The STL file format of intraoral and extraoral scanning of each model was uploaded to a three-dimensional (3D) digital software analysis program (Medit Design, Medit Compare (V1.2), Seoul, South Korea) as measured and reference data respectively. The best fit matching of the denture fitting surfaces was automatically done by the software program then comparisons between the reference and measured data were conducted. Using the software deviation display mode, root mean square of the 3D-deviation values (RMS) are calibrated in millimeters for each alignment. The color maps for 3D deviations of the whole model and then segmentation was done to generate the deviation arises only from the defected area. [22-24] Color-coded superimpositions and 3D deviation assessments using Medit Design software for the entire models and the defects are shown in Figures 2-4

The results were statistically analyzed by R statistical analysis software version 4.3.2 for Windows.[25] One-way ANOVA followed by Tukey post hoc test was conducted to evaluate the trueness of an IOS to capture digital impressions of different models with different sizes of acquired maxillary defects. The normality of the data was assessed by examining the distribution and applying the Kolmogorov-Smirnov and Shapiro-Wilk tests. The significance level was set at $p<0.05$ within all tests.

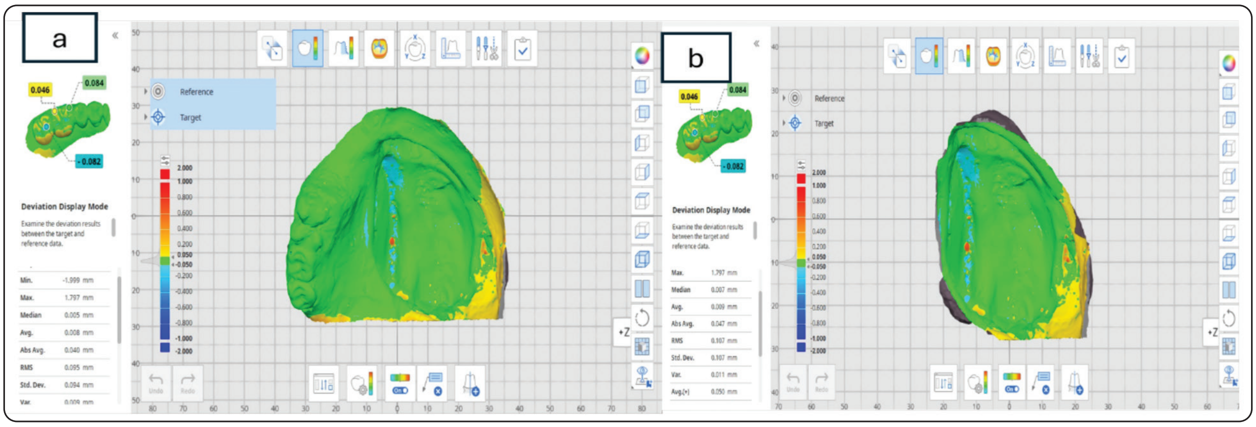

Fig. (2) A: Color-coded superimpositions and 3D deviation assessments using Medit Design software program for the entire model with defect 1. B: 3D deviation assessments using Medit Design software program for defect 2.

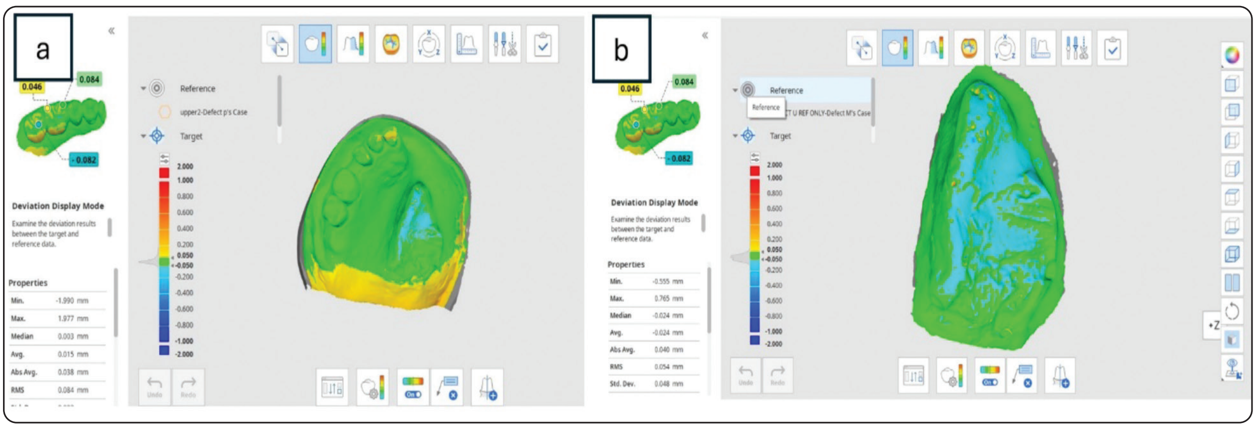

Fig. (3) A: Color-coded superimpositions and 3D deviation assessments using Medit Design software program for the entire model with defect 2. B: 3D deviation assessments using Medit Design software for defect 2.

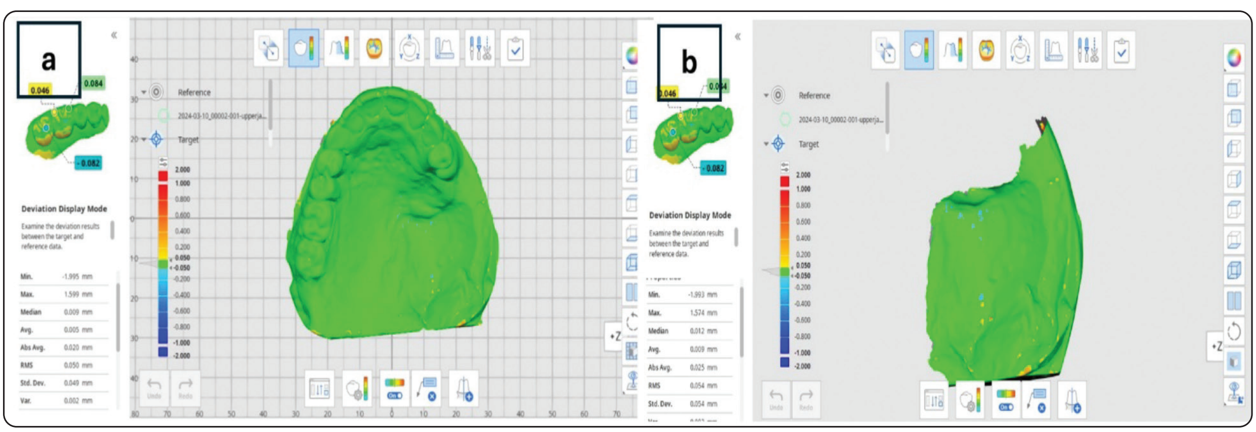

Fig. (4) A: Color-coded superimpositions and 3D deviation assessments using Medit Design software for the entire model with defect 3. B: 3D deviation assessments using Medit Design software for defect 3.

RESULTS

The results of the intraoral scan trueness for the three models and defect areas are shown in Table 1. Group I exhibited the highest mean RMS value for model deviation compared to groups II and III, with mean values of 0.094 ± 0.007 mm, 0.084 ± 0.0032 mm, and 0.050 ± 0.0079 mm respectively. A statistically significant difference was found between the three groups (p<0.05). Similarly, for defect deviation, defect 1 showed the highest mean RMS value compared to defects in groups II and III, with means of 0.088 ± 0.008 mm, 0.054 ± 0.0046 mm, and 0.009 ± 0.0019 mm respectively, and the differences between the defects were also statistically significant (*p*<0.05). Figure 5

TABLE (1) RMS deviation values of different models and defects in mm.

	Group I	Group II	Group III
RMS value	0.094 ± 0.007[a]	0.084 ± 0.0032[b]	0.050 ± 0.0079[c]
	Defect 1	**Defect 2**	**Defect 3**
RMS value	0.088±0.008[a]	0.054±0.0046[b]	0.009±0.0019[c]

Different superscript indicates statistically significant difference (p<.05)

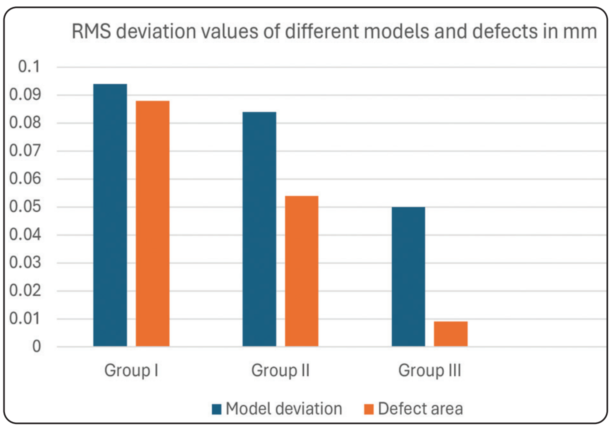

Fig. (5) RMS deviation values of different models and defects in mm.

DISCUSSION

Making an accurate impression of a maxillary-acquired defect is one of the most important steps in constructing a long-lasting, stable, and retentive obturator. Making such an impression is considered a challenging and technique-sensitive procedure for prosthodontists.[26] Digital technology has been used recently in maxillofacial prosthodontics. The reviewed literature suggests that 3D optical acquisition for maxillectomy defects is still in the developmental stage, given that the described techniques have heterogeneity when intraoral digitalization is performed and limited studies evaluated the accuracy of the IOS in the acquisition of maxillary acquired defects.[27-29] Therefore, this study was performed to assess the trueness of digital impressions of various maxillary defect sizes captured by an IOS compared to a desktop scanner**.** The results showed that there was a significant difference in the trueness of digital impressions of different models and maxillary defects captured by IOS compared to a desktop scanner, so the null hypothesis is rejected.

This study was performed in vitro to get more precise results by standardizing the size of the defects by duplicating the model. Furthermore, in vitro investigations have been proven to be more accurate since the tests may be repeated under the same conditions as the subject under study as the only variable.

Desktop scanners were proven to have high accuracy; therefore, in this study, Medit desktop scanners were used to scan the models to create reference data, as it was proven by the previous studies to have high accuracy. [30-32] Additionally the precision of the scanner was verified by repeating three scans for the reference model and superimposing them.

The IOS tip was 10mm from the recording area during the capture of digital impressions, as this distance was proven to produce more accurate results and a clearer scan during the scanning procedure.[33]

The RMS deviation values indicated that group III exhibited the highest trueness compared to the other models. This is likely because group III resembles natural dentulous casts and maintains key anatomical landmarks, unlike groups I and II which display a loss of teeth, absence of landmarks, and increased irregularities. Additionally, the larger defects in groups I and II make it more difficult for the scanner to capture them accurately. As a result, intraoral scanning trueness tends to decrease as the size of the maxillary defect increases. This finding aligns with previous studies that demonstrated a reduction in intraoral scanner trueness with increased edentulous span. [34-36] These results were further supported by segmenting the defects and measuring them separately, confirming that larger defects resulted in lower trueness measurements.

The limitations of this study include that it was in vitro design, which lacked several clinical factors such as saliva, patient movement, soft tissue texture and interference, and variations in mouth opening. Additionally, only one intraoral scanner was evaluated, and the scanner head was too large to capture finer details of the defect. The authors recommend conducting future studies in vivo and utilizing the latest version of the Medit intraoral scanner to obtain more accurate results.

Relevance to clinical practice

Precise digital impressions are essential in prosthetic treatments, especially for capturing and managing various intraoral defects. The effective utilization of an intraoral scanner in clinical practice will improve treatment accuracy and enhance patient outcomes.

CONCLUSION

Despite the limitations of this study, it can be concluded that as the size of the maxillary defect increases, the trueness of intraoral scanning decreases.

Declarations:

- ***Abbreviation***
  - IOS: intraoral scanners
  - STL: standard tessellation language
  - RMS: root mean square

Ethical declaration

It is invitro study, The Research and Ethics Committee of the Faculty of Dentistry, Ain Shams University, reviewed and approved this research project protocol with project approval number FDASU-Rec ER042401.

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