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EFFECT OF DIFFERENT DIGITAL IMPRESSION TECHNIQUES ON THE TRUENESS OF POST SPACE SCANS WITH FIXED CERVICAL DIAMETER

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ABSTRACT

Objective: The aim of this study was to measure the trueness of post space impression by 2 digital impression techniques: Impression Scanning (IS) and Model Scanning (MS) with cervical diameter 3 millimeters. **Materials and methods:** Fourteen freshly extracted single rooted lower second premolars were endodontically treated using Wave-One single file technique. Then mounted in acrylic blocks parallel to long access using a dental surveyor 2mm above the CEJ, drills in sequence 1.4 and 1.6 millimeter then diamond stone with 3 millimeter diameter were used for teeth preparation with a standardized depth of 8mm. Teeth were scanned by reference scanner InEos5 X5. The 14 teeth were impressioned using polyether impression material, scanned using 3shape desktop scanner E2. The impressions were poured to produce stone models then scanned using same scanner. All STL files were compared to the reference scanner using Geomagic control X software. **Results:** Model samples that were scanned had lower trueness values than impression scanning. **Conclusions:** Impression scanning for post space are recommended than model scanning.

KEYWORDS: Trueness, Digital impression, Conventional impression, Post space

INTRODUCTION

Treatment of endodontically treated teeth is considered a challenge owing to their brittleness and significant loss of tooth structure. In fact, such teeth are prone to higher rate of fractures compared to vital teeth. One of the treatment options is a post for the retention of the core[(1)]**.** They can be generally classified into ready-made prefabricated posts and custom-made posts. Fabrication of custom-made post done by impression either conventional or digital, the accuracy of the conventional impression depends on the materials used[(2),] impression tray types[(3)] and impression technique [(4).] Each step in the process introduces material error and/or potential human error [(5)]**.**

Recently, the use of CAD/CAM for the fabrication of post and core restoration has gained more interest due to their rapid and ease of use. Accuracy is the combination of measurement of two elements "trueness" and "precision". The term "trueness" refers to the ability of a measurement to match the actual value of the measured quantity.

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Precision is defined as the ability of the scanner to ensure repeatable outcomes in other words the ability of a measurement to be consistently repeated. With the use of (CAD/CAM), the production of a single piece post and core from newly introduced materials as hybrid ceramics can be done with high accuracy. By reducing the number of interfaces between resin composite core and the ready-made post, the chance of structural failure in the material also decreases[6,7].

Digital impressions and scanning systems were introduced in dentistry in the mid-1980s. It is predicted that most of the dentists in the U.S. and Europe would be using digital scanners for taking impressions within the next decade[8]. Digital impressions can be taken by intraoral scanners or extraoral (desktop) scanners. Intraoral scanners (IOS) are powerful devices used for optical impressions taking and are able to collect information and transmitting them to the computer with the shape and size of the dental arches through the emission of a light beam [9] The use of an IOS allows the determination of the quality of the impression on the spot; virtual 3D models of patients are obtained, which can be saved on computer without physically pouring a plaster model[10],[11]. Indirect, extraoral digitization starts with a conventional impression that is processed to a gypsum cast and then digitalized in the dental laboratory using laser scanning or computed tomographic imaging or scanning the impression itself.

Different scanning techniques of the custom post space preparation, according to the literature digital images of the prepared tooth required for CAD/CAM fabrication of the restoration can be obtained in three ways: by direct intraoral scanning, by scanning the impressions or by scanning the stone models[12,13].

MATERIALS AND METHODS

Sample preparation:

Fourteen freshly extracted single rooted lower second premolars with approximately equal root dimensions just below the cemento-enamel junction were selected. Teeth were endodontically treated using Wave-One (Dentsply Sirona- Germany) single file technique taper 6% with apical size ISO 25. Obturation was done using Continuous Wave Condensation technique with master cone ISO25 taper 6% followed by Obtura root canal filling system. Teeth after endodontic treatment were embedded in acrylic mold (Acrostone, Cold cure, Egypt) with the aid of dental surveyor to ensure correct positioning, then the labial side was marked for identification. Drilling of post spaces using dental surveyor to width 3 millimeters and depth 8 millimeters**.** Sequential drilling of the post space was done using the Olident- Poland fiber post drills kit, the first drill used was the red coded drill with a tip diameter of 1.2 millimeters followed by the blue coded drill with a tip diameter of 1.4 millimeters and finally the green coded drill with a diameter 1.6 millimeters. Then diamond stone with standardized diameter 3 millimeter (NTI Laboratory Diamond Bur) to ensure accurate width of each sample.

Sample grouping for the study:

TABLE(1) Sample grouping.

Post space Diameter / **Scanning technique**	**3mm**
Impression scanning (I.S)	I.S N=14
Model scanning (M.S)	M.S N=14
Total	28

Reference Scanning

In order to obtain a reference STL file, each sample was scanned with the desktop scanner InEos X5 (Dentsply Sirona, Germany). The desired image catalogue selected then the model was fastened to the supplied model holding plate on the rotation disk of the articulating arm using the Blue Tack filling material.

Multiple high dynamic range (HDR) exposure mode was selected. This mode captures situations requiring a large dynamic range (differences in brightness) during the exposure. Then complete reconstruction model was chosen. This option increased the calculation time for the model. Samples were numbered 1 to 7 in inlab software.

FIG (1) Reference scanning using InEos X5.

Impression of the post space

Resin fiber post 1.2 millimeter (PD FIBRAPOST, Switzerland) was inserted inside the canal to support the medium impression material (Kettenbach, Huntington Beach, USA) and avoid any distortion during the removal of the impression, then each sample was injected with medium impression material using an plastic syringe to insure delivery of the material inside the canal and gentle air pressure was applied to ensure that entrapment of air bubbles was to a minimum, then rest of medium impression material was loaded above the fiber post for about 2 cm.

Cast production of the post space preparation

Each Impression was poured with GC hard dental stone (GCFugiRock, Japan)

The stone powder was mixed with the appropriate amount of water according to the manufacturer instructions using a vacuum mixing machine.

Impression and model scanning by:

3Shape E2 scanner was used with software 3shape dental system 2021

Data was entered in the administrative page, to scan impression, impression scanning was selected and proceeded to the next step of scanning. The impression and then the model were placed on the scanning arm by the aid of bluetac. Scanning was repeated till getting the maximum depth and details of the post space. Then the processed data was exported as STL files for further interpretation with Geomagic software.

The Trueness measurement: In this study we checked accuracy by trueness only

A reverse engineering software Geomagic control X (Morrisville, North Carolina 2018) was employed to superimpose the reference STL file obtained from the InEos X5 desktop scanner to each STL file of 14 files obtained from each scanner.

1. Import and align datasets:

The initial alignment feature with enhancement of the accuracy of the alignment was selected then the best fit alignment was selected to ensure the 2 models data sets are positioned in one common coordinate system with the least possible mean deviation.

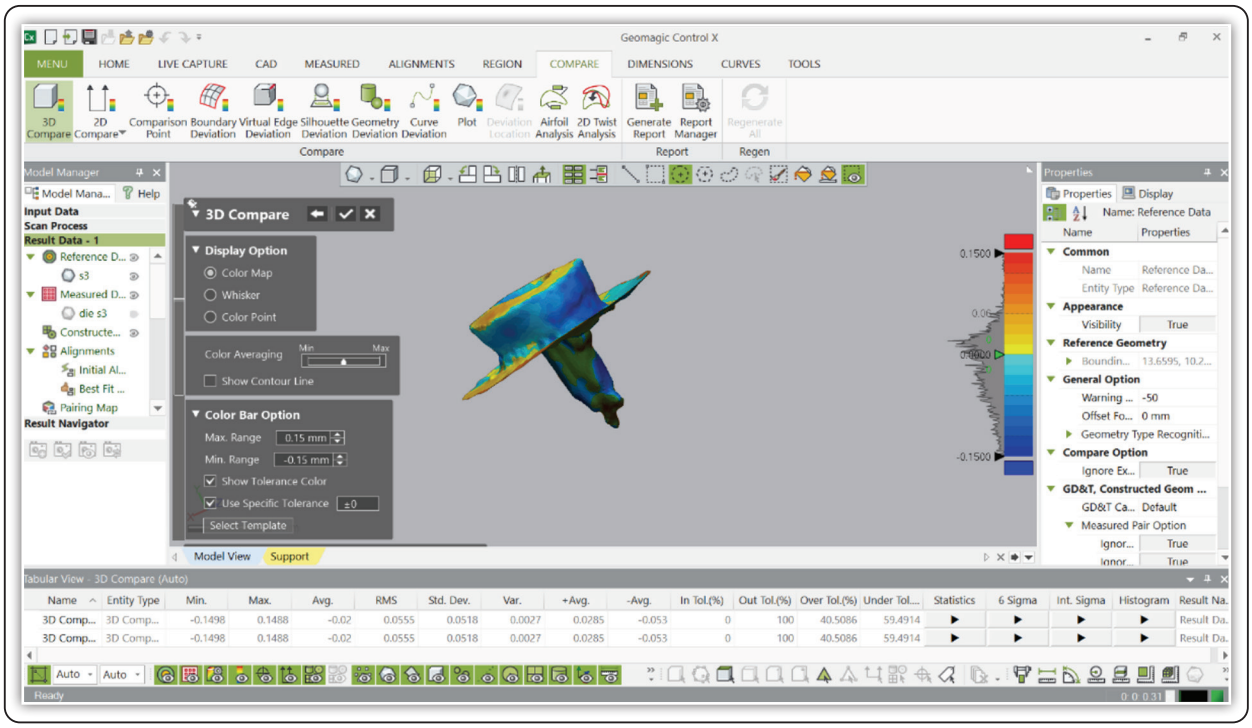

FIG (2) Showing the 3D comparison represented with a color map.

2. 3D Compare:

A color map was drawn with maximum deviation range of 0.15 mm and -0.15 mm minimum deviation and no specific tolerance.

3. Reports Generation

PDF and excel reports were created with all the calculated data collected from the superimposition process.

Statistical analysis:

Numerical data were explored for normality by checking the data distribution using Shapiro-Wilk tests. Data showed parametric distribution so; they were represented by mean root square and standard deviation (SD) values. One way ANOVA was used to study the effect of different tested variables. The significance level was set at P ≤0.05. Statistical analysis was performed with R statistical analysis software version 4.1.3 for Windows.

RESULTS

The values given in this study was for trueness only

1. Effect of different variables and their interaction:

Effect of different variables on RMS (μm) were presented in table (2)

Scanning technique had a significant effect on RMS (μm) value ($p<0.05$).

Effect of scanning technique

There was a significant difference between different groups ($p<0.001$). The highest value was found in scanned cast (86.26±6.07), followed by scanned impression (70.46±11.48. Post hoc pairwise comparisons showed different groups to have significantly different values from each other ($p<0.001$).

TABLE(2) RMS (μm) (mean±SD)

RMS (μm) (mean±SD)		p-value
Impression	Cast	
70.46±11.48[B]	86.26±6.07[A]	**<0.001***

DISCUSSION

The aim of this study was to evaluate the trueness of different scanning techniques of custom post space preparations with two widths. Considering the better features of an anatomic endodontic post, such as the root dentin preservation [14], reduced cement layer [15], increased post retention [16], and fracture resistance [17],[18], in this study the possibility of producing an anatomic endodontic post scan through the use of different scanning techniques have been investigated.

As trueness parameters cannot be evaluated in vivo yet due to missing reference structures [19], so we chose our study to be done in-vitro.

In this study, we used freshly extracted single rooted and single canal lower second premolars, that were endodontically treated, decoronated and mounted inside acrylic resin blocks [20]. This was followed by drilling of the post space to two widths of 2.5 and 3 mm[21,20]

The InEos X5 was assigned to be the reference scanner because it has accuracy of less than 15 μm which is considered as a minimum deviation according to literature and almost equivalent to the accuracy of PVS impression [22],[23]. Nulty et al.[24] reported a trueness value of (0.0 ± 1.9) when comparing full arch trueness of nine intraoral scanners and four lab digital scanners.

Expressing the accuracy in terms of trueness and precision is a common method, applied in previous studies [25].

3D Compare Analysis, a method superimposing two surfaces after best-fit-alignment, has been adopted from engineering and used in several in vitro studies[26]. Although other methods for the evaluation of the trueness and precision are reported in literature for example using 2D point to point length compare tool or 2D surface area compare tool and more recently computed tomography all these methods are used more frequently when the tested sample have a specific geometrical shape and dimension for example implant scan body [27], another drawback of the 2D comparison systems is that the readings are performed usually through measurements of sliced samples at specific locations. . The superimposition of the STL files were imported to a reverse engineering 3D analysis software "Geomagic control X in accordance with Renne et al. [26] in 2017, and Nedelcu et al.[28] in 2016, the scanned post spaces following DS technique achieved higher trueness value compared to IS and MS techniques. There was significant difference found between the two indirect data acquisition procedures, i.e. IS and MS procedures, in terms of Root Mean Square trueness value. This was in agreement with Tsintsadze et al. [29]. Since they reported that it can be concluded fiber posts fabricated following direct scanning technique demonstrated superior performance compared to posts fabricated upon impression scanning and model scanning[30]. Berrendero et al.[31] conducted in vivo studies to compare the marginal fit of single all-ceramic crowns fabricated from intraoral digital impressions and conventional impressions. They found no significance difference in the marginal and internal fit between the two techniques. Syrek et al.[32] also showed statistically significant superior marginal fit of the single crowns received from the direct data capturing compared to the indirect digitization. Although, these studies did not investigate scanning procedures of the post spaces, results of the present study are in agreement with their findings in terms of accuracy of the direct and indirect digitalization methods.

This was in disagreement with Lee et al.[33], who concluded in their studies that typodont teeth with various preparation when comparing the accuracy

of three digitalization methods methods showed that impression scanning and cast scanning provided more consistent root main square values and also lower values indicating better accuracy of the indirect techniques. The higher deviation in direct scanning method may be attributable to functional and technical challenges, with the technology available then making it difficult to stitch images together without propagating errors.

This was also in disagreement with Pinto et al.[20] who concluded that the digital impression showed lower capability to read the post-space compared to the traditional impression. Anyway, similar results between the two techniques have been obtained for post-spaces expressing a wide entrance. That is probably due to the increased amount of intraoral scanner light able to get into the post- space when a greater entrance is expressed.

Specifically, the scanned post spaces width of 3mm achieved higher trueness value compared to the 2.5mm post space scans respectively with all scanning techniques used.

CONCLUSION

Within the limitations of this study the following conclusion can be drawn:

Impression scanning for post space impression showed better trueness values than model scanning

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