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MJD

Effect of Two Post Space Depths on the Accuracy of the Scan

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Abstract:

Objective: This study aims to measure the accuracy of post space scans using 2 post space depths 1.7millimeters 2.10millimeters. **Materials and Methods:** A total of 14 human mandibular premolar teeth with similar root form and root canal shape averaging cervico-occlusal length of the crown about 8+/-0.5 mm and 14.5+/-0.5 mm for root length were collected for this study , endodontic treatment was performed for all teeth followed by coronal decapitation 2mm above CEJ and post space preparation , After the preparation of each root, the corresponding teeth were allocated randomly to two groups (n=7/ group) according to the depth of the preparation. Group A: 7 mm and Group B: 10 mm. All teeth were scanned using the (inEos X5 Sirona- Germany) to produce a reference scan, then scanning of post space directly using intraoral scanner for all teeth. **Results:** Samples with 10 mm post space (106.19±38.94) had a significantly higher RMS value than samples with 7 mm post space (70.39±28.63) (p=0.005). **Conclusion:** On the basis of the results and conditions of this study, the following conclusions can be drawn, diverse depths of the post space preparation showed varying degrees of trueness compared to the reference scan. Samples with 10 mm post space had a lower trueness value than samples with 7 mm 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. Aesthetic and functional rehabilitation of endodontically treated teeth with substantial tooth structure loss often requires a post for the retention of the core and the overall prognosis of the fixed prosthesis.[1]

Root channels are variable in shapes and anomalies influencing the restoration. They could have different oval shapes, cavities, previous restorations with excessive preparations, over instrumentation, incomplete root formation, internal resorption or developmental anomalies.

Many types of posts are available with different characteristics. They can be generally classified into ready-made prefabricated posts and custom-made posts. Ideally, posts should have mechanical properties comparable to that of the dentin, and should be cemented with a uniform, thin, and bubbles free layer of cement to increase the longevity of the post-endo restoration.

One of the main problems is the mismatch between the shape of the prefabricated post and its post space which leads to the formation of a non-uniform layer of cement, with a consequent higher probability for structural discontinuity. Moreover, the raised polymerization contraction creates internal stresses responsible for post debonding and fractures[2]. The stress produced as a consequence of the polymerization shrinkage has been identified as one of the main reasons for post based restoration failures

Due to advancement of digital and electronic technology, and the advancement in the manufacturing technology in the field of dentistry, Computer-aided design (CAD) and computer aided manufacturing (CAM) have been used in restorations fabrication.

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Contemporary scanners yield different accuracies, as different scanning technologies are implemented. The most important element to be considered when comparing scanners should be defined as "accuracy" the quality of the data derived from scanning", beyond the operational and clinical differences (the need of scanning reflective powder, speed of use, size of the scanner) and cost (purchase and maintenance) between different machines.

Accuracy is the combination of measurement of two elements, both important "trueness" and "precision". The term "trueness" describes to the ability of a measurement to match the actual value of the measured quantity. 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.

Virtual models can be created for the post space preparation, which are required for the fabrication of CAD/CAM custom post and core by direct intraoral scanning, or impression scanning, or by scanning of the stone models[3].

The latest reports have proposed use of computer-aided design/computer-aided manufacture (CAD/CAM) generated post and core restorations, and various studies have investigated CAD/CAM-produced zirconia post and core mechanisms.[4,5,6] Fiber-reinforced composite blocks were also utilized to CAD/ CAM-generate fiber posts for large root canals or irregularly shaped ones.[7,8]

Materials and Methods:

Sample preparations

Fourteen Freshly extracted Single rooted lower second premolars due to orthodontic reasons were selected and endodontically treated using Wave-One single file technique taper 6% with apical size iso 25. Obturation was done using Continuous Wave Condensation technique with master cone iso 25 taper 6% followed by Obtura root canal filling system,

Teeth were then mounted in acrylic blocks parallel to long access using a dental surveyor below level of CEJ by 2mm then the Teeth were decoronated to a level above CEJ by 2mm,

- Drilling of post spaces using dental surveyor to two different depths:
1. Group (A) 7 millimeters
2. Group (B) 10 millimeter

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. All drilling was done using a dental surveyor and a syringe with a coolant.

Reference Scanning

In order to obtain a reference STL file, each sample was scanned with the desktop scanner InEos X5.

The scanning procedure was performed with each of the 14 samples to produce 14 reference scans, samples were numbered A1 to A7 and B1 to B7.

Intraoral scanning

Primescan

Primescan AC (acquisition center) with the mobile cart was used with the software version 5.1.2. The scanner was regularly calibrated before every group scanning. For every scan, a new case was created, and all the data were entered.

Scanning workflow

The first step included the administration phase where information about the restorations and their type were created.

The second step included the acquisition; where all information was displayed in the page palette and scanning process began by activating the foot control.

The scanning approach began with the occlusal surface of the prepared tooth and the scanner head was 0 to 5 mm away from the teeth surface, as shown in Figure (15). The scanner head was moved in a mesial direction, 45 to 90 degrees tilt was done on the buccal surface and the scanner head was moved in a distal direction passing over the prepared tooth then the head was tilted to a maximum 90 degrees over the lingual surface in a mesial direction, then the proximal surfaces of the prepared tooth were scanned by moving the scanner head using a wave motion with 15 degrees tilt on the occlusal, buccal, and lingual.

During the scanning a separate operator recorded the time taken with a digital stopwatch, and all times were averaged around 7 to 10 seconds.

After the scanning was completed the model was created after rendering the acquisition phase. The data were exported with STL format.

The scanning procedure was performed with each of the 14 samples to produce 14 scans. The scans were numbered: D.S A1 to A7 and D.S B1 to B7.

The Trueness measurement

A reverse engineering software Geomagic control X 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 from each subdivision.

Import and align datasets

The reference data was imported and trimmed to remove any data that is not related to the desired scan, then the measurement data was imported which is one of the STL files of the corresponding scanner.

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.

3D Compare

The 3D compare was done only for the merged area which is the area of interest with the shortest projection of deviation and auto maximum deviation.

A color map was drawn with maximum deviation range of 0.15 mm and -0.15 mm minimum deviation and no specific tolerance. The green meant perfectly matching surface, the red meant test model surface was positively positioned relative to reference model and the blue meant test model surface was negatively positioned relative to reference model.

When two scans were superimposed, the square of the phase difference between a number of points in 3-D space was calculated (x-, y-, and z-axis). The sum of these squares was divided by the number of points, and Root mean square (RMS) was calculated as the square root of this value as show in the equation below. This may be a more reliable and accurate value than a general arithmetic mean because the difference between each data point is represented by both a positive value (red in the color-difference map and a negative value (blue in the color-difference-map. The reliability of arithmetic means is limited in cases of simple sums.

$$\mathbf{RMS} = \sqrt{\frac{\sum_{m=1}^{n}(x_{1,m} - x_{2,m})^2}{n}}$$

Reports Generation

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

Results:

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 and standard deviation (SD) values. Two-way ANOVA followed by Tukey's post hoc test was used to study the effect of different tested variables and their interaction. Comparison of main and simple effects were done utilizing bonferroni correction. The significance level was set at P ≤0.05 within all tests. Statistical analysis was performed with IBM® SPSS® Statistics Version 26 for Windows.

Effect of post space:

Mean and standard deviation (SD) values of RMS for different post spaces were presented in Table (1) and Figure (1).

Table (1): Mean ± standard deviation (SD) of RMS in microns for different post spaces.

Root mean Square (mean ± Standard deviation)		p-value
7 mm	10 mm	
70.39±28.63	106.19±38.94	**0.005***

; significant (p ≤ 0.05) ns; non-significant (p>0.05)

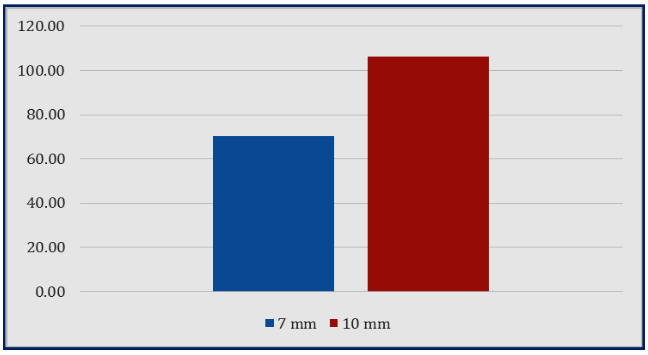

Figure (1): Bar chart showing average RMS for different post spaces

Samples with 10 mm post space (106.19±38.94) had a significantly higher RMS value than samples with 7 mm post space (70.39±28.63) (p=0.005).

Discussion:

The use of computer-aided design and computer aided manufacturing (CAD/CAM) has been increasing for fabricating indirect restoration. CAD/CAM production systems facilitate laboratory procedures and overcome the disadvantages of casting. However, manufacturers have not paid sufficient attention to the development of this technology for milling of custom-made post and cores. The digital design of post and cores using CAD technology allows more in-depth planning of the clinical treatment while the CAM process offers an expeditious and precise fabrication of the post and core, substantially reducing treatment cost.[9]

The aim of this study was to evaluate the accuracy of scanning different post space depths. Considering the better features of an anatomic endodontic post, such as the root dentin preservation[10], reduced cement layer[11], increased post retention[12,] and fracture resistance[13,14].

In this study the possibility of producing an anatomic endodontic post scan through the use of different scanning techniques have been investigated.

Chiu et al.[15] stated that the clinically acceptable marginal discrepancy value for CAD-CAM generated restorations was between 50 and 100 microns. As the first step in the digital workflow, an accurate digital scan is essential to keep the marginal discrepancy under 100 microns.[16] The tested IOSs in their study, showed statistically significant differences regarding scanning accuracy, suggesting that when scanning deep cavities for custom made CAD/CAM post and core, endocrowns, inlays, or onlays, scanning technique selection may be crucial. Moreover, according to the present study's results, scanning accuracy should be taken into consideration when adjusting preparation depth for CAD-CAM restorations.

Every CAD CAM procedure has multiple steps, with each step a potential source of error. As a result, each procedure in any CAD CAM Workflow is very important and can affect the overall performance that's why trueness and precision are among the essential factors, and it is important to highlight its effects. As trueness parameters cannot be evaluated in vivo yet due to missing reference structures[17], 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[18]. This was followed by drilling of the post space to two depths of 7 and 10 mm[5]. All sample teeth were prepared by the same operator using dental drills specific for post space preparation.

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.[19,20] Nulty et al.[21] 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.[22]

3D Compare Analysis, a method superimposing two surfaces after best-fit-alignment, has been adopted from engineering and used in several in vitro studies[23.] 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 [24], another drawback of the 2D comparison systems is that the readings are performed usually through measurements of sliced samples at specific locations. Thus, the linear method may limit the analysis of data and has the potential shortcoming of introducing bias as how the points are selected and if the points are representative in the analysis. The superimposition of the STL files were imported to a reverse engineering 3D analysis software "Geomagic control X, (3D systems, Morsiville, NC)" in accordance with Renne et al[23], and Nedelcu et al[25]. This superimposition of test and reference datasets was performed employing a "best fit alignment". Due to the lack of reference shapes, this was the best methodological compromise to obtain the objectives defined in this study. Best fit alignments were already used in several other studies as an approach for 3D dataset comparison[26,27]. Using this "best fit matching", positive and negative deviations between reference and test objects occur. This makes the interpretation of the results difficult, as negative deviations will not occur in the oral cavity when restorations are seated. As well, calculating the arithmetic mean from positive and negative deviations leads to results close to zero and is not displaying the real divergences sufficiently. The approach employed in the present study uses the mean positive and negative deviations and the standard deviation to estimate the proximity of each test dataset in relation to the reference. From these values, one mean value for each group was calculated. The mean positive and negative values for each group could be interpreted as the trueness.

STL files of each group were superimposed 1 by 1 on the imported reference STL file of our model to calculate the Trueness and the data of the root mean square (RMS) of each superimposition was collected[28] to evaluate quantitative accuracy, since it shows a high estimate of the average error, and an average value was calculated.

Samples with 10 mm post space (106.19±38.94) had a significantly higher RMS value than samples with 7 mm post space (70.39±28.63) (p=0.005).

Specifically, the scanned post spaces depths of 7mm achieved higher trueness value compared to the 10mm post space scans respectively with all scanning techniques used.

This was in agreement with Pinto et al[18]. Since they reported that the digital impression showed lower capability to read the post-space depths compared to the traditional impression and as the depths of the preparation is increased the accuracy of the scan produced is decreased.

This was also in agreement with Gurpinar et al.[29] who concluded that a pulpal chamber extension depth with a 2 mm depth showed significantly better scanning trueness than that with a 5 mm depth.

Improvements in scanners and scanning techniques will remain day after day paving the road for a more accurate scans and more applications maintaining the door open for future research to evaluate their accuracy and precision.

Conclusion:

Diverse depths of the post space preparation showed varying degrees of trueness compared to the reference scan. Samples with 10 mm post space had a lower trueness value than samples with 7 mm post space.

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