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Original Article

Dentistry Section

Volumetric Analysis of Post Space Impressions Made using Digital Scan and Cone Beam Computed Tomography Imaging: An In-vitro Study

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ABSTRACT

Introduction: Digital impressions are dental scans captured using Three-dimensional (3-D) scanning technology. Scanning deeper areas can affect the accuracy and completeness of the digital impression, potentially leading to inaccuracies in the final restoration. Scanning post spaces at greater depths and narrower diameters can pose significant challenges for digital scanning.

Aim: To compare the volume of post space impressions made using the digital impression technique (Primescan/Dentsply Sirona) with the volume obtained from Cone Beam Computed Tomography (CBCT) imaging.

Materials and Methods: The present in-vitro study was conducted between January and April 2025 in the Department of Conservative Dentistry and Endodontics at DAPM RV Dental College, Bengaluru, Karnataka, India. A total of 15 extracted single-canal, single-rooted permanent teeth were collected for this in-vitro study. All the teeth were cut coronally to maintain an equal length of 22 mm. Endodontic treatment was performed on all the teeth, followed by post space preparation, leaving behind 5 mm of gutta-percha. Group A: A CBCT reference scan was performed for all the samples; the volume of the post space was measured using on-demand software for each tooth, which served as a control. Group B: The same samples were subjected to a digital impression (Primescan/Dentsply Sirona), and the volume of the post space was recorded using Exocad software. Group B values were compared with the corresponding group A reference values.

Results: The intraoral scanned images (group B) recorded a slightly smaller volume than that obtained from CBCT. Although the mean difference between the two methods was 0.7384 mm^3, it was shown to be statistically significant ($p<0.001$).

Conclusion: Based on the analysis of the study results, it can be concluded that the mean difference in volume between CBCT and Primescan was 0.738 mm^3, with the Primescan recording 97.82% of the volume. The Primescan demonstrates clinically acceptable accuracy in scanning the post space.

Keywords: Dental radiography, Intraoral scanner, Dental casting technique

INTRODUCTION

Endodontically treated teeth always pose a restorative challenge due to their brittleness and the significant loss of tooth structure caused by caries, endodontic access preparation, instrumentation, and biochemical and structural changes in non-vital dentin [1,2]. These teeth are more prone to fractures; therefore, the use of a post is often necessary to improve the prognosis of endodontically treated teeth [1]. Posts provide the necessary retention for extra-coronal restorations and can be either cast or prefabricated. For cast posts, conventional impressions of the post space are typically obtained using either direct or indirect techniques [2,3]. Custom posts adapt well to the anatomical irregularities of the root canal and eliminate the risk of post-core separation. Due to their superior adaptation compared to prefabricated posts, they offer increased resistance to rotational forces [4,5]. However, the prognosis of such restorations remains a challenge, as the accurate replication of the post space is highly dependent on the clinician's skill.

Intraoral Scanners (IOSs) play a significant role in modern dentistry by facilitating a digital workflow that enables easier and more accurate fabrication of prostheses. This includes the use of Computer-aided Design/Computer-aided Manufacturing (CAD/CAM) technology to produce precise restorations while minimising errors associated with manual techniques. Compared to conventional impressions, digital impressions are faster, easier to store and share, and generally better accepted by patients. They also allow real-time 3D visualisation of the scanned surfaces on a monitor. The impressions are processed using software that accurately reconstructs a 3D model of the target structures [5,6,7]. Digital impressions are more time-efficient, user-friendly, and convenient. The majority of patients prefer digital impressions over conventional techniques. Additionally, intraoral scanners have streamlined communication between the dentist and the dental technician. A fully digital workflow eliminates the need for tasks such as tray preparation, disinfection, transportation of physical impressions, and the fabrication of gypsum dental casts [8,9].

With advancements in digital and manufacturing technologies in dentistry, CAD/CAM systems have been increasingly used for the fabrication of restorations [10,7]. The major advantages of digitisation include faster and more time-efficient processing, reduced risk of human error, and improved accuracy [7]. However, one limitation of digital impressions is that scanning accuracy tends to decrease as the depth of the scanned area increases. Additionally, deeper and narrower spaces, the presence of undercuts, and contamination by saliva pose significant challenges to accurate digital scanning [11].

Numerous studies have been conducted to assess the accuracy of digital impressions in comparison to conventional manual impressions. However, challenges in such studies include dimensional changes and material deformation [11,12]. Additionally, most previous research has focused on linear parameters, such as depth or width measurements. Only a limited number of studies have considered volumetric assessment, which is a three-dimensional parameter and may provide a more accurate evaluation of impression accuracy [13-15].

This study was conducted to evaluate the accuracy of an advanced digital impression system, Primescan (Dentsply Sirona), in scanning post spaces up to a depth of 17 mm by comparing the scanned volume with that obtained through CBCT.

Null Hypothesis (H0): There is no difference in mean post space volume between CBCT and digital impression techniques.

MATERIALS AND METHODS

The present in-vitro study was conducted between January and April 2025 in the Department of Conservative Dentistry and Endodontics at DAPM RV Dental College, Bengaluru, Karnataka, India. The study was approved by the Institutional Review Board (Ref. No: DAPMRVDC/03-098/2024).

Inclusion criteria:

- Teeth with single canals
- Teeth with straight canals
- Teeth without cracks
- Teeth with a fully formed root

Exclusion criteria:

- Teeth with unusual canal anatomy
- Teeth with a canal diameter of less than 1 mm
- Teeth with caries involving the root surface

Sample size calculation: The sample size for the present study was estimated using GPower software (latest version 3.1.9.7; Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). The sample size estimation was performed at a 5% alpha error (α=0.05). The sample size consisted of 15 scans each from CBCT and intraoral scans.

Study Procedure

Based on the inclusion and exclusion criteria, 15 extracted single-canal permanent teeth were collected for the study from the Department of Oral and Maxillofacial Surgery at DAPM RV Dental College, Bengaluru, Karnataka, India. The teeth were thoroughly cleaned, disinfected in a 5% sodium hypochlorite solution for 1 hour, and stored in saline. Each tooth was examined for the presence of cracks. All teeth were sectioned coronally to standardise the root length to 22 mm [Table/Fig-1].

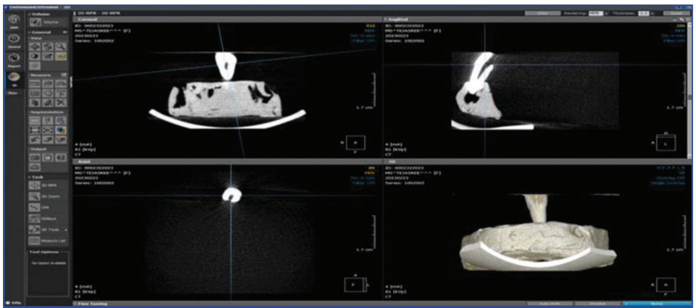
[Table/Fig-1]: Sample has been cut coronally to maintain the equal length of 22 mm.

Access openings were performed using an endo access bur. The working length was determined, and cleaning and shaping were carried out using the step-back technique. Canals were irrigated with 3% sodium hypochlorite and saline. After irrigation, the canals were dried with paper points and obturated using the cold lateral condensation technique with a zinc oxide eugenol (ZOE) sealer.

After a 1-week dwell time in saline, post space preparation was performed using a gates glidden drill #3 and peeso reamers #3, maintaining a post space width of 1.5 mm (approximately one-third of the root width). The apical 5 mm of gutta-percha was left intact. The final post space length was standardised to 17 mm with a width of 1.5 mm for all samples. All teeth were mounted in modeling wax shaped to resemble a dental arch [Table/Fig-2].

[Table/Fig-2]: Samples were named and mounted in arch shaped modelling wax.

Group A: CBCT scans were taken for all samples using a voxel size of 0.125×0.125×0.125 mm, with a tube voltage of 100.0 kV and a tube current of 2.7 mA, resulting in 15 control scans [Table/Fig-3]. The volume of the post space was measured using On-demand software. The post space, which appeared as radiolucent areas in the corresponding regions, was outlined and used to calculate the volume within the software. This value served as the control volume for each sample [Table/Fig-4].

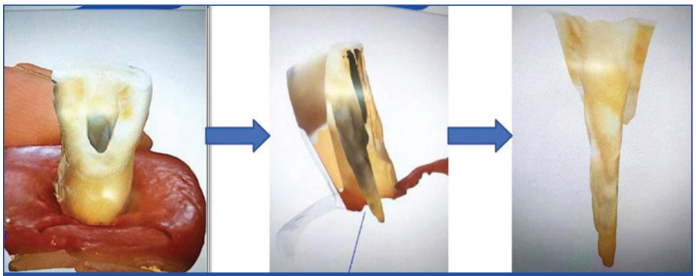


[Table/Fig-3]: CBCT scan of sample showing post space.

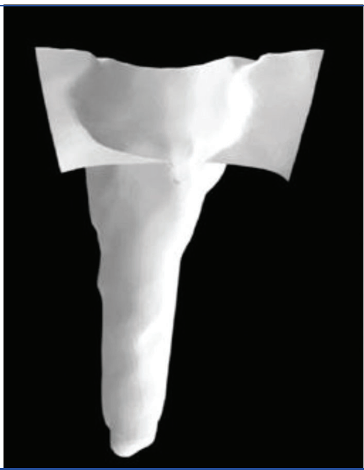
[Table/Fig-4]: Volume calculation of post space in On-demand software.

Group B: Digital scanning was performed using the Primescan system (Dentsply Sirona). The prepared post space of each sample was scanned [Table/Fig-5], and the scanned images were exported in STL format [Table/Fig-6]. The STL files (Standard Tessellation Language) of the post space scans were imported into the design software EXOCAD. This software allows for clear visualisation of the post space, distinct from the surrounding tooth structure. The post space was identified, and the software's measurement tools were used to determine its volume [Table/Fig-7].

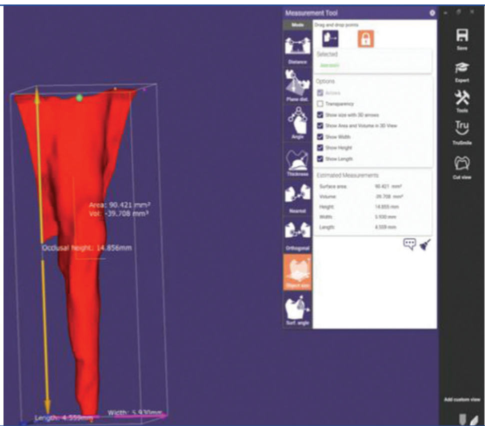
Both software programs were precalibrated to enable volume measurements in cubic millimeters. All images were blinded and analysed for volume by an independent researcher. The volumes



[Table/Fig-5]: Digital scan of sample was cut and modified to limit to the area of interest.



[Table/Fig-6]: STL file of the sample's digital scan.



[Table/Fig-7]: Volume measurement of post space digital scan in exocad software.

obtained from group B were compared with the corresponding control scan values from group A to evaluate the accuracy of the digital impressions relative to the CBCT scans.

STATISTICAL ANALYSIS

Statistical Package for Social Sciences (SPSS) for Windows Version 22.0, released in 2013 (Armonk, NY: IBM Corp.), was used to perform statistical analyses. The Shapiro-Wilk test showed that the post space volume followed a normal distribution for both methods [Table/Fig-8]. Therefore, a relevant parametric test was applied to test for significant differences in the mean post space volume between the two methods. A comparison of the mean post space volume (in mm³) between the CBCT and digital scan methods was conducted using the Student's paired t-test.

RESULTS

Group B showed a lower post space volume (33.0657±4.3254 mm³) compared to group A (33.8041±4.1416 mm³), with a mean difference of 0.7384 mm³ (95% CI: 0.5401 to 0.9367), as shown in [Table/Fig-9]. The difference in mean post space volume between group A and group B was statistically significant ($p<0.001$). Analysis of the post space volume differences (in mm³) between the two measurement methods revealed that 60% (9 out of 15) of the samples in group

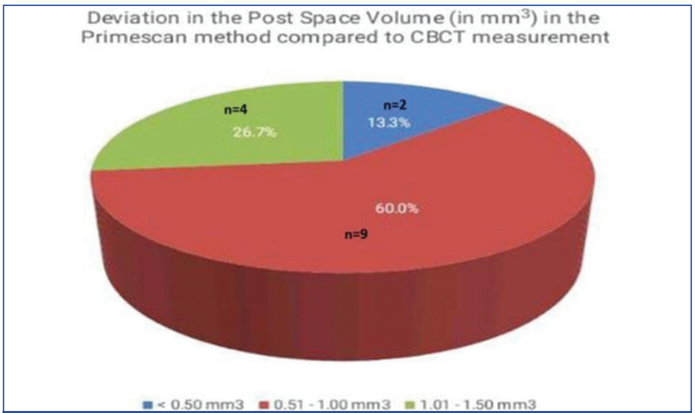
Tests of Normality							
		Kolmogorov-Smirnova			Shapiro-Wilk		
Parameter	Groups	Statistic	df	Sig.	Statistic	df	Sig.
Post Space	CBCT	0.121	15	0.20	0.976	15	0.94
	Primescan	0.125	15	0.20	0.972	15	0.88

[Table/Fig-8]: Tests of Normality.

Methods	N	Mean	SD	Mean diff	95% CI of the diff. Lower	95% CI of the diff. Upper	t	p-value
CBCT	15	33.8041	4.1416	0.7384	0.5401	0.9367	7.987	<0.001*
Primescan	15	33.0657	4.3254					

[Table/Fig-9]: Comparison of mean post space volume between CBCT and Digital scan.

B showed a reduction of 0.51-1.00 mm³ compared to group A. Additionally, 26.7% (4 out of 15) of the samples demonstrated a difference of 1.01-1.50 mm³, while 13.3% (2 out of 15) exhibited a difference of less than 0.50 mm³ [Table/Fig-10].



[Table/Fig-10]: Deviation in post space volume in Primescan compared to CBCT measurement.

DISCUSSION

In this research, the post space volume was recorded using a digital scanner, representing the latest digitised clinical impression technique. This volume was then compared with the volume recorded using a CBCT diagnostic imaging procedure. Upon comparing the two groups, the intraoral scanned images (group B) were found to record a slightly smaller volume than that obtained from CBCT. Although the mean difference between the two methods was 0.7384 mm³, it was statistically significant; therefore, the null hypothesis was rejected.

The results of the present study are consistent with previous research that has compared digital impressions with conventional impressions for post space evaluation. These studies have concluded that the measured dimensions are directly proportional to accuracy [13,16]. Meshni AA et al. suggested a clinically acceptable deviation value for post space preparation to be between 250-500 μm. This value is significantly lower than the deviations observed in the present study. Nine samples showed a difference between 0.51-1.00 mm³, four samples exhibited a difference between 1.01-1.50 mm³, and two samples demonstrated a deviation of less than 0.50 mm³ [15].

Intraoral scanners support a fully digital workflow for the fabrication of prostheses [17]. The advantages of digital impressions and scanning systems include improved patient acceptance, reduced distortion of impression materials, and the ability to provide real-time 3D visualisation of the scanned surfaces. This visualisation aids in educating and explaining the treatment plan to patients and contributes to reduced chairside time. The impressions are processed using software that accurately reconstructs a 3D model of the desired structures [18,19]. Therefore, it is essential to understand the accuracy of digitally scanning post spaces, where greater depth and complex dimensions present significant challenges. The values obtained in the current study indicate a loss of detail in the recorded impressions, which may have implications for the accuracy of post fabrication and the long-term durability of the posts.

The CBCT image of the post space was used as the control group in this study, as it is known to be more accurate than conventional radiography [20]. CBCT machines utilise a cone-shaped X-ray beam and a reciprocating solid-state flat-panel detector, which rotates once around the patient (180-360 degrees), capturing the defined anatomical volume-either the complete dental/maxillofacial region or a limited area of interest. This differs from the slice-by-slice imaging approach used in conventional CT [20]. The imaging data is stored in the Digital Imaging and Communications in Medicine (DICOM) format, which facilitates telecommunication and compatibility with third-party imaging software [21].

The results of the present study may indicate clinical limitations in using digital scanners for deep post space preparations. However, digital scanners remain in high demand due to their ease of use, convenience, and speed. Therefore, it can be suggested that modifying scanner tips to more accurately capture deeper and narrower dimensions could enhance the precision of digital impressions and lead to greater clinical success in such procedures.

Limitation(s)

This was an in-vitro study and did not replicate intraoral conditions, such as the effects of temperature and humidity in the oral environment, the presence of saliva and blood, soft tissues, patient movement, and the anatomical complexity of the oral cavity. Factors such as manual errors during digital impression recording by the operator, undercuts in the post space preparations, instrumentation errors, operator proficiency, and the angle of incidence of the scanning laser may have influenced the results.

CONCLUSION(S)

Within the limitations of the present study, it can be concluded that the volume recorded using digital impressions was not as accurate as that recorded using CBCT. The volume of the deep post space captured by the digital scanner was significantly less than that recorded by CBCT. Therefore, clinicians should exercise discretion when using digital scanners to record deep post spaces, as this may affect the prognosis of the clinical procedure.

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