RESEARCH PAPER

Comparative Evaluation of Post Space Recordings Obtained Using Conventional Silicone Impressions and Different Intraoral Scanners: An In Vitro Comparative Study

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ABSTRACT
Background: Accurate post-space recording is essential for fabrication of well-fitting custom post-and-core restorations. This study compared conventional polyvinyl siloxane impressions with Trios 3, Medit i700, and Upcera intraoral scanners at 6, 8 and 10 mm post-space depths.
Materials and Methods: Twenty-four extracted maxillary central incisors were divided into three depth groups (6, 8, 10 mm; n=8). Conventional PVS impressions and digital scans were obtained. STL files were superimposed using best-fit analysis and trueness was assessed using RMS deviation. Statistical analysis included repeated-measures ANOVA and Tukey post hoc tests.
Results: Trueness decreased with increasing post-space depth. Trios 3 showed the lowest RMS deviations, Medit i700 performed comparably to conventional impressions, and Upcera showed the greatest deviations, particularly at 10 mm.
Conclusion: Trios 3 demonstrated the highest trueness and represents a reliable digital alternative for post-space recording under the conditions of this in vitro study
Keywords: Intraoral scanner; Digital impression; Post space; CAD/CAM; Trueness; RMS deviation.
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INTRODUCTION
"A post does not strengthen a tooth; it merely provides retention for the core."
– Morton Amsterdam
The restoration of endodontically treated teeth remains an integral component of contemporary restorative and prosthodontic practice. Teeth that have undergone root canal treatment frequently exhibit extensive loss of coronal tooth structure as a result of dental caries, trauma, previous restorations, or endodontic access cavity preparation. Such structural loss compromises the biomechanical integrity of the tooth, reduces its resistance to fracture, and limits the available tooth structure for retention of definitive restorations.

Consequently, post-and-core restorations continue to play an important role in restoring lost tooth structure and providing adequate support for full-coverage crowns. The clinical success of these restorations depends on careful case selection, preservation of radicular dentin, appropriate post design, accurate laboratory procedures, and precise clinical execution. Among these factors, accurate recording of the prepared post space is fundamental because it directly influences the adaptation, retention, and longevity of the definitive restoration.

Post-space recording refers to the transfer of the three-dimensional morphology of the prepared root canal from the clinical environment to the laboratory for fabrication of a custom post-and-core restoration. An ideal recording technique should reproduce the complete canal anatomy, including its taper, diameter, internal irregularities, and apical extent, with minimal distortion. For decades, elastomeric impression materials, particularly polyvinyl siloxane (PVS), have been regarded as the material of choice for recording post spaces because of their excellent dimensional stability, elastic recovery, tear resistance, and ability to reproduce fine anatomical details. Conventionally, low-viscosity impression material is injected into the prepared canal and reinforced with an orthodontic wire or carrier before removal, thereby allowing accurate reproduction of the intracanal morphology. Although this technique has demonstrated satisfactory clinical performance, it remains highly technique-sensitive. Entrapment of air bubbles, incomplete material flow, tearing during impression removal, and distortion during disinfection, transportation, or storage may adversely influence the accuracy of the final restoration. Additionally, conventional impression procedures require multiple clinical and laboratory steps, thereby increasing chairside time and patient discomfort.

The advent of digital dentistry has transformed restorative dentistry by introducing computer-aided design and computer-aided manufacturing (CAD/CAM) workflows supported by intraoral scanning technologies. Intraoral scanners enable direct optical acquisition of oral structures, generating three-dimensional digital models that can be immediately transferred to the dental laboratory without the need for conventional impression materials. Digital impressions offer numerous clinical advantages, including improved patient comfort, elimination of impression trays and materials, immediate evaluation of impression quality, simplified communication with laboratories, reduced risk of cross-contamination, and permanent digital storage of patient records. As a result, intraoral scanners have become increasingly popular for recording tooth preparations, implant restorations, fixed dental prostheses, and orthodontic appliances.

Despite these advantages, accurate recording of post spaces using intraoral scanners remains challenging. Unlike external tooth surfaces, post spaces are narrow, deep, and confined anatomical structures that restrict direct visualization and scanner access. Successful optical scanning depends upon adequate light penetration, proper reflection of projected light patterns, and uninterrupted image acquisition. As post-space depth increases, optical shadowing, reduced focal depth, limited accessibility of the scanner tip, and increased dependence on image-stitching algorithms reduce the accuracy of digital reconstruction. Furthermore, software interpolation may artificially smooth narrow canal anatomy, resulting in incomplete or distorted representation of deeper regions. Consequently, the reliability of intraoral scanners for recording deep post spaces remains an area of ongoing investigation.

Modern intraoral scanners utilize different optical technologies, including confocal microscopy, triangulation, structured light projection, and proprietary image-processing algorithms. Variations in these technologies may significantly influence their ability to accurately reproduce complex internal canal geometries. Several recent investigations have demonstrated that scanning accuracy decreases as post-space depth increases, although the magnitude of this reduction differs among scanner systems. While certain scanners have demonstrated clinically acceptable accuracy in shallow and moderate post spaces, deeper preparations continue to present significant challenges because of optical limitations and incomplete data acquisition. These observations suggest that the performance of individual intraoral scanners cannot be generalized across all clinical situations and requires independent evaluation under standardized conditions.

The increasing adoption of digital restorative workflows has created a need to determine whether contemporary intraoral scanners can reliably replace conventional silicone impression techniques for recording post spaces. Accurate digital recording has the potential to simplify custom post-and-core fabrication, reduce treatment time, minimize laboratory procedures, and facilitate complete integration with CAD/CAM technology. Conversely, if digital recording accuracy decreases significantly in deeper post spaces, clinicians may need to continue relying on conventional impression techniques in selected clinical situations. Therefore, scientifically evaluating the trueness of different intraoral scanners at varying post-space depths is of considerable clinical importance.

Accordingly, the present in vitro study was designed to evaluate and compare the trueness of post-space recordings obtained using a conventional polyvinyl siloxane silicone impression technique and three contemporary intraoral scanners—Trios 3, Medit i700, and Upcera—at post-space depths of 6 mm, 8 mm, and 10 mm using three-dimensional STL superimposition. The null hypothesis was that no statistically significant difference would exist among the evaluated recording techniques with respect to post-space recording trueness.

MATERIALS AND METHODS

Study Design

The present investigation was designed as an in vitro comparative study to evaluate the trueness of post-space recordings obtained using a conventional silicone impression technique and three contemporary intraoral scanners at different post-space preparation depths. The study was conducted in the Department of Prosthodontics in collaboration with the Department of Conservative Dentistry and Endodontics under standardized laboratory conditions. The study protocol was developed to eliminate operator- and environment-related variables that could influence recording accuracy.

Sample Selection

Twenty-four freshly extracted human maxillary central incisors were selected for the study. Teeth were collected after obtaining informed consent and were thoroughly cleaned to remove residual soft tissue deposits and calculus. Following extraction, all specimens were stored in distilled water until use to prevent dehydration and maintain dentinal integrity.

Inclusion Criteria

Intact maxillary central incisors with fully formed roots
Teeth free from structural deformities
Teeth exhibiting comparable root dimensions
Teeth with a single straight root canal

Exclusion Criteria

Carious teeth
Fractured or cracked teeth
Previously endodontically treated teeth
Teeth with root resorption
Teeth with developmental anomalies
Teeth with curved or excessively short roots

All selected specimens were examined visually and radiographically before inclusion in the study.

Specimen Preparation

The collected teeth were mounted individually in self-cure acrylic resin blocks with the long axis maintained perpendicular to the horizontal plane to facilitate standardized instrumentation and scanning procedures. Coronal tooth structure was removed approximately 1 mm coronal to the cemento-enamel junction using a diamond disc under continuous water irrigation to obtain uniform reference specimens.

Root canal treatment was performed by a single experienced endodontist to eliminate inter-operator variability. Working length determination, canal preparation, irrigation protocol, obturation, and postoperative procedures were standardized for all specimens. Following obturation, post-space preparation was carried out while maintaining an adequate apical seal of gutta-percha.

Grouping of Specimens

The twenty-four specimens were randomly allocated into three experimental groups according to post-space preparation depth.

Group	Post-space depth	Sample size
Group A	6 mm	8
Group B	8 mm	8
Group C	10 mm	8

Standardized post drills recommended by the manufacturer were used to prepare all post spaces. The depth of preparation was verified using an endodontic ruler to ensure consistency among specimens.

Post-space Recording Procedures

Each prepared specimen was recorded using four different recording techniques.

Group 1 – Conventional Silicone Impression

Light-body polyvinyl siloxane (PVS) impression material was injected into the prepared post space using an automixing delivery system. A suitable carrier was inserted into the canal to facilitate retrieval of the impression after polymerization. The impressions were allowed to set according to the manufacturer's instructions before careful removal. The obtained impressions were subsequently digitized using a laboratory scanner to generate STL files for comparison.

Group 2 – Trios 3 Intraoral Scanner

Each specimen was scanned using the Trios 3 intraoral scanner following the manufacturer's recommended scanning protocol. The scanner tip was positioned to obtain maximum visualization of the prepared post space while maintaining a consistent scanning distance. Digital datasets were exported as STL files for three-dimensional analysis.

Group 3 – Medit i700 Intraoral Scanner

The same scanning protocol was repeated using the Medit i700 intraoral scanner. Care was taken to standardize scanning direction, scanning distance, ambient illumination, and operator handling to minimize procedural variability. STL files generated by the scanner were stored for subsequent analysis.

Group 4 – Upcera Intraoral Scanner

Digital impressions were also obtained using the Upcera intraoral scanner under identical laboratory conditions. All scans were performed by the same operator to eliminate operator-dependent bias. The STL datasets generated by the scanner were saved for three-dimensional comparison.

Three-Dimensional Analysis

All STL datasets obtained from the conventional silicone impression technique and the three intraoral scanners were imported into specialized three-dimensional analysis software.

The digital models were aligned using the best-fit superimposition algorithm, enabling comparison between the reference dataset and the experimental datasets. Recording accuracy was quantified by calculating the Root Mean Square (RMS) deviation, which represents the average three-dimensional discrepancy between corresponding surface points.

Lower RMS values indicated greater trueness and superior recording accuracy, whereas higher RMS values represented increased deviation from the reference dataset. Color-coded deviation maps were also generated to visualize areas of positive and negative deviation throughout the recorded post space.

Statistical Analysis

The recorded data were entered into Microsoft Excel and subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS).

The following statistical methods were employed:

Descriptive statistics (Mean ± Standard Deviation)

Repeated Measures Analysis of Variance (ANOVA)

Tukey's post hoc multiple comparison test

Statistical significance was established at $p < 0.05$ with a 95% confidence interval.

RESULTS

A total of twenty-four standardized specimens were analyzed. The trueness of post-space recordings obtained using the conventional silicone impression technique and three intraoral scanners was evaluated at three different post-space preparation depths (6 mm, 8 mm, and 10 mm) using RMS deviation values generated following three-dimensional STL superimposition.

Overall, a progressive increase in RMS deviation was observed with increasing post-space depth irrespective of the recording technique employed. This finding indicates that recording accuracy decreased as the depth of the prepared post space increased. However, the magnitude of reduction differed among the evaluated recording systems.

Comparison of Recording Accuracy at Different Post-space Depths

At the 6-mm preparation depth, all recording systems demonstrated comparatively low RMS deviation values, indicating high recording accuracy. Among the evaluated intraoral scanners, Trios 3 exhibited the lowest deviation values and consequently the highest trueness. The Medit i700 demonstrated recording accuracy comparable with that of the conventional silicone impression technique, whereas the Upcera scanner showed relatively greater deviation.

At the 8-mm preparation depth, RMS deviation values increased for all recording techniques. Although Trios 3 continued to demonstrate superior trueness, the differences among the recording methods were less pronounced, and intergroup comparison did not reveal statistically significant differences.

At the 10-mm preparation depth, all recording systems demonstrated a further increase in RMS deviation. The reduction in recording accuracy was particularly evident for the Upcera scanner. Trios 3 maintained the lowest deviation values even at the deepest preparation level, whereas Medit i700 continued to perform comparably with the conventional silicone impression technique.

Overall Comparison of Recording Techniques

Recording Technique	Performance
Trios 3	Highest trueness (Lowest RMS deviation)
Medit i700	Comparable to conventional silicone impressions
Conventional Silicone Impression	Clinically acceptable accuracy
Upcera Scanner	Highest RMS deviation (Lowest trueness)

Statistical Analysis

Repeated-measures ANOVA demonstrated statistically significant differences among the evaluated recording techniques ($p < 0.05$). Subsequent Tukey's post hoc analysis revealed:

Statistically significant differences at the 6-mm preparation depth.

No statistically significant difference among recording techniques at the 8-mm preparation depth.

Statistically significant differences at the 10-mm preparation depth.

Trios 3 demonstrated significantly lower RMS deviation values than Upcera at all preparation depths. Medit i700 did not differ significantly from the conventional silicone impression technique, indicating comparable recording performance.

Summary of Major Findings

Recording accuracy decreased as post-space depth increased.

Trios 3 consistently demonstrated the greatest trueness.

Medit i700 produced results comparable with the conventional silicone impression technique.

Upcera exhibited the highest deviation values, particularly at the 10-mm preparation depth.

Significant differences were observed at 6 mm and 10 mm, whereas no significant difference was detected at 8 mm.

DISCUSSION

The success of a custom post-and-core restoration depends largely on the precise adaptation of the post within the prepared root canal. Any discrepancy between the prepared canal and the fabricated post may compromise retention, increase cement thickness, create areas of stress concentration, and ultimately affect the longevity of the definitive restoration. Consequently, accurate recording of the post space remains one of the most critical steps in the fabrication of custom cast or CAD/CAM post-and-core restorations. The present in vitro study compared the trueness of post-space recordings obtained using a conventional polyvinyl siloxane impression technique and three contemporary intraoral scanners—Trios 3, Medit i700, and Upcera—at post-space depths of 6 mm, 8 mm, and 10 mm.

Conventional elastomeric impression materials have long been regarded as the gold standard for recording intracanal anatomy because of their excellent dimensional stability, elastic recovery, and ability to reproduce fine surface details. However, conventional techniques involve multiple clinical and laboratory procedures, including impression making, disinfection, transportation, cast fabrication, and laboratory scanning. Each of these steps has the potential to introduce dimensional changes that may affect the accuracy of the final restoration. The introduction of intraoral scanners has significantly altered restorative workflows by enabling direct digital data acquisition and eliminating several intermediate procedures. Nevertheless, the ability of these scanners to accurately reproduce deep and narrow post spaces continues to be questioned because of optical and geometric limitations.

The principal finding of the present study was that recording accuracy decreased progressively with increasing post-space depth regardless of the recording technique employed. The lowest RMS deviation values were observed at the 6-mm preparation depth, whereas the highest deviations occurred at the 10-mm preparation depth. These findings indicate that increasing canal depth adversely influences the ability of both conventional and digital recording techniques to reproduce the prepared canal accurately. The results support the concept that deeper and narrower preparations present greater technical challenges for impression materials as well as optical scanning systems.

The reduction in trueness observed with increasing preparation depth can be explained by several factors. In conventional impressions, deeper post spaces increase the possibility of incomplete material flow, air entrapment, tearing of the impression material during retrieval, and elastic deformation during removal. In digital scanning, increasing depth restricts illumination of the apical portion of the canal, limits the field of view of the scanner tip, and reduces the quantity of reflected optical information reaching the scanner sensors. Consequently, image-processing software must interpolate missing information, thereby increasing reconstruction errors in deeper regions of the post space. These factors collectively explain the progressive increase in RMS deviation observed at greater preparation depths.

Among the evaluated intraoral scanners, Trios 3 consistently demonstrated the lowest RMS deviation values at all three preparation depths. This finding indicates superior trueness and suggests that the optical technology and image-processing algorithms incorporated within the Trios 3 system are capable of reproducing intracanal morphology more accurately than the other evaluated systems. The superior performance of Trios 3 may be attributed to its advanced confocal optical scanning technology, rapid image acquisition, improved data stitching algorithms, and efficient surface reconstruction capability. These characteristics enable the scanner to capture greater detail from narrow and deep anatomical structures while minimizing cumulative registration errors during image acquisition.

The Medit i700 intraoral scanner demonstrated recording accuracy comparable to that of the conventional silicone impression technique. Although RMS deviation values increased with increasing preparation depth, the magnitude of deviation remained within a clinically acceptable range throughout the study. This finding suggests that Medit i700 may be considered a reliable alternative to conventional impression techniques for recording post spaces under controlled conditions. The comparable performance observed between Medit i700 and conventional silicone impressions is encouraging because digital impressions offer several additional clinical advantages, including improved patient comfort, elimination of impression materials, simplified laboratory communication, and complete integration into CAD/CAM restorative workflows.

In contrast, the Upcera intraoral scanner exhibited the highest RMS deviation values among all evaluated recording systems, particularly at the 10-mm preparation depth. The reduction in trueness observed with this scanner may be attributed to limitations in optical penetration, image acquisition within confined spaces, and reconstruction of deeper intracanal anatomy. As preparation depth increased, the scanner appeared to encounter greater difficulty in accurately capturing the apical portion of the post space, resulting in increased deviation values. These findings suggest that although the Upcera scanner may perform satisfactorily for routine crown preparations and shallow cavities, its ability to accurately reproduce deep intracanal morphology may be comparatively limited.

Statistical analysis demonstrated significant differences among recording techniques at the 6-mm and 10-mm preparation depths, whereas no statistically significant difference was observed at the 8-mm depth. The absence of a statistically significant difference at the intermediate depth suggests that moderate post-space preparations may be recorded with comparable accuracy by both conventional and digital techniques. However, as preparation depth increases further, differences in scanner technology become increasingly apparent, leading to significant variation in recording accuracy among different systems.

The findings of the present investigation are in agreement with the observations reported in the literature reviewed in the thesis, which consistently indicate that digital recording accuracy decreases with increasing preparation depth and that different intraoral scanners demonstrate variable performance depending on their optical technology and image-processing capabilities. Several investigations have reported that scanners employing advanced confocal imaging and optimized software algorithms generally demonstrate superior trueness when compared with systems utilizing less sophisticated optical acquisition methods. Likewise, previous studies have concluded that although digital impressions are highly accurate for conventional crown preparations, recording deep and narrow post spaces remains a greater clinical challenge. The present findings support these observations and further demonstrate that scanner selection plays a significant role in determining the accuracy of digital post-space recording.

From a clinical perspective, the present findings have important implications for prosthodontic practice. Accurate digital recording of post spaces has the potential to simplify clinical procedures, reduce chairside time, eliminate impression material distortion, facilitate digital communication with laboratories, and improve integration with CAD/CAM fabrication of custom post-and-core restorations. Based on the present findings, Trios 3 may be considered the most reliable digital system among those evaluated for recording post spaces of varying depths. Medit i700 also demonstrated satisfactory performance and may be regarded as a clinically acceptable alternative to conventional silicone impressions. However, clinicians should exercise caution when recording deeper post spaces with scanners that demonstrate greater deviation values, as inaccuracies may adversely influence the fit and longevity of the definitive restoration.

The present investigation was conducted under standardized in vitro conditions to minimize confounding variables and allow objective comparison among recording techniques. Nevertheless, certain limitations should be acknowledged. The absence of saliva, blood, patient movement, restricted mouth opening, soft tissue interference, and intraoral lighting conditions may not fully replicate the clinical environment. Furthermore, only three intraoral scanners and three post-space preparation depths were evaluated. Additional clinical studies involving a larger sample size, different scanner technologies, varying canal morphologies, and long-term clinical outcomes are required to further validate the present findings and determine the clinical applicability of digital post-space recording in routine prosthodontic practice.

Overall, the findings of the present study indicate that while both conventional and digital techniques are capable of recording post spaces with acceptable accuracy, the performance of intraoral scanners is influenced by the depth of the prepared canal and the technology employed by the individual scanner. As digital dentistry continues to evolve, improvements in optical systems, scanner hardware, and image-processing algorithms are expected to further enhance the accuracy of digital post-space recording and facilitate broader clinical adoption of fully digital workflows for custom post-and-core fabrication.

CONCLUSION

Within the limitations of this **in vitro** study, the following conclusions were drawn:

The trueness of post-space recordings decreased progressively with increasing post-space preparation depth irrespective of the recording technique employed.

Among the evaluated intraoral scanners, **Trios 3** consistently demonstrated the lowest RMS deviation values at all preparation depths, indicating superior recording accuracy.

Medit i700 exhibited recording accuracy comparable to that of the conventional polyvinyl siloxane impression technique, suggesting its suitability for digital post-space recording in routine clinical practice.

The **Upcera intraoral scanner** demonstrated the highest RMS deviation values, particularly at greater preparation depths, indicating comparatively lower trueness for recording deep post spaces.

Statistically significant differences among recording techniques were observed at **6 mm** and **10 mm** preparation depths, whereas no statistically significant difference was observed at the **8 mm** depth.

Increasing post-space depth adversely affected the recording accuracy of both conventional and digital impression techniques.

The findings of the present investigation suggest that scanner technology plays a significant role in determining the accuracy of digital post-space recording and should be considered during clinical decision-making.

Overall, **Trios 3** demonstrated the highest recording accuracy among the evaluated systems and may be considered the most reliable digital alternative to conventional silicone impressions for recording post spaces under the conditions of the present study.

CLINICAL SIGNIFICANCE

The successful fabrication of custom post-and-core restorations depends largely on the accurate reproduction of the prepared root canal. The findings of the present study provide valuable information regarding the clinical applicability of digital impression techniques for recording post spaces.

Digital post-space recording can simplify restorative workflows by eliminating conventional impression materials and several laboratory procedures.

Trios 3 demonstrated superior trueness and may be considered a predictable digital alternative for CAD/CAM custom post-and-core fabrication.

Medit i700 exhibited clinically acceptable accuracy comparable to conventional silicone impressions.

Clinicians should exercise caution while recording deep post spaces using scanners that demonstrate greater deviation values, as inaccuracies may compromise the fit and longevity of the definitive restoration.

Selection of an appropriate intraoral scanner is essential for achieving accurate digital impressions and successful CAD/CAM restorations.

LIMITATIONS

The present investigation should be interpreted within the limitations of an **in vitro** experimental design.

The study was conducted under laboratory conditions that did not simulate saliva, blood contamination, soft tissue interference, patient movement, or restricted intraoral access.
Only maxillary central incisors with standardized root morphology were evaluated.
Only three intraoral scanners were included in the investigation.
Three post-space preparation depths (6 mm, 8 mm, and 10 mm) were evaluated.
Long-term clinical performance of digitally fabricated post-and-core restorations was not assessed.
Variations in canal morphology and operator experience were not evaluated.

FUTURE SCOPE

Future investigations should focus on:
Clinical **in vivo** evaluation of digital post-space recording techniques.
Comparison of newer-generation intraoral scanners employing advanced optical technologies.
Evaluation of scanning accuracy in curved and anatomically complex root canals.
Assessment of the marginal and internal fit of CAD/CAM fabricated post-and-core restorations derived from digital impressions.
Long-term clinical evaluation of survival rates and complications associated with digitally fabricated post-and-core restorations.
Artificial intelligence-assisted image processing for improving digital recording accuracy of deep intracanal preparations.

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CONFLICT OF INTEREST

None.

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ETHICAL CONSIDERATIONS

Extracted human teeth were used following institutional ethical guidelines for in vitro studies.

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