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Assessment of the Dead Space Between Cemented Post and Remaining Gutta-Percha in Various Types of Teeth Using Radiographic Imaging Among Undergraduate Students: A Retrospective Study

Mahir A Mirah[1] , Hani M Ghabbani[2] , Abdulmajeed A Mahrous[3], Abdulmajeed A Baik[4], Shadan H Sharbib[5] , Amira S Alghazaly[6], Anfal M Alqussier[1]

Aim: Endodontically treated teeth often require post and core which are quite reliant on the seal at the interface of post and remaining GP to avoid microleakage and subsequent failure of the treatment. The aim of this study was to assess the discrepancy between the end of the post and the remaining gutta-percha in endodontically treated teeth restored by undergraduate dental students at Taibah University.

Materials and methods: This is a cross-sectional retrospective study of 290 periapical radiographs of endodontically treated teeth with fiber post. The amount of gap in mm was measured from the radiographs and grouped into four categories according to the extent of the gap from no gap to more than 2mm gap and chi square used to to assess variations in gap presence across different tooth types.

Results: Of the teeth evaluated, 78.3% showed no gap between the post and gutta-percha, indicating a high level of student proficiency. Gaps of over 1 mm were present in only 6.5% of cases, with minimal instances exceeding 2 mm.

Conclusion: The study found that undergraduate students are capable of handling post-space preparations with a high success rate of keeping the gap sizes to the minimum. These results support the need for proper clinical training as well as the need for ongoing education in order to improve this area.

Keywords: Dead Space, Gutta-Percha, Post.

1. Department of Restorative Dental Science, College of Dentistry and Hospital, Taibah University, Madinah, Saudi Arabia.
2. Department of Dentistry, King Faisal Specialist Hospital and research center, Madina, Saudi Arabia.
3. College of Dentistry and Hospital, Taibah University, Madinah, Saudi Arabia
4. Endodontics Resident, College of Dentistry and Hospital, Taibah University, Madinah, Saudi Arabia.
5. Graduate Student, College of Dentistry, Taibah University, Madinah, Saudi Arabia.
6. Endodontics Division, Department of Restorative Dental Science, College of Dentistry and Hospital, Taibah University, Madinah, Saudi Arabia.

Corresponding author: Mahir A Mirah, e-mail: mahirmirah@gmail.com

Introduction

Teeth requiring root canal therapy often present significant damage and may necessitate a post and core placement. Various circumstances contribute to the success of root canal treatment, including the quality of the coronal seal, the preoperative condition of the apical tissue, and the techniques used for obturation.[1-3] In accordance with the basic principles of resistance and retention form required for the crown, a post is placed within the canal space of these teeth to retain the core which ensures a proper coronal structure.[4, 5] Nonetheless, the effectiveness of a full-length root canal filling in creating a seal might be threatened during the preparation of post-space. This could result in bacterial and endotoxin infiltration from the crown into the root canal leading to failure of the root canal therapy.[6]

Fan, Wu and Wesselink [7] revealed that postponing preparation resulted in greater coronal leakage compared to immediate preparation. Therefore, it is mandatory to restore the coronal portion of the tooth after endodontic treatment.[6, 8] During post-space preparation, care must be taken to prevent the apical seal integrity from being threatened.[9] If the apical seal becomes compromised, there is a chance that the tooth will re-infect and necessitate retreatment.[10] Maintaining an effective apical seal is essential for preventing the penetration of bacteria, exudates, or infectious materials from peri-radicular spaces into the root canal, and vice versa.[11] Several studies recommend retaining 4–5 mm of apical gutta-percha to ensure a reliable apical seal.[11-13] It has been suggested that the gap between the post and remaining gutta-percha plays a significant role in the potential inclusion of microorganisms following post-placement.[13] However, no study measured the gap between the gutta-percha and the apical end of the post in the teeth that have undergone root canal treatment. Therefore, the objective of this study is to measure the gap between the end of the post and the remaining gutta-percha in the root canal of the teeth that have undergone root canal treatment performed by undergraduate dental students at Taibah University.

Material and Methods

The research protocol received ethical approval from the ethics committee of the College of Dentistry, Taibah University with study reference no. TUCDREC/050324/MMirah.

The cross-sectional retrospective study consisted of periapical radiographs of endodontically treated teeth with GP and fiber post. Inclusion criteria: The teeth with fiber posts were prepared by undergraduate students and interns with good quality periapical postoperative radiographs without any procedural mistakes like perforation. Exclusion criteria: Teeth with procedural mistakes, or teeth with poor quality of periapical post-operative radiograph.

The sample size calculations were based on the expected effect size (Cohen's d) of 0.25 [14, 15], which was obtained from a previous similar study. By using G*Power, Version 3.1.9.7 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany), with an alpha level of 0.05, a desired power of 0.90, and an expected effect size of 0.25, the minimum required sample size was 271 participants. In this study, we include 290 participants, slightly above the minimum required sample size.

A total of 290 periapical radiographs were obtained from the R4 system at the College of Dentistry between March and April 2024. Two consultants, using the postoperative periapical radiographs, assessed the distance between the end of the post and the gutta-percha in millimeters. The measurements were conducted using ImageJ software, Version 1.53 (National Institutes of Health, Bethesda, MD, USA). A calibration image was imported into ImageJ software to ensure all images' measurements were accurate. Then, the gap between the end of the gutta-percha and the

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post was measured using a straight line and recorded in millimeters.

The data was then recorded in an Excel sheet. The results were categorized into four groups: Group I had no gap, Group II had a gap >0 to 1 mm, Group III had a gap >1 to 2 mm and Group IV had a gap >2mm between the end of the post and the remaining gutta-percha.

The data were analyzed utilizing SPSS, Version 13.0 (IBM Corp., Armonk, NY, USA), with descriptive statistics calculated to tabulate the frequency of students' proficiency. The proficiency levels across different tooth types were compared through chi-square tests, and a p-value of 0.05 was set as the threshold for statistical significance.

The data was exported from the Excel sheet into the statistical package for social science 16 (SPSS, version16, Inc, Chicago, IL, USA) for analysis. Chi-square test was used to explore relationships between variables. The significance level sets at p-value ≤0.05.

Results

A total of 290 endodontically treated teeth with post and core restorations were assessed. Table 1 shows the number of teeth with dead space between the end of the post and the gutta-percha in millimeters among the six tested teeth groups. Among the samples, 227 teeth (78.3%) exhibited no gap between the apical end of the fiber post and gutta-percha, while 45 teeth (15.5%) had a gap of >0 to 1 mm, 16 teeth (5.5%) had a gap of >1 to 2mm, and two teeth (0.7%) had a gap of >2 mm. A comparison of gap size found between the apical end of the fiber post and gutta-percha in teeth from different dental arch segments is illustrated in Figure 1.

Among 181 assessed teeth in the maxillary arch, 144 teeth (79.5%) were restored without any gaps. While 28 teeth (15.5%) showed gap between 0 and 1 mm, seven teeth (3.9%) had a gap of >1 to 2 mm, and only two teeth (1.1%) with more than 2 mm gap. In the mandibular arch, 83 out of 109 examined teeth (76.1%) teeth were restored with no gap. Yet, 17 teeth (15.6%) had a gap of >0 to 1 mm, and nine teeth (8.3%) had a gap of >1 to 2 mm. In the maxillary anterior, total of 117 teeth were treated and examined. Ninety-four teeth (80.3%) showed no gap between the post and remaining gutta-percha. Nevertheless, 19 teeth (16.2%) of them showed >0 to 1 mm gap, two teeth (1.7%) had a gap of >1 to 2 mm, and two teeth (1.7%) revealed a gap exceeding 2 mm. In the maxillary posterior, 50 teeth (78.1%) exhibited no gaps between the post and the gutta-percha. However, nine of them (14.1%) showed >0 to 1 mm gap, and five teeth (7.8%) showed a gap of >1 to 2 mm.

Table.1: Number of teeth with different gap sizes between the gutta-percha and the apical end of the fiber post among the six tested groups.

Teeth Type	Group I n (%)	Group II n (%)	Group III n (%)	Group VI n (%)	Total n (%)	P-value
Maxillary anterior	94 (80.30)	19 (16.20)	2 (1.7%)	0	117 (40.34)	0.459
Maxillary premolar	37 (75.50)	8 (16.30)	4 (8.2%)	2 (1.70)	49 (16.90)	
Maxillary molar	13 (86.70)	1 (6.70)	1 (6.7%)	0	14 (4.83)	
Mandibular anterior	23 (63.90)	9 (25.00)	4 (11.1%)	0	36 (12.41)	
Mandibular premolar	40 (85.10)	4 (8.50)	3 (6.7%)	0	48 (16.55)	
Mandibular molar	20 (76.90)	4 (15.40)	2 (7.7%)	0	26 (8.97)	

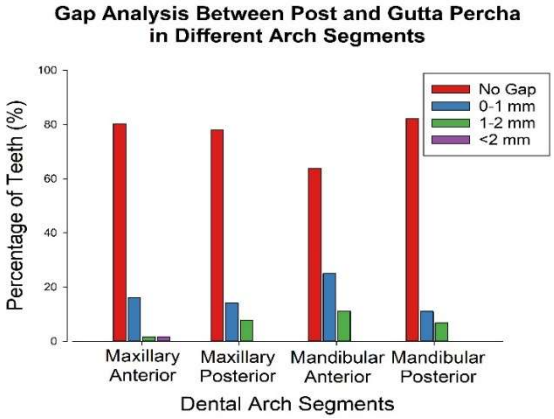

Figure 1: A comparison of gap size found between the apical end of the fiber post and Gutta-percha in teeth from different dental arch segments.

A total of thirty-six endodontically treated teeth with post and core in the mandibular anterior were included. Twenty-three of them (63.9%) exhibited no gap between the apical end of the fiber post and gutta-percha. Yet, nine teeth (25%) showed >0 to 1 mm gap between the post and gutta-percha, and four teeth (11.1%) revealed a gap of >1 to 2 mm. However, none of the teeth showed a gap greater than 2 mm between the post and gutta-percha. In the mandibular posterior region, sixty teeth (82.2%) exhibited no gaps between the post and gutta-percha. While eight teeth (11%) showed >0 to 1 mm gap, and five teeth (6.8%) revealed a gap of >1 to 2 mm. However, none of the teeth exhibited a gap greater than 2 mm.

Discussion

Endodontically treated teeth usually require extra-coronal restorations alongside post and core placement.[16] Post and core must meet certain prosthodontic criteria to ensure the success of the permanent restoration and to maintain an intact apical seal.[17-19] Post-space preparation is considered as one of the basic skills taught in dental schools, as undergraduate dental students must carry out the clinical procedure of placing posts and cores as clinical requirements.

Post-space preparation involves the removal of gutta-percha from the coronal and middle parts of the canal to create a space that fits an intra-canal post.[15, 17, 20] Ideally, no gap should exist between the apical end of the post and the most coronal part of the remaining gutta-percha.[17-20] If a gap exists, it may negatively affect the apical seal, leading to microleakage. This provides a pathway for bacterial infiltration and potentiating emergence of periapical lesions.[18-20] Studies have suggested that a gap up to 0.2mm is tolerated.[17-20] However, larger gaps may be associated with failure of endodontic treatment due to microleakage and development of periapical lesions. Sayed, Ahmad, Naim, et al. [15] reported unsatisfactory clinical outcomes associated with teeth with gaps larger than 1 mm, while Naim, Ahmad, Ageeli, et al. [20] and Baik [17] reported that gaps of 2-3 mm were associated with increased rates of microleakage leading to the development of periapical lesions of more than two-thirds of these cases within one year follow up. Therefore, it is of great importance to regularly monitor, evaluate, and improve the clinical skills of dental students regarding post-space preparation and post-placement.

The Periapical radiographs in this study were two-dimensional type of radiography. Despite their two-dimensional nature, their performance is considered acceptable during endodontic treatment and post-space preparation procedures.[21, 22] When compared to cone beam computed tomography (CBCT), periapical radiographs are cost effective, and expose patients to minimal amounts of radiation.[22] However, they have many inherent limitations such as image distortion and superimposition.[23] On the contrary, CBCT provides three-dimensional representation of the anatomical structures, better resolution, and better detection of root anatomy.[22, 24] However, the decision to expose the patient to the additional radiation and additional costs of CBCT must be carefully evaluated considering the risk to benefit ratio of each case.[21]

The guidelines of the European Society of Endodontology recommend that the use of CBCT should be limited to certain cases. Which are management of root resorption, planning surgical endodontic treatment, assessment of complex root anatomy, and cases of maxillofacial trauma. In addition to the diagnosis of periapical pathology in the presence of contradictory signs and symptoms, conformation of the source of nonodontogenic pathology, and to evaluate the causes of endodontic failure.[25] Therefore, the use of CBCT to assess the outcomes of post-space preparation, and to measure the space between the cemented post and remaining gutta-percha solely for research purposes is not justified.

The maxillary teeth account for most teeth included in this study, this is in agreement with

the findings of previous studies.[15, 18, 26-28] This finding could be attributed to the ease of isolation in the upper arch, and the absence of tongue movement which can potentially interfere with visibility. The majority of the included maxillary teeth in the current study were anterior teeth, which is in line with earlier studies.[26, 27] However, different studies included a higher number of maxillary premolars.[15, 17, 18, 28] The lower percentage of posterior teeth included in our study may be explained by the tendency of students to choose simpler cases for post preparation and placement. Treating multi-rooted teeth may result in a variety of complications, including perforations and root fractures. Thus, many students tend to prefer treating single rooted teeth.[15]

There was no gap between the cemented posts and gutta-percha in most of the cases. This observation might be explained by the assumption that the students who did the endodontic treatment also prepared and cemented the post, given that they were the most familiar with the anatomy of the canal system. Previous investigations also revealed comparable findings [18, 27]. Other authors reported higher [15, 26] and lower [17, 19, 20] percentages than the current study's findings. These differences might be attributed to the different numbers of cases included in each study, as well as the differences in the students' academic levels.

In our study, the maxillary teeth show a higher percentage of teeth with no gap between the cemented posts than mandibular teeth. This observation could be explained by the fact that these teeth are single-root and have a considerably simpler anatomy than maxillary posterior teeth, especially for undergraduates. While in mandibular teeth espically anterior teeth are not common to receive root canal treatment and extra-coronal restorations.[29] Thus, the current study included fewer mandibular anterior teeth, which is consistent with earlier investigations.[15, 26, 28]

Compared to previous published studies [26, 28], the current study reported a higher percentage of teeth with gaps between the apical end of the post and the remaining gutta-percha. This outcome might be explained by the assumption that it could be challenging for undergraduate students to choose the appropriate post size that fits the prepared space, and to adapt it properly. Similar to the finding of Naim, Ahmad, Ageeli, et al. [20] which reported only 0.7% of the included teeth had a gap larger than 2mm. Baik [17] reported that gaps larger than 2 mm were associated with higher rates of periapical diseases.

Based on the current study's outcome, the evaluated students' overall clinical performance is considered acceptable. The majority of the analyzed cases were within the recommended standards. This result is consistent with previous studies reporting acceptable outcomes of post placement when performed by dental students.[15, 17, 18, 26-28]

While our study provides valuable insights into the performance of dental students in post-space preparation and placement, the entire presented data was collected from the dental clinics of Taibah University, restricting its generalizability. In addition, possible variations in performance based on students' gender or different academic levels were not explored in this study. Considering the effect of using different post types and resin cements on the gap formation between the apical end of the post and the remaining gutta-percha might provide valuable insights for future research.

Conclusion

Within the limitation of this study, undergraduate dental students demonstrated clinical competence to perform post-space preparation. Most of the cases had no space between the post and the gutta-percha. However, the presence of gaps greater than 1 mm in a small percentage of cases highlights the need for ongoing monitoring and enhancement of clinical training to further reduce such occurrences.

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Data availability

The data of this study are available from the corresponding author upon request.

Declarations

The authors declare that there is no conflict of interest.

Ethics approval and consent to participate

The study was approved by the ethics committee of the College of Dentistry, Taibah University (reference no. TUCDREC/050324/MMirah). General consent for research use of images was obtained, allowing the use of radiographic images for various research purposes as part of the standard protocol when patients opened their files.

Competing interests

The authors declare that they have no competing interests

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