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ORIGINAL RESEARCH

Radiographic Assessment of the Quality of Post and Core Restorations and the Effect of the Gap Between the Post-Restoration and the Remaining Root Canal Filling on the Apical Status in a Saudi Subpopulation

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Background: The objective of this study was to assess the quality of post and core restorations carried out by general dentists in the Hail region of Saudi Arabia using periapical radiographs. Additionally, the assessment included the examination of periapical lesions.

Methods: A comprehensive analysis was conducted on 301 periapical digital radiographs to assess various factors including the type of post, type of coronal restoration, post length in relation to crown and root length, presence of any abnormalities in the post space, condition of the remaining gutta-percha (GP), gap between the end of the post and the GP, and the presence of apical lesions. Analysis was conducted to determine the frequency distribution and cross-tabulation of the variables.

Results: Prefabricated metallic posts were most commonly used (62.1%), followed by metal posts which were found in 28.9% of the cases, and fiber posts which were used in 9.0% of the cases. The length of the posts in relation to the tooth were 2:1 in 32.6%, followed by 1:1 (27.9%) and 1:2 (23.6%). Parallel posts were used in 54.2% of cases, while the remaining 45.8% used tapered posts. Smooth posts were utilized in 77.1% of the cases, while serrated posts were utilized in 22.9%. Approximately 54.2% of the cases exhibited remaining GP of more than 5 mm, whereas 35.2% demonstrated adequate GP between 3–5 mm and 8.0% with remaining GP less than 3 mm. According to the study's findings, 65.1% of the samples under investigation had full coverage indirect restorations placed.

Conclusion: It was found that the post and core procedures' quality was comparable to earlier epidemiological studies. However, a significant proportion of posts were deemed to have poor technical quality, and apical periodontitis was seen in slightly more than one-third of the cases.

Keywords: post and core system, apical status, technical quality, endodontically treated teeth, Saudi Arabia

Background

Teeth that have undergone endodontic treatment are susceptible to root fractures as a result of the loss of substance.[1] Hence, the precise positioning of the coronal restoration following endodontic therapy is a crucial factor in ensuring the tooth's longevity. An appropriate restoration not only restores the appearance and functionality of the tooth but also inhibits the release of microorganisms.[2,3] Nevertheless, there is currently no confirmed causal association between

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fractures and the specific kind of restoration. Research has focused on determining the most appropriate material or technique for the rehabilitation of teeth treated with endodontics.[4]

Endodontic treatment is of significant importance in guaranteeing the preservation of teeth and the effectiveness of post and core treatment.[5] The restoration of teeth that have had endodontic treatment and have experienced significant loss of coronal tooth structure necessitates the utilisation of dental posts and core materials, which serve to enhance the retentive characteristics of the coronal restoration.[6] Many post systems have been developed, including prefabricated posts made of titanium or stainless steel and custom posts made of gold or non-precious metals.[7] In recent years, other options have been created for aesthetic posts, such as glass fiber and ceramic posts in various sizes and shapes.[8] The clinical results of the restoration are influenced by the unique mechanical properties of each material, including bonding qualities, flexural strength, and modulus of elasticity.[7,8]

The clinical examination and diagnostic periapical radiography play a crucial role in establishing the specific kind, length, and diameter of the post.[9] The available evidence indicates that tapered posts demonstrate reduced retention in comparison to parallel posts, whereas still retaining clinically acceptable levels of retention for both post types. Based on the findings presented in the research, it has been demonstrated that parallel-sided posts provide a more homogeneous dispersion of stresses and provide improved tensile and shear stress resistance in comparison to tapered posts.[10] The study revealed that the strains in the coronal section were mostly impacted by the length of the post rather than its diameter. More precisely, it was noted that posts that were short and wide led to greater distribution of stress in the coronal section of tooth. However, it was noted that positioning posts beyond two-thirds of the root led to increased levels of stress in the apical region.[11] Trabert et al suggested that the diameter of the post should not surpass one-third of the root diameter at any specific location.[12] Prior studies have also shown that there is a direct correlation between the ratio of root size to post size and the likelihood of root fracture. This implies that larger preparations may raise the chances of root fracture occurring.[13]

In order to maintain the integrity of the apical seal, it is imperative to maximize the ideal length of a post. The optimal length of a post should be maximized while ensuring the integrity of the apical seal. It is advised that the post's length be at least as long as the height of the clinical crown.[14] As indicated in other studies, the ideal length for a post is roughly two-thirds of the length of the root, and the gutta-percha (GP) should be between 3 and 5 mm at the apex.[15] Inadequate post length can lead to less retention and higher stress, which may ultimately result in root fracture. It is ideal for there to be no gap between the post and the remaining GP. This region has the potential to serve as a habitat for bacteria, which could have a detrimental effect on the success of the endodontic treatment and raise the chances of developing a periapical lesion.[16] The remaining length of the GP needed to maintain the integrity of the apex and achieve a proper seal should be between 3 to 5 mm,[17] as retaining more than 5 mm of GP material while still preserving the optimal length of the post, as suggested by Naim et al,[18] has the highest chances of overall success.

The failure mode and survival rates of posts and cores were the main subjects of many retrospective studies. The different materials used to make posts and cores, as well as the different post geometries and cement types used, were specifically compared by researchers. Nonetheless, these factors might not be as important as the amount and caliber of the remaining coronal dentin.[19,20] The restorative processes performed after endodontic therapy and their impact on the case's prognosis have received a lot of attention.[21–23] Other research, however, found that posts have no influence on the state of the periapical region or the efficacy of endodontic therapy.[24–26]

The technical quality of the remaining GP and post and core restorations performed on patients by general dentists in the Hail region was previously assessed by Almansour et al.[27] They reported that the evaluated posts' technical quality was considered to be below optimum. However, the prior study's sample size was small. Furthermore, only the radiographic technical quality of post and core restorations was investigated, but the precise effect of a gap between the root canal filling and the post restoration was not addressed. Additionally, it was not discussed how this gap could affect apical status, including infection and periapical health. As a result, this study assesses the clinical implications of apical status and the significance of the gap in restorations, in addition to technical quality. Therefore, the primary aim of this research is to evaluate technical quality of post and core restorations and the effect of the gap between the post restoration and the remaining root canal filling on the apical status via periapical radiographs.

Methods

Ethics and Consent

The present work has been granted approval by the Research Ethics Committee (REC) at the University of Hail, with the reference number H-2023-406. Informed permission was not required because of the study's retrospective design, according to the College of Dentistry's ethical board. The authors confirm that all experiments were performed in accordance with relevant guidelines and regulations.

Analysis of post and core restorations was done in the province of Hail by retrospective cross-sectional observational research in the Hail Dental Centre. The Hail Dental Centre is a public dental polyclinic offering free dental care. The dental procedures are mostly performed by specialists in the field who deal with more complex cases. The population recruited included patients living in Hail City and the nearby regions. The dataset was composed of 301 digital periapical radiographs that were obtained from post and core restorations that were used to restore teeth that had undergone endodontic treatment. The radiographs were obtained from a cohort of general dentists within the time frame 2018 to 2023. The inclusion criteria included individuals who were 18 years of age or older and had received post-core restorations at Hail Dental Centre. Additionally, patients were required to possess a minimum of two periapical radiographs, one taken after post cementation and the other taken at least one year following the restoration. Only radiographs taken one year after post cementation were included in the analysis. Patients below the age of 18, those with inadequate radiographs or where the periapical area was not diagnostically visible, and incomplete records were excluded. No personally identifiable information, such as names, file numbers, or identifiable patient data, was gathered. The authors securely saved all information.

The data collection procedure was dependent on information obtained from the patient's medical record and a radiography software (CSR4 software, Carestream Dental LLC, GA, USA). Each sample's data was recorded using a custom-designed form for the sole purpose of this study. The study employed the FOCUS™ Intraoral X-ray imaging system, (KaVo™, Finland). The radiographs were taken using an RVG type sensor, which incorporates a film xcp holder to provide accurate positioning. The exposure settings consisted of a predetermined kilovoltage (kV) of either 60 or 70, accompanied by a customisable exposure duration spanning from 0.02 to 3.2 seconds. The period of exposure was contingent upon various elements, including the particular tooth under imaging, the patient's size, and the chosen mode of exposure. The patients' radiographs were then visualised on the R4 system utilizing the "Kodak Dental Imaging" software.

A data collection sheet was created to gather information on various aspects, such as the type of post, coronal restoration type, post length relative to crown and root length, presence of any abnormalities in the post space, status of the remaining GP, space between the end of the post and the GP, and apical lesions. Apical lesions were considered present if they were ≥2 mm in diameter, according to the Periapical Index (PAI) scoring system. The data recorded in this study is outlined in Table 1.

Table 1 Parameters of Dental Post-Core Restorations Used in the Study

Definition	Criteria	Parameters
Type of post	Custom metal	
	Glass fiber post	
	Prefabricated metal	
Post length in relation to crown and root length	1:1	Equal to the crown and root length
	2:1	More than crown and root length
	1:2	Less than crown and root length

(*Continued*)

Table 1 (Continued).

Definition	Criteria	Parameters
Remaining gutta-percha	3–5mm	If the remaining gutta percha is 3 to 5mm
	Extruded beyond	If the remaining gutta percha extruded beyond the root apex
	Less than 3mm	If the remaining gutta percha less than 3mm
	More than 5mm	If the remaining gutta percha more than 5mm
Fracture post	Absent	If there is no post fracture
	Present	Favorable if the post fracture above the cervical line of the restored tooth
		Unfavorable if the post fracture below the cervical line of the restored tooth
Coronal status		
Type of coronal restoration	Direct	Any direct restoration that appeared radiographically.
	Caries	Any restoration with recurrent caries.
	Full coverage indirect	Any full coverage indirect restoration that appeared radiographically.
	Partial coverage indirect	Any partial coverage indirect restoration that appeared radiographically.
Apical status		
Apical lesion	Absent periapical lesion	Normal periapical structure
	Present periapical lesion	Well defined radiolucency ≥ 2 mm in diameter.

Prior to conducting the evaluation, the examiners had a calibration instruction. Before commencing the experimental reading, the examiners, namely RHA, FYA, and NMA, underwent calibration procedures overseen by SAA, RKA, and AAM, in accordance with the predetermined standards and variations previously described. A random selection of twenty percent of the sample was thereafter assessed by the examiners. The kappa coefficient was computed to assess the level of agreement among observers, yielding a value of 0.92. The observers engaged in a simultaneous evaluation and discussion during cases of disagreement, ultimately arriving at a definitive consensus. Following the initial assessment, the identical examiner performed a subsequent analysis with a two-week interval. The subsequent analysis was performed in a blinded manner, where the examiner was not provided with information about the previous findings. Around 20% of the sample was allocated for this specific objective, with the intention of assessing the reliability of observations made by the same observer. The intra-observer agreement, which measures the degree of consensus among observers, was determined to be 0.87.

The statistical analysis was conducted using IBM Inc. SPSS for Windows v22.0. This software was employed to conduct the frequency distribution and cross-tabulation. The chi-square tests were applied to identify statistically significant differences between the groups. The Generalized Estimating Equation was used to calculate the effect size presented as the odds ratio (OR) and the 95% confidence interval (95% CI). The p-value was established at a significance level of 5%.

Results

A total of 301 teeth from 201 patients were included in the analysis. The age of the participants ranged from 18–85 years (mean 47 ± 14 years) with 48.8% male and 51.2% female. The teeth most commonly involved included the lower right first molar (10%) followed by the upper right second premolar (8%) and the lower left first molar (7.6%). The upper teeth represented 55.1% while lower teeth represented 44.9% of the included cases.

Table 2 presents the comprehensive analysis of frequency and percentage according to many factors including post type, post length, coronal restoration, presence of any abnormalities in the post space, status of the remaining GP, space between the end of the post and the GP, and apical status. The study's findings reveal that prefabricated metallic posts were the most frequently used, accounting for 62.1% of the cases. Metal posts were employed in 28.9% of the cases,

Table 2 Technical Quality of Dental Post-Core Restorations in the Studied Sample

Variables		Frequency	Percent
Type of post	Custom metal	187	62.1
	Glass fiber	27	9.0
	Prefabricated metal	87	28.9
Length of post in relation to crown and root length	1:1	84	27.9
	1:2	71	23.6
	2:1	98	32.6
	Other	48	15.9
Presence of abnormalities in post space	Ledge	26	8.6
	No	256	85.0
	Other	11	3.7
	Perforation	8	2.7
Status of the remaining gutta-percha	3–5 mm	106	35.2
	Extruded beyond	8	2.7
	Less than 3 mm	24	8.0
	More than 5 mm	163	54.2
Fracture root	Absent	298	99.0
	Favorable	1	0.3
	Unfavorable	2	0.7
Shape of the post	Parallel	163	54.2
	Tapered	138	45.8
Post design	Serrated	69	22.9
	Smooth	232	77.1
Space between the end of post and gutta-percha	Absent	83	27.6
	Present	218	72.4

(*Continued*)

Table 2 (Continued).

Variables		Frequency	Percent
If the space presents	2 mm or more	23	7.6
	Less than 2 mm	195	64.8
Apical lesion	Absent	193	64.1
	Present	108	35.9
Type of coronal restoration	Caries	8	2.7
	Direct	86	28.6
	Full coverage indirect	196	65.1
	Partial coverage indirect	11	3.7

while fibre posts were used in 9.0% of the cases. The analysis of periapical radiographic images pertaining to the length of posts, as assessed by the criteria for optimum post length employed in this study, indicated that in about 32.6% of the cases, the posts were 2:1 length of the root, followed by 1:1 (27.9%) and 1:2 (23.6%). The post that was most commonly utilised was parallel, accounting for 54.2% of usage, while tapered posts were employed in 45.8% of cases. Smooth posts were employed in 77.1% of the cases, while serrated posts were utilized in 22.9% of the cases. The assessment of the presence of abnormalities in post space indicated the presence of a ledge in 8.6% and fractured root in 1.0% of the cases. Approximately 54.2% of the cases exhibited remaining GP of more than 5 mm, whereas 35.2% demonstrated adequate GP between 3–5 mm and 8.0% with remaining GP less than 3 mm. The extrusion of root filling beyond the apical foramen was noted in 2.7% of the cases. Figure 1 shows some examples of post and core restorations reported in this study.

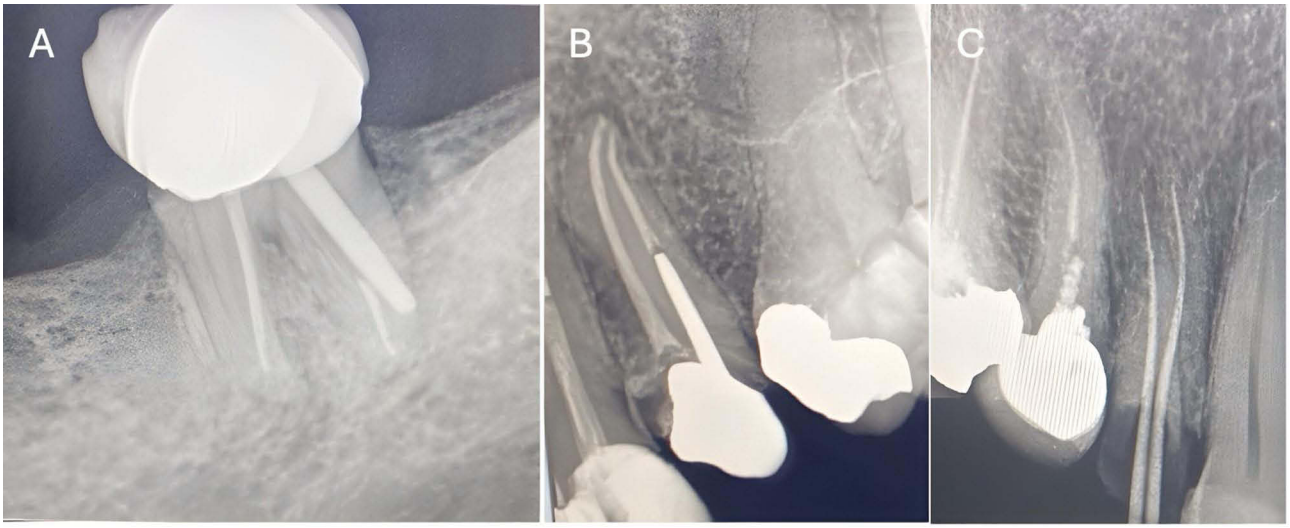

Figure 1 Examples of the restoration of endodontically treated teeth using various post and core restorations. (**A**) A glass fiber post placed in a mandibular left second molar showing ledge formation on a full coverage indirect restoration. (**B**) A custom metal post placed in a maxillary left second premolar with a fallen full coverage indirect restoration and presence of an apical lesion. (**C**) A prefabricated metal post placed in a maxillary right second premolar showing more than 5 mm of remaining GP, a space between the end of the post and the GP of more than 2 mm, and a length of post in relation to crown and root length of 1:2.

Table 3 Association Between Coronal Status, Remaining Gutta-Percha, Space Between the End of Post and Gutta-Percha and Type of Post and Between the Incidence of Apical Lesions

Variables		Apical Radiolucency		P-Value (from Chi^2)	OR (95% CI)	P-Value (from GEE)
		Absent N (%)	Present N (%)			
Coronal status	Caries	1 (12.5)	7 (87.5)	0.007*	Ref	Ref
	Direct restoration	62 (72.1)	24 (27.9)		8.87 (1.60–49.16)	0.012
	Full coverage indirect	122 (62.2)	74 (37.8)		1.47 (0.84–2.56)	0.174
	Partial coverage indirect	8 (72.7)	3 (27.3)		1.25 (0.33–4.79)	0.746
Space between the end of post and gutta-percha	No space	47 (56.6)	36 (43.4)	0.248	Ref	Ref
	2 mm or more	15 (65.2)	8 (34.8)		0.59 (0.35–0.98)	0.043
	Less than 2 mm	131 (67.2)	64 (32.8)		0.53 (0.20–1.37)	0.189
Status of the remaining Gutta percha	3–5 mm	60 (71.4)	24 (28.6)	< 0.000	Ref	Ref
	More than 5 mm	54 (76.1)	17 (23.9)		0.72 (0.30–1.73)	0.467
	Less than 3 mm	62 (63.3)	36 (36.7)		0.86 (0.37–2.00)	0.724
	Extruded beyond	17 (35.4)	31 (64.6)		4.32 (0.78–24.11)	0.095
Type of post	Custom metal	128 (68.4)	59 (31.6)	0.040	Ref	Ref
	Glass fiber	12 (44.4)	15 (55.6)		2.39 (1.05–5.43)	0.038
	Prefabricated metal	53 (60.9)	34 (39.1)		1.42 (0.83–2.43)	0.198

Note: *Fischer-Exact Test.

Of the 301 endodontically treated teeth, 83 (27.6%) had no gap between the post and remaining GP, 195 (64.8%) had a gap of less than 2 mm, and 23 (7.6%) had a gap of more than 2 mm. The findings of this study revealed that crown restorations accounted for 65.1% of the total restorations placed, while direct coronal restorations constituted 28.6%. The overall prevalence of apical lesions was 35.9% as shown in Table 2.

There was a statistically significant association between the type of coronal restoration, the status of the remaining GP and the type of post and between the incidence of apical lesions ($p > 0.05$) as shown in Table 3. However, there was no statistically significant association between the space between the end of the post and GP and apical lesions ($p > 0.05$).

Discussion

Within the limitations of this study, the technical quality of the post and core procedures was found to be consistent with that of prior epidemiological investigations. Nevertheless, a large number of posts were considered to have a subpar technical quality, with a high prevalence of apical periodontitis, reaching slightly more than one-third of the cases.

Various criteria have been proposed to evaluate the efficacy of post and core restorations. Whether used alone or in conjunction with clinical evaluation, radiographic assessment is the primary basis for most of these criteria.[28,29] The results of this study are based only on the analysis of radiographic data. A limitation of periapical radiographs is that they assess the quality of the root canal filling and coronal restoration using a two-dimensional representation of three-dimensional structures. On the other hand, radiographic images serve as indicators of periapical infection or coronal leakage, constituting a vital diagnostic tool.[27]

Several authors in the literature have proposed an adequate post length to substantiate the core. Goodacre and Spolnik proposed that an optimal post length should be around 75% of the root canal length, if possible, or at least the same length as the crown.[30] The current study found that 32.6% of the cases had a post length to crown height ratio of 2:1, which is lower than the ratios reported by Mattoo et al (58%) and Al-Hamad et al (37.9%), but higher than the ratio reported by Mathar and Almutairi (25.4%).[31–33] In this study, a ratio of post length of 1:2 was seen in 23.6% of the cases,

which contrasts with the findings published by Al-Hamad et al[32] This observation can be ascribed to the efficacy of techniques employed in post-preparations. The study found that 27.9% of the cases had a post length to crown length ratio of 1:1, which is considered appropriate. This aligns with the findings of McLean,[34] who emphasized that the length of the post within the root canal should be at least equal to the height of the crown.

Ensuring the apical seal is a critical aspect of post space design, in addition to considering the amount and quality of the remaining root filling and root canal therapy. In order to provide a sufficient seal, it is recommended to leave 3 to 5 mm of GP material apically. Abramovitz et al[35] showed that a 3 mm thickness of GP resulted in an inconsistent apical seal. Hence, it was advised to leave a residual GP of 4 to 5 mm. The study indicated that both the length of the residual root canal filling and the adhesion between the post and the root canal dentin were important factors in causing coronal microleakage. Furthermore, it has been noted that there is a need to enhance the seal of both post and cores in order to prevent recontamination.[35] Within our investigation, a notable percentage (35.2%) of the evaluated cases displayed 3–5 mm of remaining GP. In contrast to the findings published by Meshni et al,[31] 55.7% of the samples tested demonstrated a comparable level of remaining GP. In addition, Mathar and Almutairi[33] documented a lower proportion (28%) of cases where there was 3–5 mm of residual GP. Kvist et al found that root fillings shorter than 3 mm have a higher frequency of apical periodontitis compared to roots with longer residual fillings.[36] As per De Cleen's findings, at least 3 mm of GP must be present in the root canal.[37] The study showed that a 3 mm thickness of GP is not sufficient to ensure a consistent seal at the apex. Therefore, it was recommended to have a remaining GP thickness of 4 to 5 mm in order to maintain the apical seal.[36] The present study revealed a statistically significant rise in the occurrence of apical periodontitis in roots that had posts and a remaining root filling length of less than 3 mm, or in which the GP filling had been removed. This study found that only 8.0% of the cases analysed had root fillings that were less than 3 mm in length and yet intact. This finding confirms the rationale for why this situation occurs. Furthermore, the limited sample size in the research population had a negligible impact on the overall findings. In order to facilitate clinical decision-making based on scientific data, it is advisable to conduct extended studies to evaluate the long-term clinical outcomes. A comprehensive evaluation of clinical and radiographic factors is crucial for achieving favourable outcomes in the repair of teeth that have received endodontic treatment with post and core restorations.

In the present study, custom posts were used in the majority of cases (62.1%), whereas fiber posts and prefabricated metal posts were used in 9.0 and 28.9% of cases, respectively. The results of Nimigean et al[38] have disclosed similar findings; as custom-made posts made up 69.6% of the cases included in their analysis. Based on the research, it has been noted that tapered posts have lower retention compared to parallel posts. However, both types of posts show clinically suitable levels of retention.[34] The results of the present investigation found that a tapering post was present in 45.8% of cases. This result contradicts the findings presented by Jamani et al,[39] who reported a tapering rate of 74%.

The study revealed that clinical outcomes were notably unfavorable when there was a gap over 2 mm between the GP and the cemented post. The success rate of post-and-core restorations for endodontically treated teeth was just 29%.[40] The presence of microleakage of saliva and anaerobic bacteria after post and core treatment may be the underlying cause. An acceptable result was achieved in 53% of cases, even when the difference was less than 2 mm. After a period of 5 years, teeth that were restored without any space between the post and GP exhibited a favourable outcome of 83%.[40] The current study revealed that 27.6% of the posts had direct interaction with GP with showing healthy periapical tissue in 56.6% of the cases. This observation can be linked to the premise that the general dentists performing the root canal procedure were the same ones doing the post preparation and possessed the greatest skill in detecting root curvatures during additional apical preparations.[31] However, this value was lower than the results reported by Mattoo et al (75%) and Mendonca et al (51.9%).[16,31] About 64.8% of the posts analyzed in this study featured a gap of less than 2 mm. In only 7.6% of instances, the gap between the post's end and the remaining GP was either 2 mm or greater. Ozkurt et al carried out a study revealing that about 50.8% of teeth exhibited no gap between the post restoration and the remaining root canal filling, with 65% showing healthy periapical tissue, while in 19.9% of the instances, a gap was observed, with only 15% having a healthy periapex.[41]

The quality of coronal restoration has been identified as a potential component that could have an impact on the periradicular condition.[42] The results of this study show that teeth with adequate restorations in the coronal region had much better periradicular conditions than teeth with inadequate or no restorations. In the context of endodontic therapy,

reducing the risk of reinfection is the main goal of coronal restoration. It is important to remember, though, that the process of bone remodelling and healing may be impacted by the restoration. Tronstad et al[23] conducted an extensive analysis on a larger sample of teeth (n = 1001) that was carefully chosen based on rigorous criteria, and their findings were consistent with previous research. Despite much discourse in the existing scholarly literature, the issue of coronal leakage has been identified as a significant contributing factor to the failure of endodontic treatment.[43] Clinicians must focus on how well the post fits against the root canal walls and ensure that it protrudes far enough into the root to deliver sufficient retention and stability. Furthermore, the restorative material must also possess adequate seal, which may help reduce the possibility of gaps and enhance the restoration's overall quality.

This study's shortcomings include the difficult challenge of evaluating post and core repair quality and apical conditions using two-dimensional images of three-dimensional structures. Due to the cross-sectional design of this study, it was not possible to determine the disease activity or healing, which is a potential restriction. Another constraint is that radiographs were solely evaluated at a defined time frame, without any subsequent data provided after the conclusion of endodontic therapy or post placement. Thus, it was not possible to determine the status of the periapical lesion, whether it was healing or active. Nevertheless, using a cross-sectional design makes it possible to include a sizable number of patients—something that is challenging to accomplish and manage in longitudinal studies. Increasing the size of the sample in studies may mitigate the influence of interpretation bias. The present investigation was carried out at a single research facility, thereby limiting the generalizability of the findings to the entire nation. Performing further inquiries using a substantial number of samples that precisely reflect the full Saudi Arabia community might yield more precise prevalence rates.

Conclusions

Within the limitations of this study, the technical quality of the post and core procedures was found to be consistent with that of prior epidemiological investigations. Nevertheless, a large number of posts were associated with a high prevalence of apical periodontitis, reaching slightly more than one-third of the cases. There was no association between the occurrence of a gap between the end of the post and the GP and between the occurrence of a periapical lesion.

Clinicians should strive to achieve optimal adaptation and sealing of the post-restoration system to minimize the risk of apical pathology and improve the long-term prognosis of the tooth. To ensure that the most recent methods and techniques are used in clinical practice, improvements in dental education and training are required both at dental schools and among practitioners.

Data Sharing Statement

The datasets created and/or analysed for the current study are not publicly accessible because ethics approval was given on the grounds that only the researchers involved in the study would have access to the identified data; however, they are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

Ethical approval for this retrospective study was obtained from the University Ha'il Ethical Review Committee with an ethical approval number H-2023-406. Due to the retrospective nature of the study, the informed consent was waived by the Ethics Committee of the College of Dentistry, University of Hail, Saudi Arabia. The patient data were confidentiality kept and were used only for the purpose of this study.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors have no potential competing interests to declare.

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