Medicina Clínica Práctica 8 (2025) 100481

MEDICINA CLINICA PRÁCTICA

www.elsevier.es/medicinaclinicapractica

Original

Impact of quality of root canal fillings and coronal restorations on the prevalence of apical periodontitis in an adult Saudi subpopulation

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ARTICLE INFO

Article history:
Received 30 August 2024
Accepted 10 October 2024
Available online 18 November 2024

Keywords:
Apical periodontitis
Dental restorations
Outcome assessment
Periapical disease
Root canal obturations
Root canal treatment
Treatment outcome

ABSTRACT

Objectives: This cross-sectional study aimed to evaluate the prevalence of apical periodontitis among healthy Saudi adult patients and to examine the impact of root canal filling quality and coronal restoration quality on periradicular health.
Methods: We used periapical radiographs for this study and categorized the teeth as either diseased or healthy based on the periapical index scores. Two pre-calibrated examiners independently evaluated the radiographs. Any uncertain situation was discussed with another senior examiner. Data were statistically analyzed by applying the Chi-square test or Fisher exact test at a 5% ($P < .05$) level of significance using IBM SPSS 29.0 software (IBM Corp, Armonk, NY).
Results: The overall prevalence of apical periodontitis in endodontically treated teeth was 29.04%. 47.79% of teeth had adequate endodontic treatments. The success rate for teeth with adequate endodontic treatment was significantly higher at 96%, compared to a 48% success rate in teeth with inadequate endodontic treatment ($P < .001$). Additionally, 70.1% of the teeth had adequate coronal restorations. Teeth with adequate coronal restorations showed a significantly higher success rate at 78.33% compared to the 53.7% success rate of teeth with inadequate coronal restorations ($P < .001$).
Conclusions: The quality of endodontic treatment determines the outcome. Therefore, improvements in root canal treatment procedures are advisable in general and specialist dental practices to enhance periradicular health. The coronal restoration is also an essential component of the overall treatment. The optimal treatment outcome can be achieved with the adequate quality of both endodontic treatment and coronal restoration.

Impacto de la calidad de los empastes del conducto radicular y las restauraciones coronales en la prevalencia de periodontitis apical en una subpoblación de adultos saudíes

Palabras clave:
Periodontitis apical
restauraciones dentales
evaluación de resultados
enfermedad periapical
obturaciones de conductos radiculares
tratamiento de conductos radiculares
resultado del tratamiento

RESUMEN

Objetivos: Este estudio transversal tuvo como objetivo evaluar la prevalencia de periodontitis apical en pacientes adultos sanos saudíes y examinar el impacto tanto de la calidad del relleno del conducto radicular como de la calidad de la restauración coronal en la salud perirradicular.
Métodos: Se utilizaron radiografías periapicales para los análisis, y los dientes se clasificaron como sanos o enfermos según el sistema de puntuación del índice periapical. Dos examinadores precalibrados evaluaron las radiografías de manera independiente. Cualquier situación incierta fue discutida con otro examinador sénior. Los datos se analizaron estadísticamente aplicando la prueba de chi-cuadrado o la prueba exacta de Fisher con un nivel de significancia del 5% ($p < 0.05$) utilizando el software IBM SPSS 29.0 (IBM Corp, Armonk, NY).
Resultados: La prevalencia general de periodontitis apical en dientes tratados con conducto radicular fue del 29.04%. El 47.79% de los dientes tenía tratamientos endodónticos adecuados. La tasa de éxito para los dientes con tratamiento endodóntico adecuado fue significativamente mayor, con un 96%, en comparación con la tasa de éxito del 48% en dientes con tratamiento endodóntico inadecuado ($p < 0.001$). Además, el 70.1% de los dientes tenía restauraciones coronales adecuadas. Los dientes con restauraciones coronales adecuadas mostraron una

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https://doi.org/10.1016/j.mcpsp.2024.100481

tasa de éxito significativamente mayor del 78.33%, en comparación con la tasa de éxito del 53.7% de los dientes con restauraciones coronales inadecuadas ($p < 0.001$).
Conclusiones: La calidad del tratamiento endodóntico determina el resultado. Por lo tanto, se recomienda mejorar los procedimientos de tratamiento de conductos radiculares en las prácticas dentales generales y especializadas para mejorar la salud perirradicular. La restauración coronal también es un componente esencial del tratamiento general. El resultado óptimo del tratamiento se puede lograr con la calidad adecuada tanto del tratamiento endodóntico como de la restauración coronal.

Introduction

Root canal treatment is frequently indicated for apical periodontitis, an inflammation of the periradicular tissues caused by pathogens within the root canal system, typically diagnosed through radiographic imaging due to its often asymptomatic nature.[1] The success rate of endodontic treatment has historically been reported to range between 35% and 93%.[2,3] The variations in the root canal treatment outcome are influenced by several factors, including the presence or absence of strictly controlled clinical conditions, tooth-related factors, the operator's level of competency, and patient-related factors.[4]

Bacteria and their toxins can occur along the root canal fillings despite the adequate quality of obturation and modern canal shaping and cleaning procedures.[5] A cross-sectional study involving 1010 teeth that underwent root canal treatment indicated that coronal restorations had a more significant impact when compared to root fillings.[6] In a cone beam computed tomography (CBCT) based study, findings from a global sample of 20 836 teeth show that teeth with inadequate obturation length have 3.1 times higher odds of association with periradicular lesion than teeth with adequate obturation length.[7] In the same study, the periapical lesions were more prevalent in teeth with inadequate root canal fillings (72.7%) than those restored with crowns (46.1%).

Tronstad et al.[8] and Siqueira et al.[9] suggest that the outcome of the endodontic treatment is more influenced by the quality of the root canal fillings than by the quality of coronal restorations.

This cross-sectional study sought to evaluate the prevalence of apical periodontitis in endodontically treated teeth within an adult urban Saudi subpopulation and to investigate the impact of the quality of endodontic filling and coronal restorations on the periapical health of these teeth. The null hypothesis tested was that no difference exists in the prevalence of periapical lesions with respect to the quality of root canal fillings and coronal restorations.

Materials and methods

The following formula was used to calculate the sample size.

$$n = \frac{Z^2\, P(1-P)}{e^2}$$

The sample size was calculated on the basis of the previous study.[10] The estimated prevalence of apical periodontitis was 33%. The Z value was set at 1.96 for a 95% confidence interval, with the precision level (d) established at 0.05. Using the above-mentioned formula, the required minimum sample size was 1040 teeth. This study included 346 healthy adult patients who had full-mouth periapical radiographic series in their records. The dental radiologist took all the radiographs using digital imaging. The image sensor plates were read through the DIGORA Optime (Sordex, Helsinki, Finland) workstation. Images were analyzed using SCANORA software without any enhancement. Inside the dark room, the radiographic images of the first 1040 endodontically treated teeth were assessed at 8× magnification on the digital monitor (Hwelett-Pickard ProDisplay P232 matrix of 1920×1080 pixels; Hewlett-Pickard, CA).

Teeth were categorized based on the quality of their root fillings and coronal restorations. The modified criteria from Tronstad et al.[8] and reported elsewhere in the literature[10] were used for assessment (Table 1).

Periapical index (PAI) scoring[11] was used to evaluate the outcome of endodontic treatment. Teeth with scores of PAI 1 (normal periradicular architecture) or PAI 2 (minimal bony structural changes in periradicular area) were considered healthy. Teeth with scores of PAI 3 (bone structure changes with some mineral loss), PAI 4 (periodontitis with the well-defined radiolucent area), or PAI 5 (severe periodontitis with expanding lesion) were considered diseased.[10,11]

Two pre-calibrated specialist examiners with more than 10 years of experience independently evaluated the radiographs (consensus was reached at 92%). Any uncertain situation was discussed with another senior examiner. Data were statistically analyzed by applying the Chi-square test or Fisher exact test at a 5% ($P < .05$) level of significance using IBM SPSS 29.0 software (IBM Corp, Armonk, NY).

Results

In this study, 1040 endodontically treated teeth were radiographically evaluated. 635 (61.06%) were from male patients and 405 (38.94%) were from female patients. Table 2 presents the distribution of teeth included in the study. The maxillary molars were the teeth that underwent treatment most frequently, followed by the mandibular

Table 1
Quality assessment criteria.

Quality	Endodontic treatment	Coronal restoration
Adequate	1. Root fiiling present in all of the canals 2. Absence of any voids 3. Length of root filling is within 2 mm of the apex	Radiographically intact permanent restoration
Inadequate	1. Unfilled canals 2. Presence of voids 3. Length of the root filling is shorter than 2 mm from the apex 4. Grossly overfilled canals	1. Presence of temporary restoration 2. Permanent restoration with any of the following that can be radiographicallly detected 1. Overhangs 2. Open margins 3. Recurrent caries

Table 2
Distribution of endodontically treated teeth.

Tooth	Maxillary	Mandibular
Central incisor	71 (6.83%)	36 (3.46%)
Lateral incisor	68 (6.54%)	12 (1.15%)
Canine	72 (6.92%)	24 (2.31%)
Premolar	215 (20.67%)	86 (8.27%)
Molar	239 (22.98%)	217 (20.87%)
Total	665 (63.94%)	375 (36.06%)

Table 3
Quality of endodontic treatment and periradicular condition of the teeth (Fisher's exact test).

Periapical index (PAI) score	Adequate treatment ($n=497$)	Inadequate treatment ($n=543$)	Total ($n=1040$)
1	394 (79.28%)	147 (27.07%)	541 (52.02%)
2	83 (16.70%)	114 (21%)	197 (18.94%)
3	5 (1.01%)	142 (26.15%)	147 (14.13%)
4	12 (2.41%)	94 (17.31%)	106 (10.19%)
5	3 (0.60%)	46 (8.47%)	49 (4.71%)
Success rate (PAI 1 & 2)	96%	48%	
P-value	<.001[a]		

[a] Statistically highly significant difference between success rates in adequate and inadequate treatments.

molar teeth, maxillary premolar teeth, and mandibular premolar teeth. The least frequent teeth that underwent endodontic treatment were the mandibular incisors.

Table 3 shows the periradicular condition of the included teeth in relation to the quality of endodontic treatment. According to the PAI scores, 738 (70.96%) teeth were healthy with a PAI score of 1 or 2, and 302 (29.04%) were diseased. Adequate endodontic treatment was present in 497 (47.79%) teeth, with 394 (79.28%) teeth with a PAI score of 1 and 83 (16.7%) teeth with a PAI score of 2. 543 (52.21%) teeth had inadequate endodontic treatment with 147 (27.07%) teeth with a PAI score of 1 and 114 (20.99%) teeth with a PAI score of 2. A significant 96% success rate was found in teeth with adequate treatment, compared to a 48% success rate in teeth with inadequate treatment ($P < .001$).

Table 4 shows the quality of coronal restorations and PAI scores for the teeth. Adequate coronal restorations were present in 729 (70.1%) teeth, of which 445 (61.04%) teeth were scored as PAI 1 and 126 (17.28%) were scored as PAI 2. Whereas inadequate coronal restorations were present in 311 (29.90%) teeth, of which 96 (30.87%) teeth were scored as PAI 1 and 71 (22.83%) teeth scored as PAI 2. In teeth with adequate coronal restorations, a significant 78.33% success rate was found compared to a 53.7% success rate in teeth with inadequate coronal restorations ($P < .001$).

Table 5 presents the combined results of the quality of coronal restorations and endodontic treatment of teeth. Teeth with adequate root fillings and adequate coronal restorations had the highest success rate of 95.48% (169/177), followed by the teeth with adequate root filling and inadequate coronal restoration with a success rate of 80.77% (42/52). There was a statistically significant difference between both groups, indicating that the outcome of adequately treated root canals is influenced by the quality of coronal restorations ($P < .05$).

Teeth with adequate coronal restorations and inadequate root fillings had a success rate of 63.48% (332/523). The teeth with inadequate coronal restorations and inadequate root fillings had the lowest success rate of 47.71% (156/327). Comparison between teeth having adequate endodontic treatment with inadequate restorations and, inadequate endodondontic treatment with adequate coronal restorations showed higher success rate in the former group of teeth (80.77% versus 63.48%, $P < .05$).

This indicates that the quality of root fillings had a greater influence on clinical success. Teeth with adequate endodontic treatment demonstrated a statistically highly significant better outcome when further categorized based on the quality of their root fillings, regardless of whether they had adequate or inadequate coronal restorations ($P < .001$).

A total of 572 (55%) teeth had a post, 406 (70.98%) of which were healthy. Whereas 468 (45%) of teeth were without a post, and 323 (69.02%) were healthy. The difference in the periradicular health between teeth with and without a post was not statistically significant ($P > .05$).

Table 4
Quality of coronal restoration and periradicular condition of the teeth (Chi-square test).

Periapical index (PAI) score	Adequate restorations ($n=729$)	Inadequate restorations ($n=311$)	Total ($n=1040$)
1	445 (61.04%)	96 (30.87%)	541 (52.02%)
2	126 (17.28%)	71 (22.83%)	197 (18.94%)
3	108 (14.81%)	39 (12.54%)	147 (14.13%)
4	38 (5.21%)	68 (21.86%)	106 (10.19%)
5	12 (1.65%)	37 (11.90%)	49 (4.71%)
Success rate (PAI 1 & 2)	78.33%	53.7%	
P-value	<.001[a]		

[a] Statistically highly significant difference between success rates in adequate and inadequate treatments.

Discussion

The null hypothesis was rejected as the periradicular health in endodontically treated teeth was found to be influenced by the quality of endodontic treatment and the coronal restoration. The results of the present study revealed that the teeth having root canal fillings of inadequate quality exhibit a significantly higher prevalence of apical periodontitis, irrespective of the quality of the coronal restoration, compared to those with adequately treated root canals. This study was carried out at a single center to determine the prevalence of apical periodontitis in endodontically treated teeth among healthy individuals in a Saudi subpopulation. The results demonstrate that 738 (70.96%) of the endodontically treated teeth were healthy, while 302 (29.04%) had radiographically detectable apical periodontitis, based on PAI scores. These results are consistent with those reported in other epidemiological studies.[7,10,12–16]

A meta-analysis, which reviewed 77 studies, reported that the prevalence of apical periodontitis is widely ranged between 5% and 74%.[17] The findings from another meta-analysis by Tibúrcio-Machado et al.,[16] which included 114 studies, suggest a 39% global prevalence of apical periodontitis in endodontically treated teeth with a greater risk of acquiring apical periodontitis in patients with pre-existing medical conditions.

Recently, a meta-analysis of 13 studies found that apical periodontitis has a prevalence of 47% in root-filled teeth within the Saudi population.[18] Since our study included records of only medically healthy patients, this may explain why the prevalence of apical periodontitis in our study falls on the lower end of the global range.[16] In teeth with inadequate endodontic treatment, the periradicular status was found to have higher PAI scores. In this study, the outcome was affected mainly by the quality of endodontic treatment, which is consistent with the previous literature. Our findings align with those of Al-Nazhan et al.,[19] who found a significant association between inadequate endodontic treatment and apical periodontitis in the Saudi population across 4 major provinces.

The outcome is influenced more by the quality of endodontic treatment than the quality of the coronal restoration. This is evident upon examining the various contributing elements as combined factors resulting in healthier teeth (Table 5). Furthermore, our results showed a significantly higher success rate in teeth with adequate endodontic fillings but inadequate coronal restorations—considered the least favorable condition for teeth having adequate root canal fillings—compared to teeth with inadequate endodontic fillings but adequate coronal restorations, which is the most favorable condition for cases with inadequate root canal treatment. These results are consistent with those of Tavaras et al.,[10] who conducted a study on endodontically treated teeth in the French population and assessed the prevalence of apical periodontitis. Inadequate endodontic treatment suggests the possibility of incomplete root canal disinfection and the persistence of microbes and their toxins, leading to treatment failures.[20]

Table 5
The combined quality of endodontic treatment and coronal restoration as related to the periapical status of teeth ($n = 1040$) (Chi-square test).

Endodontic treatment	Coronal restoration	PAI 1	PAI 2	PAI 3	PAI 4	PAI 5	Healthy (PAI 1 & 2)	Healthy (PAI 1 & 2)
Adequate	Adequate	149/177 (84.18%)	20/177 (11.30%)	2/177 (1.13%)	5/177 (2.82%)	1/177 (0.56%)	169/177 (95.48%)[a]	211/229 (92.14%)[c]
Adequate	Inadequate	33/52 (63.46%)	9/52 (17.31%)	1/52 (1.92)	4/52 (7.69%)	5/52 (9.62%)	42/52 (80.77%)[a,b]	
Inadequate	Adequate	205/523 (39.2%)	127/523 (24.28%)	107/523 (20.46%)	50/523 (9.56%)	34/523 (6.5%)	332/523 (63.48%)[b]	488/850 (57.41%)[c]
Inadequate	Inadequate	96/327 (29.36%)	60/327 (18.35%)	63/327 (19.27%)	70/327 (21.41%)	38/327 (11.62%)	156/327 (47.71%)	

[a] Statistically significant difference between teeth with adequate endodontic treatment and adequate coronal restorations and those with adequate endodontic treatment and inadequate coronal restorations ($P<.05$).
[b] Statistically significant difference between teeth with adequate endodontic treatment and inadequate restorations and those with inadequate endodontic treatment and adequate restorations ($P<.05$).
[c] Statistically highly significant difference between teeth with adequate and inadequate endodontic treatment irrespective of the quality of coronal restoration ($P<.001$).

It is important to mention that some studies report varying results regarding the impact of coronal restoration quality on the periradicular health of root canal treated teeth. Ray and Trope[6] found that the quality of coronal restorations had a more significant impact on treatment outcomes. In contrast, other researchers[8,9] suggested that while the quality of coronal restorations may have some influence, it is generally considered less critical, with a possible correlation to periradicular health. Gillen et al.[21] did not find any significant difference in the odds of healing of apical periodontitis when results from their data on the quality of the endodontic treatment and coronal restorations were combined to obtain pooled estimates. Two recent studies with large sample sizes and multivariate analysis approaches reported that while the quality of endodontic therapy significantly impacts the treatment outcome, the quality of coronal restoration does not predict post-treatment disease.[22,23]

The present study's findings indicate that while the quality of endodontic treatment was the most significant factor affecting treatment outcomes, adequate coronal restoration cases showed better rates of healthy teeth, even when the endodontic treatment quality was not accounted for. Success rates were consistently noted as higher in teeth with proper coronal restorations, regardless of whether the endodontic treatment was adequate or inadequate. Moreover, combined data on the endodontic treatment quality suggests a notably lower incidence of apical periodontitis in the teeth with adequate coronal restorations compared to those with inadequate restorations. This indicates that the quality of coronal restorations plays an essential role in treatment outcomes, likely by preventing reinfection due to coronal seal.

In this study, slightly more than half of the included teeth had posts. We did not find a significant association between the presence of posts and apical periodontitis, which is consistent with other researchers' findings.[10,24,25]

Cross-sectional studies have a significant limitation: they cannot determine whether a periradicular lesion is healing or deteriorating.[26] This limitation stems from the study design, which captures data at a single point in time, providing only a snapshot of the condition without insights into its trajectory. As a result, cross-sectional analyses cannot consider the temporal dynamics critical to understanding the progression or resolution of periapical lesions. Moreover, this approach does not account for the full spectrum of causal factors that can significantly influence the outcome or the course of periapical healing. Among these factors are the timing of the treatment, which can affect the healing process, and the specific clinical procedures employed during the treatment.[26] Additionally, the proficiency, experience, and qualifications of the clinician performing the treatment play a crucial role in the success or failure of the procedure.[27] Besides these limitations, cross-sectional studies still provide meaningful results because of the fair distribution of included variables and lesser reporting bias than longitudinal studies.[28]

Another limitation of this study is the possible inadequacies of radiographs as a diagnostic tool. For example, radiographs may fail to detect issues like leaking occlusal margins or cracks in restorations. Similarly, apical periodontitis lesions confined to the cancellous bone might go undetected during radiographic examination.[29] Future research using more advanced techniques, such as CBCT, could help address and reduce this limitation.[30]

Conclusion

The endodontic treatment outcome is determined by the quality of endodontic treatment. Therefore, improvements in root canal treatment procedures are advisable in general and specialist dental practices to enhance periradicular health. The coronal restoration is also an essential component of the overall treatment. The optimal treatment outcome can be predictably achieved if both the coronal restoration and the endodontic treatment have adequate quality.

Ethical approval

The study protocol was approved by the Institutional Review Board (IRB) of Qassim University, Saudi Arabia (registration no. 24–93-05).

Funding

This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of competing interest

The author declares no conflict of interest.

Acknowledgments

The author acknowledges the support of Dr. Prabu Ismail and Dr. Atif Agwan at the Qassim University College of Dentistry for assisting with the second and third-time evaluation procedures of radiographs in this study.

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