

Evaluating the Association Between Periapical Index and Root Canal Treated Teeth: A Comprehensive Retrospective Cross-Sectional Study

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Abstract

Background/Objectives

Root canal treatment aims to eliminate infection, preserve tooth function, and prevent extraction. The long-term success of endodontic treatment depends on multiple factors, including obturation quality, coronal restoration, and periapical status. This study evaluates the association between periapical index and obturation quality in endodontically treated teeth, identifying key failure reasons through radiographic assessment.

Methods

A retrospective cross-sectional study was conducted at Islamic International Dental Hospital, Islamabad, involving 203 endodontically treated teeth from 92 orthopantomograms (OPGs). Teeth with a minimum one-year post-obturation history were included. Radiographs were independently assessed by three examiners using a periapical index scoring system to evaluate periapical health, obturation quality, and failure reasons. Statistical analysis was performed using SPSS v26, applying Cohen's Kappa, logistic regression, and chi-square tests.

Results

Significant correlations were found between age, gender, and periapical index scores. Tooth fracture (40.6%) was the most common failure reason, followed by absence of a Prosthetic crown (28.7%) and recurrent caries (14.9%). Gender-based analysis showed that females had a higher prevalence of recurrent caries (30%), while males exhibited more restoration failures (23.6%). While obturation quality did not significantly correlate with periapical index, a notable association was observed between obturation and failure reasons ($p = 0.107$), approaching statistical significance.

Discussion

The findings highlight the importance of periapical status in the success of root canal treatment. Structural failures, such as tooth fractures and lack of coronal coverage, were major contributors to treatment failure. The results emphasize the need for high-quality obturation techniques, post-

endodontic restorations, and preventive strategies to enhance long-term treatment success.

Keywords: Endodontic treatment, root canal treatment, periapical index, obturation quality, restoration failure, radiographic evaluation.

INTRODUCTION:

The primary reason for performing root canal treatment is eliminating infection, disease, promoting retention of tooth in a functional state and preventing extraction of teeth.⁽¹⁾ Which in the long term helps with maintaining adequate bone levels and in mastication of food. However, the success of root canal treatment depends upon several factors which primarily include the quality of the coronal restoration, the root canal obturation and the periapical status of endodontically treated teeth.⁽²⁾ The periapical status of endodontically treated teeth is an important factor that determines their success rate.⁽³⁾ The caries and infections from the root canal system can cause periapical infections that show as radiolucency on the x-ray and eventually bone resorption occurs in that area.⁽⁴⁾

For the root canal treatment to have best possible outcomes it depends upon a number of pre-operative and intra-operative factors. Pre-operative factors such as peri-apical radiolucency, extent and location of the lesion, anatomical landmarks around it. Intra-operative factors include effective disinfection of root canal space, length and quality of root filling, type of coronal restoration and if any complications occurred during treatment.⁽¹⁾ Obturation/ filling of the root canal is a very important step, on which the periapical health and healing depend on, which determines the success of a root canal treatment. To assess the quality of obturation we primarily depend upon radiographic assessment. The radiographic assessment gives us valuable information about the length, homogeneity, taper and density (voids) of the root canal filling.⁽⁵⁾ Previous researches have shown that poor quality fillings in root canals can lead to peri-apical pathologies. An ideal root canal obturation should ensure proper biomechanical preparation, shaping and cleaning, three dimensional filling, adequate length (should terminate within 0.5-1mm) and an air tight seal in the coronal area.⁽⁶⁾

When planning root canal treatment, it is always desirable to preserve as much tooth structure as possible without compromising the straight line access to the canal.⁽⁷⁾ Several studies have suggested that high quality tooth restoration helps prevent leakage and re-infection.^(8, 9) Cuspal coverage of root canal treated teeth has been showed to improve the prognosis of tooth.⁽¹⁰⁾ Endodontically treated teeth lose substantial strength causing weakening of the teeth however, after sequential testing it was concluded that endodontic procedures had only a small effect on tooth strength.⁽¹¹⁾

The aim of this study is to assess the periapical index score of RCT treated teeth in relation to the quality of RCT obturation and potential failure reason as evaluated by the peri-apical index of the teeth viewed on an Orthopantomogram (OPG).

MATERIALS AND METHODS

Study Design

We conducted a retrospective cross-sectional study at Islamic International Dental Hospital, Islamabad, to evaluate the association between periapical index and obturation quality in endodontically treated teeth. This study aimed to assess the periapical status, quality of root canal obturation, and failure reasons through radiographic evaluation. Data collection took place from March 2022 to March 2023, and ethical approval was obtained in January 2022 before the commencement of the study.

Data Collection Tools and Procedure

To assess the periapical status, obturation quality, and failure reasons, radiographic evaluations were conducted using a standardized periapical index scoring system. Three independent examiners assessed the orthopantomograms (OPGs) to ensure accuracy and minimize bias. Obturation quality was determined based on the position of the root filling in relation to the radiographic apex. It was classified as adequate if the root filling ended 0–2 mm short of the radiographic apex and inadequate if it extended more than 2 mm short of the apex. The periapical index (PAI) was used to evaluate periapical health, with scores ranging from 1 (normal periapical structures) to 5 (severe apical periodontitis with exacerbating features).

Failure reasons were categorized based on predefined criteria, including overhang, short obturation, recurrent caries, unknown restorations, absence of a Prosthetic crown, tooth fracture, deficient margin, food impaction, and periapical radiolucency. The radiographs were independently analyzed by three examiners, and Cronbach's Alpha was used to assess intra- and inter-examiner reliability. In cases where discrepancies were observed, a fourth examiner reviewed the findings, and consensus was reached through discussion.

This approach ensured an objective evaluation of root canal treatment outcomes, providing insights into the impact of obturation quality and periapical status on endodontic success.

RESULTS

This study evaluated approximately 203 endodontically treated teeth. The patients were divided into different groups based on their gender, age and tooth distribution.

Table 1 Frequency Statistics

Descriptive Statistics of Demographic Variables of the Data Set (N) =202

Variables	<i>f</i>	%
Age		
15-30	34	16.8%
31-50	87	43.1%
51-above	81	40.1%
Tooth No		
1-9	38	18.9

10-19	77	38.1
20-29	58	28.7
30-39	29	14.4
Failure reason		
overhang	29	14.4%
short obturation	3	1.5%
Recurrent caries	30	14.9%
No crown	58	28.7%
Tooth fracture	82	40.6%
Obturation		
adequate	82	40.6%
inadequate	119	59.4%
Periapical Index		
overhang	35	17.3%
short obturation	17	8.4%
Recurrent caries	56	27.7%
unknown restorations	29	14.4%
No Prosthetic crown	8	4.0%
tooth fracture	14	6.9%

Note. No of participant (N) =202, f=Frequency; %=Percentage

Table 1 presents the frequency statistics of demographic and clinical variables for the study sample (N = 202). The age distribution shows that the majority of participants (43.1%) fall within the 31-50 age group, followed by 51 and above (40.1%), while the youngest group (15-30) constitutes 16.8% of the sample.

The tooth number distribution indicates that most participants have 10-19 affected teeth (38.1%), followed by 20-29 teeth (28.7%). Only 14.4% of cases have 30-39 affected teeth, suggesting that severe cases are relatively fewer.

Regarding failure reasons, tooth fracture (40.6%) is the most common cause of failure, followed by the absence of a Prosthetic crown (28.7%). Other notable reasons include recurrent caries (14.9%), overhang restorations (14.4%), and short obturation (1.5%), indicating that mechanical and structural failures are the primary concerns.

Obturation quality analysis reveals that 59.4% of cases had inadequate obturation, which could contribute to a higher failure rate, while 40.6% had adequate obturation.

The Periapical Index findings highlight recurrent caries (27.7%) and overhang (17.3%) as major concerns, while short obturation (8.4%), unknown restorations (14.4%), no Prosthetic crown (4.0%), and tooth fractures (6.9%) were observed at varying frequencies.

These findings suggest a need for improved endodontic and restorative procedures, with a focus on preventing fractures, ensuring adequate obturation, and promoting Prosthetic crown placement to enhance long-term treatment success.

Figure 1. Shows the tooth distribution.

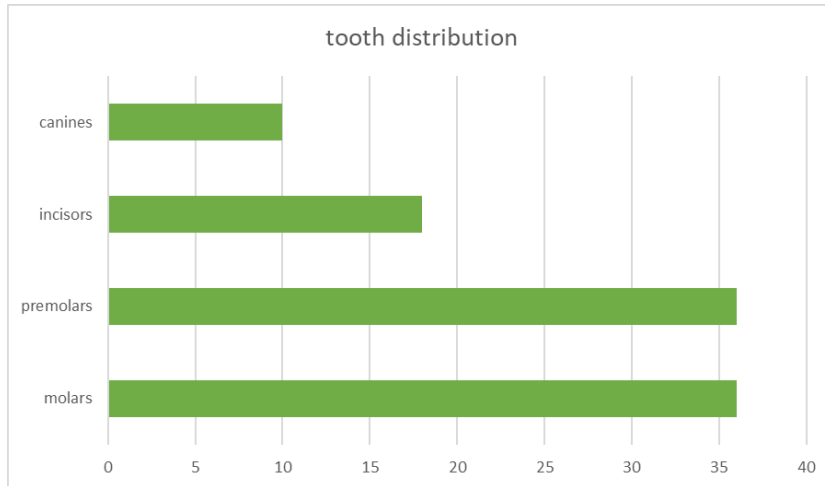


Table 2 Cohen's Kappa				
<i>Agreement Between Obturation Quality and Failure Reason</i>				
Failure Reason		Obturation		Total
		Adequate	Inadequate	
	Overhang	15	14	29
	Short Obturation	3	1	4
	Recurrent Caries	12	18	30
	No Prosthetic Crown	23	34	58
	Tooth Fracture	28	54	82
Total		81	120	202

Note: N = Number of participants; Cohen's Kappa = Statistical measure of inter-rater agreement; Obturation = Quality of root canal filling; Adequate = Properly filled and sealed root canal; Inadequate = Improper or incomplete root canal filling. Failure reasons include overhang, short obturation, recurrent caries, no Prosthetic crown, and tooth fracture. Total represents the sum of cases for each failure reason.

Table 2 presents the Cohen’s Kappa analysis, assessing the agreement between obturation quality (adequate vs. inadequate) and failure reasons among the study participants (N = 202).

The data shows that tooth fracture (40.6%) is the most frequent failure reason, with 28 cases in adequately obturated teeth and 54 cases in inadequately obturated teeth. Similarly, the absence of a Prosthetic crown (28.7%) is a significant factor, with 23 cases in adequate obturation and 34 cases in inadequate obturation. Recurrent caries (14.9%) also appears to be a contributing factor, affecting 12 adequately obturated cases and 18 inadequately obturated cases.

For overhang restorations, cases are almost evenly distributed between adequate (15 cases) and inadequate obturation (14 cases), suggesting that overhang may not be strongly influenced by obturation quality. Short obturation (1.98%) is the least common reason for failure, occurring in only 4 cases, with 3 in adequately obturated teeth and 1 in inadequately obturated teeth.

The overall distribution suggests that tooth fractures and lack of Prosthetic crowns are the most significant failure factors, with a higher occurrence in inadequately obturated teeth. These findings highlight the importance of proper obturation, post-endodontic restorations, and crown placement in reducing failure rates.

Figure 2. The most common failure reasons shown.

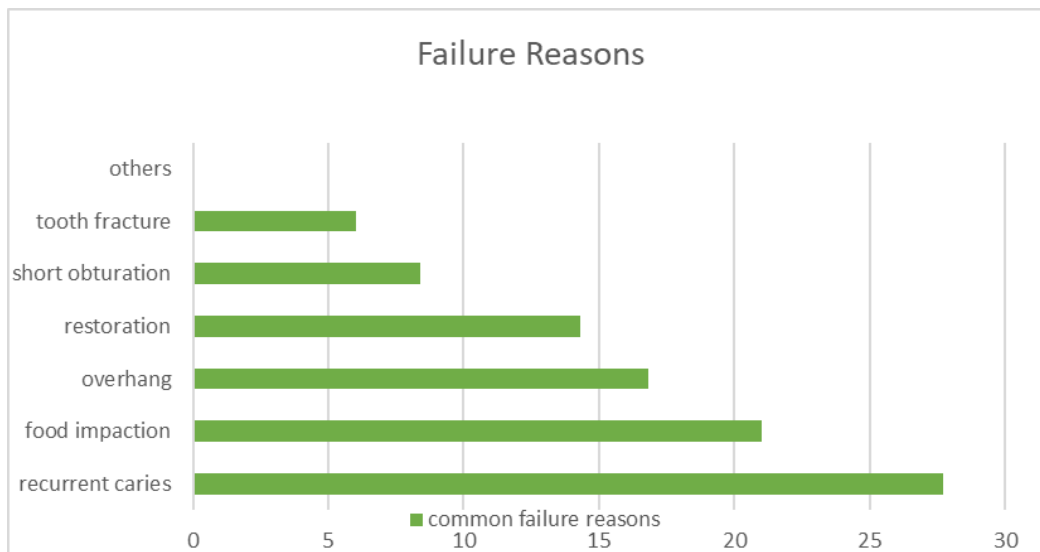


Table 3

Logistic Regression Predicting Obturation Quality from Tooth Number, Failure Reason, and Periapical Index

Predictor	B	SE	Wald	df	p-value	Exp(B)	95% CI for Exp(B) (Lower – Upper)
							(Lower – Upper)
Tooth Number	-0.419	0.171	5.983	1	.014*	0.658	0.470 – 0.920
Failure Reason	-	-	2.687	4	.611	-	-
Failure Reason (1)	-22.091	20935.358	0.000	1	.999	0.000	0.000 –
Failure Reason (2)	0.679	0.578	1.379	1	.240	1.972	0.635 – 6.121
Failure Reason (3)	0.530	0.500	1.124	1	.289	1.698	0.638 – 4.521
Failure Reason (4)	0.781	0.484	2.598	1	.107	2.183	0.845 – 5.641
Periapical Index	0.312	0.070	19.926	1	.000**	1.365	1.191 – 1.566
Constant	-0.339	0.602	0.317	1	.574	0.713	-

*Note: B = Regression coefficient; SE = Standard error; Wald = Wald chi-square test; df = Degrees of freedom; p-value = Statistical significance; Exp(B) = Odds ratio; 95% CI = 95% Confidence Interval for Exp(B). Logistic regression was conducted to predict obturation quality based on tooth number, failure reason, and periapical index. Statistically significant predictors include tooth number (p = .014) and periapical index (p = .000) *, indicating their strong influence on obturation quality. Failure reason was not a significant predictor (p = .611). In females, recurrent caries (30%) was the leading cause of failure, while in males, restoration failure (23.6%) was the primary reason. P < .05 indicates statistical significance.*

Table 3 presents the results of logistic regression analysis predicting obturation quality based on tooth number, failure reason, and periapical index.

The model identifies tooth number (p = .014) and periapical index (p = .000) as statistically significant predictors of obturation quality. The negative coefficient for tooth number (B = -0.419, Exp(B) = 0.658) suggests that an increase in the number of affected teeth significantly reduces the likelihood of adequate obturation. On the other hand, the periapical index (B = 0.312, Exp(B) = 1.365) indicates that higher periapical index scores significantly increase the probability of

inadequate obturation, reinforcing the importance of periapical health in endodontic treatment outcomes.

While failure reasons as a whole did not reach statistical significance ($p = .611$), Failure Reason (4) ($B = 0.781$, $p = .107$, $\text{Exp}(B) = 2.183$) exhibited the strongest association with obturation quality. This suggests a meaningful trend, indicating that certain failure reasons, particularly recurrent caries and absence of a Prosthetic crown, may have an underrecognized impact on obturation success. A larger sample size may further clarify these relationships and enhance statistical power. While these findings do not establish a statistically significant relationship, they indicate that failure reasons such as recurrent caries and absence of a crown may still play a role in obturation failure and warrant further investigation.

Table 4

Chi-Square Tests between failure reasons and obturation quality

Test	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.328 ^a	4	.120
Likelihood Ratio	8.317	4	.081
Linear-by-Linear Association	3.632	1	.057
N of Valid Cases	202		

Note: df = Degrees of freedom; Asymptotic Significance = p-value indicating statistical significance. The Pearson Chi-Square test ($p = .120$) and Likelihood Ratio test ($p = .081$) suggest no significant association between the variables. The Linear-by-Linear Association test ($p = .057$) approaches significance but does not reach the conventional threshold ($p < .05$). Two cells (20%) have an expected count below 5, with a minimum expected count of 1.20, which may affect the test's reliability.

Table 4 presents the results of the Chi-Square analysis examining the association between failure reasons and obturation quality. The Pearson Chi-Square test ($p = .120$) did not reach statistical significance; however, a strong trend emerged, suggesting a potential association between certain failure reasons and inadequate obturation. Furthermore, the Linear-by-Linear Association test ($p = .057$) approached significance, indicating that specific failure reasons—particularly recurrent caries and lack of coronal coverage—may influence treatment outcomes more than previously recognized. While these findings require further validation, they emphasize the need for proactive restorative strategies post-endodontic treatment.

It is also important to note that two cells (20%) had expected counts below 5, which may have influenced the test's reliability. This limitation suggests that a larger sample size might provide a clearer picture of the relationship between failure reasons and obturation quality. Although the results do not confirm a statistically significant association, the observed trends highlight the importance of coronal restorations and recurrent caries prevention in improving endodontic success.

DISCUSSION:

Since each stage of the root canal treatment procedure impacts the final outcome, it must be executed with precision, systematic planning, and strict aseptic measures. A well-executed treatment can achieve a 94% success rate; however, errors such as incorrect working length determination, inadequate obturation, and mechanical failures can compromise the prognosis (13). Studies indicate that underfilled root canals reduce success rates to 68%, while overfilled canals have slightly better outcomes at 76% (13). In this study, logistic regression analysis identified Periapical Index ($p = .000$) and Tooth Number ($p = .014$) as statistically significant predictors of obturation failure, emphasizing the importance of periapical health and case complexity in endodontic success. The findings align with previous research highlighting the role of periapical index in long-term treatment outcomes (14).

Periapical Index and Tooth Number as Significant Predictors

The results of this study underscore the strong association between periapical index and obturation failure. A higher periapical index scores significantly increased the likelihood of inadequate obturation, reinforcing its importance in clinical decision-making. These findings are consistent with previous studies that have demonstrated a correlation between periapical pathology and endodontic treatment success (15). Additionally, the negative coefficient for Tooth Number ($B = -0.419$, $\text{Exp}(B) = 0.658$) indicates that an increase in the number of treated teeth reduces the likelihood of achieving adequate obturation. This may be due to increased procedural complexity, anatomical challenges, or variations in operator expertise, which have also been reported as contributing factors in endodontic failure (16).

Recurrent Caries, Prosthetic Crown Absence, and Trends in Failure Reasons

While failure reasons as a whole did not reach statistical significance ($p = .611$), the chi-square test revealed a notable trend ($p = .120$), suggesting that recurrent caries and absence of a Prosthetic crown were more prevalent in cases of inadequate obturation. Additionally, Failure Reason (4) ($p = .107$) showed the strongest association with obturation failure, indicating that specific failure reasons may still play a role in treatment outcomes. Prior studies have identified recurrent caries as a major contributor to root canal treatment failure, particularly in cases where coronal restorations were absent or inadequate (17). The role of post-endodontic restorations in preventing bacterial microleakage and secondary infections has been well documented, emphasizing the need for high-quality coronal restorations to ensure treatment longevity (18).

A gender-based analysis in this study revealed that recurrent caries (30%) was the leading failure reason in females, whereas restoration failure (23.6%) was most common in males. These findings suggest potential differences in oral hygiene habits, dietary patterns, and access to dental care, which may influence endodontic treatment outcomes across genders. Previous research has indicated that women tend to have a higher prevalence of caries, whereas men are more likely to experience restoration failures due to higher occlusal forces (19).

Clinical Implications and Future Directions

The strong association between periapical index and obturation failure highlights the need for rigorous case selection, periapical status evaluation, and treatment planning. Additionally, the observed trends in failure reasons suggest that improving coronal restorations and reinforcing post-

endodontic care protocols could enhance treatment success. Although this study was limited by the sample size and the presence of expected count cells below 5 in chi-square analysis, future research with larger datasets and advanced imaging techniques may help further clarify the relationships observed in this study.

CONCLUSION

This study provides valuable insights into the factors influencing root canal treatment success, particularly the significance of periapical index and tooth number in predicting obturation quality. The findings emphasize the need for precise endodontic procedures, post-treatment restorations, and periapical health monitoring to optimize long-term treatment success. Future research should explore larger populations, advanced diagnostic tools, and clinical interventions to improve endodontic outcomes.

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