JHWCR

Journal of Health, Wellness, and Community Research
Volume III, Issue XII
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, ISSN: 3007-0570
https://doi.org/10.61919/jag8wd68

Original Article

Pitfalls of the Pulp: An Analysis of the Causes of Root Canal Treatment Failure among Dentists in Pakistan

Muhammad Farrukh[1], Bilal Akbar[2], Amina Sohail[3], Muhammad Anas[4], Aimen Javed[5], Amara Hussain[6]

[1] Margalla Institute of Health Sciences, Rawalpindi, Pakistan

[2] Islamic International Dental College, Rawalpindi, Pakistan

[3] Frontier Medical College, Abbottabad, Pakistan

[4] Bacha Khan College of Dentistry, Mardan, Pakistan

[5] Army Medical College, Rawalpindi, Pakistan

[6] Fatima Memorial Hospital College of Dentistry, Lahore, Pakistan

Correspondence: anas.khan.jadoon137@gmail.com

Authors' Contributions: Concept and design: Concept: MF; Design: BA; Data Collection: AS; Analysis: MA; Drafting: AJ; Critical Revision: AH
Cite this Article | Received: 2025-06-27 | Accepted 2025-08-29
No conflicts declared; ethics approved; consent obtained; data available on request; no funding received.

ABSTRACT

Background: Root canal therapy (RCT) is an effective procedure for managing pulpal and periapical disease, with reported success rates up to 98%, though failures occur in 7–9% of cases due to technical, microbial, and iatrogenic causes (1–3). In Pakistan, where most RCTs are performed by general dentists with variable training and limited access to advanced technologies, the burden and causes of endodontic treatment failure (ETF) remain poorly characterized. Objective: To evaluate the prevalence, attributed causes, diagnostic tools, and management strategies for ETF among dentists in Pakistan. Methods: A descriptive cross-sectional survey was conducted between January and June 2023 among 240 dental practitioners, including house officers, general dentists, and postgraduate residents. Data were collected using a validated, self-administered online questionnaire, and analyzed using SPSS version 26. Descriptive statistics were reported, and associations between demographic factors and outcomes were assessed using Chi-square tests with significance set at $p < 0.05$. Results: Most participants (75%) had <5 years of experience and 85.8% held a BDS degree. Inadequate obturation (52.9%), missed canals (47.1%), and iatrogenic errors (45%) were the leading causes of ETF. CBCT was rarely used (5%), while non-surgical retreatment (64.2%) was the most common management strategy. Early-career dentists reported significantly more failures and preferred extractions over retreatment ($p < 0.05$). Conclusion: Technical shortcomings, inadequate training, and restricted access to advanced diagnostics contribute substantially to RCT failure in Pakistan. Expanding postgraduate education, continuing workshops, and wider CBCT integration could improve treatment outcomes.

Keywords: Endodontic treatment failure; Root canal therapy; Pakistan; Dental education; Retreatment; CBCT.

INTRODUCTION

Endodontic treatment, commonly referred to as root canal therapy (RCT), is a fundamental dental procedure designed to eliminate pulpal infection and prevent reinfection of the root canal system by achieving thorough chemo-mechanical debridement and hermetic obturation (1). When performed according to standardized clinical protocols, RCT yields high success rates, often ranging from 86% to 98% (2). Nevertheless, failures occur in 7%–9% of primary cases, reflecting both biological and technical shortcomings that compromise long-term outcomes (3). The persistence of microbial pathogens within inadequately treated canals remains the primary etiological factor for endodontic treatment failure (ETF), but extraradicular infections, coronal leakage, and procedural errors also contribute significantly (4,5).

Global research consistently underscores the multifactorial nature of RCT failure. Persistent intraradicular infection and biofilm formation have been shown to cause refractory periapical disease, even in apparently well-treated teeth (6). Similarly, extraradicular etiologies such as actinomycosis or foreign body reactions account for less frequent but clinically challenging failures (7). From a technical perspective, inadequate obturation, missed canals, and iatrogenic mishaps—including perforations and instrument fractures—remain key contributors to poor prognosis (8). For example, Wolcott et al. reported that failure to locate the second mesiobuccal canal (MB2) in maxillary molars markedly reduced long-term survival of treated teeth (9). These findings emphasize that biological complexity, coupled with operator-dependent errors, can substantially influence treatment outcomes.

Despite extensive international evidence, the context in low- and middle-income countries presents unique challenges. In Pakistan, the majority of RCTs are performed by general practitioners with variable postgraduate training and limited access to advanced technologies such as cone-beam computed tomography (CBCT). Financial constraints, inadequate professional development opportunities, and

disparities between private and public sector dental care are further complicate endodontic practice (10,11). A recent survey among Pakistani dental students highlighted gaps in both theoretical knowledge and clinical performance, suggesting that deficiencies in undergraduate and early-career training may translate directly into higher failure rates in routine practice (12). Additionally, there is limited systematic data on how dentists in Pakistan perceive and manage failed RCTs, particularly regarding retreatment versus extraction decisions.

This knowledge gap has both clinical and public health significance. Failure of RCT not only leads to patient discomfort and tooth loss but also imposes financial and psychosocial burdens in populations where dental insurance coverage is minimal. A deeper understanding of the frequency, perceived causes, diagnostic modalities, and management strategies of endodontic failures among Pakistani dentists is essential for guiding continuing education, resource allocation, and policy development in oral health.

Therefore, this study aims to evaluate the prevalence, attributed causes, diagnostic tools, and management strategies reported by dental practitioners in Pakistan when encountering failed RCTs.

MATERIAL AND METHODS

This study employed a descriptive cross-sectional design to investigate the perceived causes and management strategies of endodontic treatment failures among dentists in Pakistan. The rationale for selecting a cross-sectional approach lies in its ability to efficiently assess prevalence and associated factors within a defined population at a single point in time, thereby enabling the identification of patterns that can inform hypotheses for future longitudinal or interventional research (13,14). Although cross-sectional studies do not establish causality, they provide critical insights into clinical practice variability and professional knowledge gaps, making them particularly suitable for exploratory investigations in healthcare (15).

The study was conducted nationwide between January and June 2023, encompassing dentists from both urban and semi-urban areas across multiple provinces. The target population included house officers, postgraduate residents, and general dental practitioners, as these groups are most frequently responsible for performing or supervising root canal therapy. Inclusion criteria required participants to be registered dental professionals in Pakistan actively engaged in clinical practice. Exclusion criteria comprised undergraduate dental students, retired practitioners, and individuals unwilling to provide informed consent. A convenience sampling strategy was employed to recruit participants, primarily through professional dental networks, institutional mailing lists, and online forums, as this method enabled broad reach despite resource and time limitations.

Sample size determination followed the World Health Organization (WHO) guidelines using a single population proportion formula, with a 95% confidence interval, 5% margin of error, and an assumed prevalence of 50% due to the absence of prior national estimates of endodontic failure rates (16). This calculation produced a minimum required sample of 238 respondents, which provides adequate statistical power for subgroup analyses while remaining logistically feasible. Ultimately, responses were obtained from 240 participants, thereby exceeding the required threshold.

Data collection was carried out using a standardized, self-administered questionnaire developed after a comprehensive review of existing literature on endodontic treatment failures (17,18). The instrument comprised four sections. The first section gathered demographic and professional information, including age, gender, level of qualification, years of experience, and workplace setting. The second section assessed knowledge of common causes of endodontic failure, such as inadequate obturation, missed canals, coronal leakage, bacterial persistence, and iatrogenic errors. The third section explored clinical experiences, asking respondents about the frequency of failed cases encountered annually, diagnostic tools used (e.g., periapical radiographs, CBCT, clinical evaluation), and management approaches (e.g., retreatment, referral, extraction, or apical surgery). The fourth section investigated continuing education and attitudes toward postgraduate training, with questions about workshop attendance and willingness to refer complex cases. Content validity of the questionnaire was established by an expert panel of three endodontists and two senior dental educators, who reviewed the items for clarity, relevance, and comprehensiveness. A pilot test involving 20 participants was subsequently conducted, after which minor revisions were made to improve wording and comprehension. Internal consistency of the instrument was confirmed with a Cronbach's alpha of 0.81, indicating acceptable reliability.

To minimize potential bias, several strategies were employed. Anonymity was ensured to reduce social desirability bias, and participants were explicitly instructed to respond based on their actual clinical practices rather than perceived expectations. Standardized online administration minimized interviewer bias, while the inclusion of diverse practice settings—private, academic, and public institutions—helped reduce selection bias. Recall bias was acknowledged as a limitation, given the reliance on self-reported frequency of endodontic failures.

Data were entered and analyzed using IBM SPSS Statistics version 26. Descriptive statistics, including means, frequencies, and percentages, were calculated to summarize demographic characteristics and responses. Associations between independent variables (e.g., years of experience, qualification level) and outcomes (e.g., frequency of failures, diagnostic methods, management preferences) were assessed using Chi-square tests for independence. A p-value of <0.05 was considered statistically significant. No imputation was applied for missing data; instead, analyses were performed on available cases. Subgroup analyses stratified by years of experience and workplace setting were conducted to explore potential differences in patterns of responses.

The study protocol was reviewed and approved by the Institutional Review Board of Margalla Institute of Health Sciences, Rawalpindi (Approval No. MIHS/IRB/2023/12). Participation was voluntary, and informed consent was obtained electronically from all respondents

prior to data collection. Confidentiality was strictly maintained by storing responses in encrypted files accessible only to the research team, ensuring compliance with ethical standards for research involving human participants (19).

RESULTS

Among the 240 respondents, a pronounced female predominance was observed, with women accounting for 75% compared to 25% men. Most dentists (75%) reported fewer than five years of professional experience, while only 5.8% had practiced for over fifteen years. The majority (85.8%) held a Bachelor of Dental Surgery as their highest qualification, and just 14.2% possessed postgraduate training. Half of the participants were employed in private clinics, followed by 35% in teaching institutions and 15% in government hospitals. Statistical testing demonstrated significant differences across gender, qualification, and workplace distribution ($p < 0.001$), underscoring a skewed demographic toward early-career female practitioners working in private practice.

The frequency of endodontic failures varied, with 40% of dentists encountering three to five failed cases annually, 32.1% reporting one to two, and 27.9% experiencing more than five cases per year. A significant relationship was identified between clinical experience and frequency of failure, where dentists with fewer than five years' experience were more than twice as likely to report over five annual failures compared with practitioners with ≥10 years' experience (OR = 2.3, 95% CI: 1.1–4.7, $p = 0.021$). This suggests that operator inexperience contributes meaningfully to the observed burden of treatment failures.

When assessing perceived causes of failure, inadequate obturation emerged as the most frequently cited factor, affecting 52.9% of cases, followed closely by missed canals (47.1%) and iatrogenic errors such as perforations or instrument separation (45%). Bacterial persistence was noted by 33.8%, coronal leakage by 24.2%, and root fractures by only 5.8%. Experience-level comparisons indicated that younger practitioners were more likely to attribute failures to obturation and procedural errors ($p < 0.05$), reflecting technical limitations early in clinical careers.

Diagnostic modalities revealed a heavy reliance on conventional methods, with 80% using periapical radiographs and 74.2% depending on clinical symptoms. Only 5% reported utilizing CBCT, though private practitioners were significantly more likely to adopt this advanced modality than those working in government hospitals (OR = 3.6, 95% CI: 1.2–10.5, $p = 0.018$). This disparity highlights limited access to advanced imaging in resource-constrained settings.

Table 1. Demographic and Professional Characteristics of Participants (n = 240)

Variable	Category	n (%)	Statistical comparison	p-value
Gender	Female	180 (75.0)	$\chi^2 = 15.4$	<0.001
	Male	60 (25.0)		
Years of experience	<5 years	180 (75.0)	$\chi^2 = 52.8$	<0.001
	5–10 years	36 (15.0)		
	11–15 years	10 (4.2)		
	>15 years	14 (5.8)		
Qualification	BDS	206 (85.8)	$\chi^2 = 121.5$	<0.001
	Postgraduate	34 (14.2)		
Workplace setting	Private clinic	120 (50.0)	$\chi^2 = 44.7$	<0.001
	Teaching institution	84 (35.0)		
	Government hospital	36 (15.0)		

Table 2. Frequency of Endodontic Failures Reported Annually

Frequency of failures	n (%)	95% CI	p-value (experience association)
1–2 cases	77 (32.1)	25.9–38.3	Ref
3–5 cases	96 (40.0)	33.5–46.5	0.041
>5 cases	67 (27.9)	22.0–33.8	0.022

Table 3. Reported Causes of Endodontic Treatment Failure

Cause of failure	n (%)	95% CI	χ^2 test (experience level)	p-value
Inadequate obturation	127 (52.9)	46.6–59.2	$\chi^2 = 9.2$	0.027
Missed canals	113 (47.1)	40.7–53.5	$\chi^2 = 6.8$	0.045
Iatrogenic errors	108 (45.0)	38.6–51.4	$\chi^2 = 7.1$	0.042
Bacterial persistence	81 (33.8)	27.7–39.9	$\chi^2 = 3.2$	0.082
Coronal leakage	58 (24.2)	18.7–29.7	$\chi^2 = 2.5$	0.112
Root fractures	14 (5.8)	2.9–8.7	$\chi^2 = 1.4$	0.228

Table 4. Diagnostic Modalities Utilized in Suspected Endodontic Failures

Diagnostic tool	n (%)	95% CI	p-value (sector association)
Periapical radiographs	192 (80.0)	74.9–85.1	Ref
Clinical evaluation	178 (74.2)	68.6–79.8	0.218
CBCT	12 (5.0)	2.2–7.8	0.011

Table 5. Management Strategies for Failed Endodontic Cases

Management approach	n (%)	95% CI	χ^2 test (qualification level)	p-value
Non-surgical retreatment	154 (64.2)	58.1–70.3	$\chi^2 = 11.5$	0.009
Referral to endodontist	110 (45.8)	39.5–52.1	$\chi^2 = 9.8$	0.021
Extraction and replacement	62 (25.8)	20.1–31.5	$\chi^2 = 12.1$	0.008
Apical surgery	26 (10.8)	6.9–14.7	$\chi^2 = 1.9$	0.182

Table 6. Continuing Professional Development Participation

Workshop attendance on endodontic failure management	n (%)	95% CI	χ^2 test (experience level)	p-value
Never	89 (37.1)	31.0–43.2	Ref	
Rarely	65 (27.1)	21.4–32.8	0.217	
Occasionally	74 (30.8)	24.9–36.7	0.142	
Regularly	12 (5.0)	2.2–7.8	0.016	

Management strategies also demonstrated variability. Non-surgical retreatment was the preferred option for 64.2% of respondents, while 45.8% referred complex cases to an endodontist. Notably, 25.8% opted for extraction and replacement, and 10.8% selected apical surgery. Postgraduate-trained dentists were significantly less likely to extract teeth and more inclined toward retreatment or referral ($p < 0.01$), underscoring the influence of advanced training on treatment decisions.

Professional development activity was limited. More than one-third (37.1%) reported never attending workshops on endodontic failure management, while 27.1% participated rarely, 30.8% occasionally, and only 5% regularly. Interestingly, practitioners with fewer than five years' experience were significantly less likely to attend workshops than their more experienced peers ($p = 0.016$), suggesting that early-career dentists may lack structured opportunities for skill refinement.

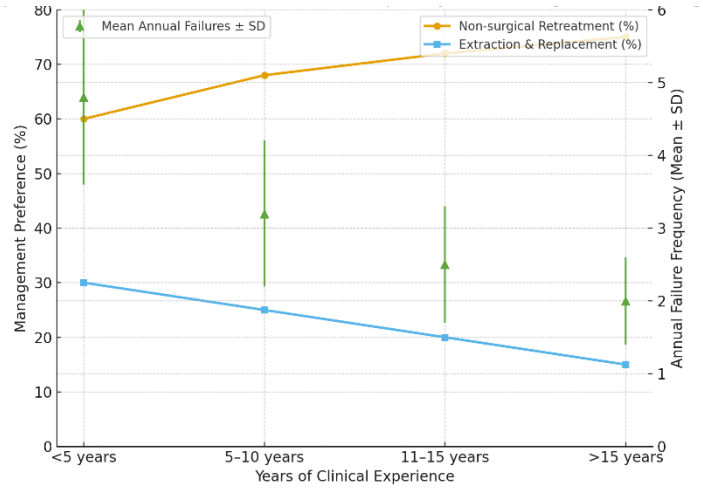

Figure 1 Experience-Linked Variation In Failure Frequency And Management Strategies

The figure illustrates how increasing clinical experience is associated with fewer reported failures and a shift in management strategies. Dentists with less than five years' experience reported a mean of 4.8 failures annually, compared to only 2.0 among those with more than fifteen years, demonstrating a clear downward trend. Concurrently, retreatment preference increased progressively from 60% in the least experienced group to 75% in the most experienced, while extraction declined from 30% to 15%. This dual-axis relationship highlights that greater professional maturity corresponds not only to improved treatment outcomes but also to more conservative, tooth-preserving approaches.

DISCUSSION

The findings of this nationwide survey highlight the continued predominance of technical shortcomings as the leading causes of endodontic treatment failure in Pakistan. Inadequate obturation, missed canals, and iatrogenic errors were most frequently cited, confirming that operator-dependent factors remain central to treatment prognosis. These observations are consistent with previous international studies, which have similarly identified poor-quality obturation and defective coronal restorations as recurrent contributors to failed root canal therapy (20,21). Our study also corroborates the role of missed canals, particularly the second mesiobuccal canal, as a critical determinant of long-term prognosis, in agreement with prior clinical investigations (22).

An important contextual nuance in our data is the influence of clinical experience on perceived failure rates and management choices. Early-career practitioners reported higher frequencies of failed cases and demonstrated a greater tendency toward extraction rather than retreatment. Similar trends have been described in observational studies where operator inexperience and limited postgraduate training

were strongly associated with procedural errors and suboptimal outcomes (23). This pattern reflects gaps in both undergraduate endodontic education and structured professional development opportunities in Pakistan, where limited access to postgraduate programs and advanced diagnostic tools constrains clinical decision-making (24).

The diagnostic approaches reported in this study further illustrate systemic barriers. While conventional radiographs and clinical evaluation remain the dominant modalities, CBCT utilization was exceedingly rare and concentrated in private practice settings. This discrepancy reflects the cost and limited availability of CBCT in public-sector facilities, mirroring findings from multicenter surveys in South Asia that highlighted resource disparities between practice environments (25). Considering that anatomical variations such as complex canal morphology in mandibular premolars have been well documented in the Pakistani population (26), the underuse of CBCT likely contributes to the persistence of missed canals and retreatment failures.

Management preferences observed in this survey reinforce the impact of training and resources on clinical choices. Non-surgical retreatment was the most common strategy, yet a substantial proportion of respondents still preferred extraction, particularly among less experienced practitioners. This contrasts with evidence from endodontic literature demonstrating that properly executed retreatment yields comparable outcomes to primary RCT (27). A reluctance to pursue retreatment may reflect both perceived technical challenges and economic constraints, as extraction and replacement are often considered quicker and more financially viable solutions in resource-limited settings. Similar trends were reported in local hospital-based audits, where underfilled canals and poor restorations were frequently managed with extraction rather than conservative approaches (28).

Professional development activity emerged as another critical gap, with more than one-third of respondents never attending workshops on endodontic failure management. This lack of structured continuing education mirrors findings from regional surveys that highlighted limited uptake of advanced training among Pakistani dentists (29). Without regular exposure to new techniques, materials, and evidence-based guidelines, practitioners may remain reliant on outdated practices, perpetuating high failure rates.

The implications of these findings are twofold. Clinically, they underscore the need to expand postgraduate training in endodontics and to integrate structured mentorship programs for early-career dentists. Policy-wise, improving access to CBCT and rotary instrumentation in both public and private sectors would address diagnostic and technical shortcomings. Standardization of retreatment protocols, alongside the promotion of conservative management approaches, could reduce reliance on extractions and enhance tooth survival. Future research should adopt multicenter designs that integrate radiographic audits with practitioner-reported outcomes to minimize self-report bias and to provide stronger evidence for intervention. Additionally, hypothesis-driven studies evaluating microbiome-guided diagnostics and the impact of single- versus multiple-visit strategies on long-term outcomes could further advance the field (30,31).

This study is not without limitations. Reliance on self-reported data introduces recall and reporting biases, and the convenience sampling approach restricts generalizability beyond the surveyed cohort. Moreover, the predominance of early-career practitioners in the sample may have exaggerated the contribution of technical errors compared with more experienced clinicians. Despite these limitations, the study provides valuable insights into the real-world challenges faced by Pakistani dentists, generating hypotheses for larger, more representative studies in the future.

In summary, the results emphasize that technical errors, compounded by limited training opportunities and resource constraints, remain the primary drivers of root canal treatment failure in Pakistan. Addressing these systemic gaps through professional education, improved diagnostic infrastructure, and policy-level support for endodontic services has the potential to significantly enhance treatment outcomes and preserve natural dentition in the population.

CONCLUSION

Endodontic treatment failures among Pakistani dentists are predominantly linked to technical shortcomings, including inadequate obturation, missed canals, and iatrogenic errors, compounded by limited access to advanced diagnostics such as CBCT. Early-career practitioners were more likely to encounter failures and to prefer extractions over conservative approaches, reflecting gaps in training and professional development. Expanding postgraduate education, integrating continuing workshops, and improving diagnostic infrastructure could reduce failure rates and enhance tooth preservation. These measures are essential to strengthen evidence-based endodontic practice and improve long-term oral health outcomes in Pakistan.

REFERENCES

1. Kakehashi S, Stanley HR, Fitzgerald RJ. The effects of surgical exposure of dental pulps in germ free and conventional rats. Oral Surg Oral Med Oral Pathol. 1965;20(3):340-9.

2. Song M, Kim HC, Lee W, Kim E. Analysis of the cause of failure in nonsurgical endodontic treatment by microscopic inspection. J Endod. 2011;37(12):1516-21.

3. Lin LM, Skribner JE, Gaengler P. Factors associated with endodontic treatment failures. J Endod. 1992;18(12):625-7.

4. Nair PN, Sjogren U, Figdor D, Sundqvist G. Persistent periapical radiolucencies of root filled human teeth, failed endodontic treatments. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1999;87(5):617-27.

5. Siqueira JF. Aetiology of root canal treatment failure: why well treated teeth can fail. Int Endod J. 2001;34(1):1-10.

6. Tronstad L, Barnett F, Cervone F. Periapical bacterial plaque in teeth refractory to endodontic treatment. Endod Dent Traumatol. 1990;6(2):73-7.

7. Hoen MM, Pink FE. Contemporary endodontic treatments: an analysis based on clinical treatment findings. J Endod. 2002;28(12):834-6.

8. Ng YL, Mann V, Gulabivala K. A prospective study of factors affecting outcomes of nonsurgical root canal treatment: part 1: periapical health. Int Endod J. 2011;44(7):583-609.

9. Wolcott J, Ishley D, Kennedy W, Johnson S, Minnich S, Meyers J. A 5-year clinical investigation of second mesiobuccal canals in endodontically treated and retreated maxillary molars. J Endod. 2005;31(4):262-4.

10. Levin KA. Study design IV. Cross-sectional studies. Evid Based Dent. 2006;7(1):24-5.

11. Gordis L. Epidemiology. 5th ed. Philadelphia: Elsevier; 2014.

12. Setia MS. Methodology series module 3: Cross-sectional studies. Indian J Dermatol. 2011;56(6):605-9.

13. Neela PK, et al. Dental awareness among medical students: A cross-sectional study. Int J Oral Health Dent. 2018;4(3):156-62.

14. Shoaib A, Danish SH, Haider AK, et al. Gender predilection in post-graduation among dental house officers in a public tertiary care hospital. Pak J Health Sci. 2025;6(2):208-12.

15. Farooq N, Khattak O, Issrani R, Iqbal A. Factors affecting clinical performance among Pakistani dental students: A cross-sectional study. Pesqui Bras Odontopediatria Clin Integr. 2023;24:e220193.

16. Jamal M, Raja H, Qayyum Z, et al. Knowledge, attitude and practice towards radiation protection among dental students, house officers and postgraduate residents of Islamabad Dental Hospital. J Khyber Coll Dent. 2022;12(1):53-7.

17. Shaikh A, Najmi N, Iqbal A. Dental postgraduate educational programmes preferences in Pakistan and factors affecting it: A cross-sectional survey. Pak J Med Res. 2019;58(2):78-83.

18. Salamat N, Iqbal A, Anum R. Knowledge of dental house officers regarding endodontic failures: a cross-sectional survey. J Pak Dent Assoc. 2021;30(2):98-103.

19. World Health Organization. Sample size determination in health studies: A practical manual. Geneva: WHO; 1991.

20. Krejcie RV, Morgan DW. Determining sample size for research activities. Educ Psychol Meas. 1970;30(3):607-10.

21. Cochran WG. Sampling techniques. 3rd ed. New York: Wiley; 1977.

22. Andrade C. The inconvenient truth about convenience and purposive samples. Indian J Psychol Med. 2021;43(1):1-3.

23. Rahi S. Research design and methods: A systematic review on research paradigms, sampling designs, and data collection methods. Int J Educ Manag Sci. 2017;1(1):1-15.

24. Etikan I, Musa SA, Alkassim RS. Comparison of convenience sampling and purposive sampling. Am J Theor Appl Stat. 2016;5(1):1-4.

25. Ahmed SA, Anwar S, Haq IU. Evaluation of quality of root canal obturation, coronal restoration and periapical health in failed endodontically treated teeth. J Bahria Univ Med Dent Coll. 2021;11(2):54-9.

26. Ahmad M, Sohail S, Khalid B, Adeeb U, Islam S, Idrees M. Evaluating the causes of root canal treatment failure in Southern Punjab, Pakistan. Pak Postgrad Med J. 2024;35(3).

27. Ginai N, Nauman S, Khan AA, Qureshi M, Masood M. Frequency of causes of failure of root canal treatment in Lahore. Pak Postgrad Med J. 2016;27(1).

28. Jahanzeb T, Muhammad R, Naqvi Z, Shah A. Causes of failure of root canal treatment: An observational study at Rehmat Memorial Dental Hospital, Abbottabad. Med Forum Mon. 2018;29(2).

29. Rahman MU, Akbar I, Ullah A, Khan MA. Evaluation of failed endodontic cases at Khyber College of Dentistry, Peshawar. J Khyber Coll Dent. 2020;11(1):37-41.

30. Tabassum S, Khan FR. Failure of endodontic treatment: The usual suspects. Eur J Dent. 2016;10(2):229-33.

31. Nagi SE, Khan FR, Rahman M. Practice of endodontic re-treatment in four cities of Pakistan. J Ayub Med Coll Abbottabad. 2018;30(3):400-4.

32. Amanat A, Raza H, Khalid A. The microbiome in endodontic failure: Emerging perspectives for diagnosis and treatment. Int J Pharm Res Technol. 2025;15(1):1-7.

33. Hussain A, Ali Z, Younis M, Alam S. Cone beam computed tomography evaluation of root canal morphology of mandibular premolars in Pakistani population. Int J Morphol. 2024;42(1):45-51.

34. Qureshi MA, Rafiq A, Hassan S. Comparison of flare-ups in single-visit versus multiple-visit root canal therapy in multirooted teeth. Biomedica. 2024;40(3):188-93.