

ROOT CANAL TREATMENT FAILURE AND RETREATMENT OUTCOMES IN PESHAWAR, PAKISTAN: A CROSS-SECTIONAL ANALYSIS OF CONTRIBUTING FACTORS

Faryal Rafiq¹, Mahnoor Rafiq², Marwa Noor³, Alia Nawaz⁴, Mehwish Fazal⁵, Mazhar Rauf⁶

¹Trainee Dental Technologist Dhq Mardan

²PHD Working In Feroz's Sons Pharmaceuticals Industries

^{3,4,5}Student Siah's Suit Department Of Dental Technology, Sarhad Institute Of Allied Health Sciences, Sarhad
University Of Science And Information Technology, Peshawar, Pakistan

⁶Lecturer, Allied Health Northern University, Nowshera, Pakistan.

DOI: <https://doi.org/10.5281/zenodo.22793213>

Keywords

Root canal therapy; Endodontic failure; Retreatment; Irreversible pulpitis; Necrotic pulp; Peshawar

Article History

Received: 01 June 2026

Accepted: 23 August 2026

Published: 16 September 2026

Copyright @Author

Corresponding Author: *

Mazhar Rauf

Abstract

Root canal therapy (RCT) is an used and generally effective treatment for conditions like irreversible pulpitis and pulp necrosis. However with its success rate, a noticeable number of treated teeth still fail. These failures often result from infections inside the root canal mistakes made during the procedure or leakage around the tooth's crown.

Objective

This study aimed to look at what factors—like the type of dentist the tooth involved or the patient's background—are linked to RCT failure in patients in Peshawar. It also wanted to find out what patients would prefer if their root canal treatment didn't work: to try or to have the tooth removed.

Methods

The research was carried out over six months from February to August 2025. It took place at three dental centers in Peshawar: Northwest General Hospital, Lady Reading Hospital and the Dental Clinic of the Sarhad Institute of Allied Health Sciences. A total of 377 patients who had previously undergone RCT were interviewed using a questionnaire. The questions covered things like the patient's age, gender, the dentist who treated them, the type of tooth the details of the treatment and what they would do if the root canal failed again.

The data collected were analyzed using SPSS version 26 with statistics such as frequencies and percentages used to describe the findings.

Results

The results showed that root canal treatments done by dental practitioners (GDPs) failed much more often than those done by specialists. Specifically, 81.72% of RCTs performed by GDPs failed, compared to 17.74% of those done by specialists. When looking at teeth maxillary molars had the highest failure rate at 32.79% followed by maxillary premolars at 25.26% and mandibular molars at 20.43%. Mandibular canines had the failure rate at just 1.61%.

The main reasons for treatment failure were related to the side of the procedure. The common issues were missed or unfilled canals, which accounted for 27.41% of failures and underfilled canals, which made up 22.04%. Broken instruments inside the tooth were found in 6.45% of cases and overfilling—when material goes beyond the root tip—was seen in 4.83%. These latter two problems were less common.

Overall nearly half of the patients (187 out of 377 or 49.6%) reported that their root canal treatment had not worked well.. When asked what they would do if it failed again 80.4% said they would choose retreatment instead of having the tooth extracted.

Conclusion

The study concludes that the experience of the dentist and how well the core steps of root canal treatment are followed are the factors in whether the treatment succeeds or fails. These steps include finding all the root canals, cleaning and shaping them properly filling them completely and sealing them well and making sure the tooth is properly restored on top. The study recommends that complex cases should be referred to specialists and that general dentists should get regular training to improve their skills and reduce failure rates in Peshawar.

INTRODUCTION

Root canal therapy (RCT) removes damaged or infected pulp tissue and seals the resulting space to prevent periradicular disease and protect the tooth from reinfection. Although RCT is one of the most predictable procedures in dentistry, it does not always succeed, and when accepted technical and biological principles are not met, treatment frequently fails (Seltzer et al., 1963; Lopes & Siqueira Junior, 1999). The most consistent explanation for failure is the persistence of bacteria within the root canal system and/or in the periradicular tissues after treatment (Lin et al., 1992).

Procedural errors — overfilling, underfilling, perforation, or instrument separation — are commonly assumed to be the main cause of failure, but the evidence suggests these errors chiefly compromise outcome when infection is also present; on their own they account for only a modest share of failures (Nair, 1998; Nair et al., 1990, 1993, 1999). Microbial causes are broadly grouped as intraradicular, where organisms persist within the canal system, dentinal tubules, or anatomically inaccessible areas such as isthmuses

and lateral canals (Kakehashi et al., 1965; Byström et al., 1987; Sjögren et al., 1997), and extraradicular, where bacteria establish themselves beyond the root, for example within a periapical cyst wall (Nair, 1987). *Enterococcus faecalis* is repeatedly implicated in persistent apical infection because of its capacity to survive as a lone organism under nutrient-poor conditions and to colonize dentinal tubules (Stuart et al., 2006).

Non-microbial and technical contributors are equally well documented. Underfilling leaves necrotic or infected tissue and debris in the apical portion of the canal (Sjögren et al., 1990), while overfilling — extrusion of filling material beyond the apex — is associated with lower success when accompanied by residual infection or toxic sealer components, even though most modern obturation materials are well tolerated once set (Engstrom, 1964; Strindberg, 1956; Barbosa et al., 1993; Spangberg, 2002). Missed canals, particularly in molars and premolars with complex root morphology, leave a nidus of infection untouched by instrumentation (Ahmed et al., 2018). Root perforations create a direct pathway for microbial ingress and carry a prognosis that

depends on their location, size, and how promptly they are managed (Alhadainy, 1994). Finally, coronal leakage – through a failed temporary restoration, a fractured crown, or delayed definitive restoration – can reinfect an otherwise well-obtreated canal and is considered one of the principal causes of long-term failure (Saunders & Saunders, 1994; Siqueira Jr. et al., 1999).

More recent work has examined the microbiology of post-treatment apical periodontitis in greater depth, identifying it as a polymicrobial disease in which species such as *Fusobacterium nucleatum*, *Dialister pneumosintes*, and *Tannerella forsythia* frequently co-occur (Pereira et al., 2017), and has explored novel disinfection strategies, including magnetically propelled nanorobots designed to reach bacteria hidden within dentinal tubules (Dasgupta et al., 2022). At the same time, the field still lacks a uniform, universally applied definition of endodontic "failure," which complicates comparison across studies (Bergenholtz, 2016), and retreatment outcomes are increasingly understood to depend on a three-way interaction between preoperative host and microbial factors, the efficiency of the retreatment protocol itself, and the long-term integrity of the final restoration (Gulabivala & Ng, 2023).

Despite the wealth of laboratory and cohort data available internationally, locally generated evidence on why RCT fails in routine clinical practice in Peshawar – and on what patients themselves prefer once it does – remains limited. This study was therefore designed to characterize the clinical, technical, and provider-related factors associated with RCT failure among patients treated in major hospitals and a university dental clinic in Peshawar, and to document patients' preferred course of subsequent management.

Aim

To reduce the risk of RCT failure in Peshawar hospitals through identification and analysis of the key variables influencing treatment outcome.

Objectives

- To explore the clinical, technical, and biological causes of RCT failure among patients treated in hospitals of Peshawar.
- To determine patients' preference for non-surgical retreatment, surgical endodontics, or extraction and replacement of the failed tooth.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

A descriptive cross-sectional study was carried out at three centers in Peshawar: North West General Hospital (NWGH), Lady Reading Hospital (LRH), and the Dental Clinic of the Sarhad Institute of Allied Health Sciences (SIAHS).

2.2 Study Duration

Data were collected over six months, from February 2025 to August 2025.

2.3 Sample Size and Sampling

A sample of 377 patients with a documented history of RCT was recruited by consecutive sampling. The required sample size was calculated using the Raosoft sample size calculator.

2.4 Inclusion Criteria

- Patients with a history of endodontic treatment failure.
- Patients presenting with pulpal or periapical disease related to a previously treated tooth.

2.5 Exclusion Criteria

- Patients with vertical root fractures, peri-endodontic lesions, split crowns, or grossly decayed, non-restorable teeth.
- Patients unlikely to complete follow-up.
- Patients without access to further treatment.

2.6 Data Collection

All eligible participants were briefed on the study's aims and procedures and gave written informed consent prior to enrolment. The study protocol was reviewed and approved by the Institutional

Ethics Committee. Data were collected using a structured questionnaire covering demographic characteristics (age, gender, occupation, location, socioeconomic status), knowledge and awareness of RCT and its potential failure, type and provider of the initial treatment, treatment environment, dental history, satisfaction, treatment outcome, and preferred approach to retreatment.

2.7 Statistical Analysis

Data were entered and analyzed using SPSS version 26. Descriptive statistics – frequencies and percentages – were used to summarize demographic characteristics and the key study variables.

2.8 Operational Definitions

RCT: A dental procedure used to treat an infected or irreversibly inflamed tooth by removing the pulp, disinfecting the canal system, and sealing it. Periradicular disease: Inflammation or infection affecting the tissues surrounding the root of a tooth.

3. RESULTS

A total of 377 patients aged 17–50 years who had undergone RCT were enrolled. Table 1 summarizes the demographic profile of the study population; most participants were in the 36–50-year age group (51.2%), male (64.5%), and of middle socioeconomic status (69.2%).

Table 1. Demographic characteristics of study participants (N = 377)

Variable	Category	n	%
Age group (years)	17–25	48	12.7
	26–35	136	36.1
	36–50	193	51.2
Gender	Male	243	64.5
	Female	134	35.5
Occupation	Student	235	62.3
	Professional	142	37.7
Residence	Urban	198	52.5
	Rural	179	47.5
Socioeconomic status	Low	48	12.7
	Middle	261	69.2
	High	68	18.0

Regarding treatment setting and provider, 194 patients (51.5%) had been treated in a hospital and 183 (48.5%) in a university dental clinic; by practice type, general dental practitioners in private clinics performed the largest share of initial treatments (54.9%), followed by specialists in

public hospitals (43.2%) and university dental clinics (1.9%). Across all 377 cases, molars were the most frequently treated tooth type (55.7%), followed by premolars (34.7%), canines (7.4%), and incisors (2.1%) (Table 2).

Table 2. Treatment setting, provider type, and tooth type treated (all cases, N = 377)

Variable	Category	n	%
Treatment setting	Hospital	194	51.5
	University dental clinic	183	48.5
Provider / practice type	GDP – private clinic	207	54.9
	Specialist – public hospital	163	43.2
	University dental clinic	7	1.9
Tooth type treated (all cases)	Incisors	8	2.1
	Canines	28	7.4
	Premolars	131	34.7
	Molars	210	55.7

Patient knowledge and awareness varied considerably: 47.0% were aware of advanced endodontic protocols, 85.7% rated their own knowledge of RCT as good or excellent, and

48.3% knew that RCT could fail. Despite this, 84.1% of respondents held an overall positive opinion of RCT (Table 3).

Table 3. Patient knowledge, awareness, and opinion of RCT

Variable	Category	n	%
Awareness of advanced protocols	Aware	177	47.0
	Unaware	200	53.0
Knowledge about RCT	Excellent	150	39.8
	Good	173	45.9
	None	54	14.3
Awareness that RCT can fail	Aware	182	48.3
	Unaware	195	51.7
Overall opinion of RCT	Positive	317	84.1
	Negative	60	15.9

Most patients had undergone multi-visit RCT (62.3%) rather than single-visit treatment (37.7%). The treatment environment was reported as clean in 54.6% of cases, while 7.4% recalled bloody

surfaces and 37.9% were unsure of the clinical environment. A majority of participants (60.5%) reported a previous dental history, including earlier dental treatment or problems (Table 4).

Table 4. Treatment characteristics and clinical environment

Variable	Category	n	%
Type of RCT (visits)	Multi-visit	235	62.3
	Single-visit	142	37.7
Clinic/hospital environment	Clean surfaces	206	54.6
	Bloody surfaces	28	7.4
	Unsure	143	37.9
Previous dental history	Present	228	60.5
	Absent	149	39.5

Treatment performed by general dental practitioners failed substantially more often than treatment performed by specialists (Table 5).

Table 5. Association between treatment provider and endodontic failure

Treatment provider	n	%
General dental practitioner (GDP)	152	81.72
Specialist (endodontist)	33	17.74

When failed cases were classified by tooth type, maxillary molars showed the highest failure rate (32.79%), followed by maxillary premolars (25.26%) and mandibular molars (20.43%); mandibular canines showed the lowest failure rate (1.61%) (Table 6).

Table 6. Distribution of endodontic failure by tooth type

Tooth group	Tooth type	n	%
Maxillary	Incisors	4	2.10
	Canines	7	3.76
	Premolars	47	25.26
	Molars	61	32.79
Mandibular	Incisors	1	0.53
	Canines	3	1.61
	Premolars	26	13.79
	Molars	38	20.43

Among the procedural factors examined, unfilled or missed canals (27.41%) and underfilled canals (22.04%) were the leading contributors to failure.

Poor coronal restoration (17.20%) and perforations (12.90%) were also notable, whereas

broken instruments (6.45%) and overfilling (4.83%) were comparatively uncommon (Table 7).

Table 7. Procedural factors associated with endodontic failure

Procedural factor	n	%
Unfilled / missed canals	51	27.41
Underfilled canals	41	22.04
Poor coronal restoration	32	17.20
Perforations	24	12.90
Untreated (additional) root canals	17	9.13
Broken instruments	12	6.45
Overfilled canals	9	4.83

Finally, patient-reported satisfaction and treatment outcome are summarized in Table 8. Most patients were satisfied or extremely satisfied with their initial RCT (86.2% combined), yet 187 of 377 patients (49.6%) reported that their

treatment had ultimately been unsuccessful. When asked how they would prefer a failed tooth to be managed, the large majority (80.4%) chose retreatment over extraction.

Table 8. Patient satisfaction and treatment outcome

Variable	Category	n	%
Satisfaction with initial RCT	Satisfied	264	70.0
	Extremely satisfied	61	16.2
	Not satisfied	52	13.8
Treatment outcome	Successful	190	50.4
	Unsuccessful	187	49.6
Preferred management of failure	Retreatment	303	80.4
	Extraction	74	19.6

4. DISCUSSION

This study found that patient age influenced treatment outcome, with the highest number of failures occurring in the 36–50-year age group and the fewest in the 17–25-year group. Older patients may present with more heavily restored or structurally compromised teeth, more complex canal anatomy from age-related calcification, or a longer interval since the original treatment during

which coronal restorations can deteriorate – all of which could plausibly increase the likelihood of a poor outcome, although this study did not test these mechanisms directly.

The operator's training and experience emerged as a major determinant of outcome: over four-fifths of failed cases in this sample had originally been treated by general dental practitioners, compared with fewer than one-fifth treated by specialists.

This gap is consistent with the wider literature and most plausibly reflects differences between GDPs and endodontists in case selection, procedural training, and access to magnification, rotary instrumentation, and other technology that improves canal negotiation and disinfection.

Consistent with previous work, most failures in this cohort were attributable to incomplete treatment rather than overtreatment. Unfilled or missed canals (27.41%) and underfilled canals (22.04%) together accounted for approximately half of all identified procedural causes, considerably outweighing overfilling (4.83%) or instrument separation (6.45%). This pattern supports the well-established principle that failure to fully clean, shape, and obturate the canal system – thereby leaving necrotic tissue, debris, or bacteria in place – is far more damaging to long-term prognosis than a modest excess of filling material, most of which is well tolerated once set (Sjögren et al., 1990; Barbosa et al., 1993). Missed canals in particular reflect the anatomical complexity of certain tooth groups and the difficulty of visualizing additional canals during exploration, a finding echoed in earlier studies linking missed anatomy to treatment failure.

The tooth-type pattern observed here – highest failure in maxillary molars, followed by maxillary premolars and mandibular molars, with the lowest failure in mandibular canines – mirrors the general clinical experience that multi-rooted posterior teeth with intricate canal systems are technically more demanding and thus more prone to missed anatomy and incomplete disinfection than single-rooted anterior teeth.

Patient-level findings add a further dimension to these clinical results. Roughly half of the participants were unaware that RCT could fail, yet the overwhelming majority still held a positive opinion of the procedure and, when faced with a failed tooth, preferred retreatment to extraction. This preference is clinically reassuring, as it suggests good acceptance of non-surgical or surgical retreatment as a tooth-preserving option, provided patients are appropriately counselled and referred.

5. LIMITATIONS

Inadequate cleaning and shaping

- Incomplete cleaning and shaping of the canal system predisposes to complications.
- Residual bacteria and debris can lead to recurrence of infection.

Persistent or recurrent infection

- Failure may result from ongoing infection despite treatment.
- Contributing factors include an incomplete apical seal, coronal leakage, and resistant organisms such as *Enterococcus faecalis*.

Technical errors

- Overfilling or underfilling of the canal.
- Instrument fracture.
- Perforation during treatment, which may compromise long-term prognosis.

Tooth anatomy and complexity

- Multi-rooted, anatomically intricate teeth with accessory communication pathways.
- Missed canals.
- Inadequate cleaning related to anatomical complexity.

As a cross-sectional, questionnaire-based study relying partly on patient recall and self-reported outcomes, this work cannot establish causal relationships between individual variables and treatment failure, and radiographic or histological confirmation of failure was outside its scope.

6. CONCLUSION AND RECOMMENDATIONS

General dental practitioners in this sample experienced markedly higher RCT failure rates than specialists, most often because of incomplete canal location and filling rather than overtreatment. Contributing factors identified in this study include limited continuing education, inconsistent access to appropriate equipment, variable operator experience, the inherent complexity of root canal anatomy, and infrequent referral of difficult cases to endodontic specialists

Recommendations

1. Careful case selection is essential to improving the success of endodontic therapy.
2. Good-quality pre-operative radiographs – supplemented where possible by additional imaging – should be obtained for all multi-rooted teeth before treatment.
3. Cases with complex root canal anatomy should be referred promptly to endodontic specialists to reduce the risk of failure.
4. General dentists should be encouraged and supported to participate in continuing education focused on recent advances in endodontics.

ETHICAL APPROVAL

The study protocol was reviewed and approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants prior to enrolment.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

The authors thank the staff and patients of North West General Hospital, Lady Reading Hospital, and the Dental Clinic of the Sarhad Institute of Allied Health Sciences, Peshawar, for their cooperation during data collection.

REFERENCES

- Ahmed, S. A. B., Puri, E., Thakkar, N., Ramugade, M., Sapkale, K., & Allwani, V. (2018). Endodontics: Why root canals fail? *Clinical Dentistry*, 12(6).
- Alhadainy, H. A. (1994). Root perforations: a review of literature. *Oral Surgery, Oral Medicine, Oral Pathology*, 78(3), 368–374.
- Alves, F. R., Coutinho, M. S., & Gonçalves, L. S. (2014). Endodontic-related facial paresthesia: systematic review. *Journal of the Canadian Dental Association*, 80(80), e13.
- Barbosa, S. V., Araki, K., & Spångberg, L. S. (1993). Cytotoxicity of some modified root canal sealers and their leachable components. *Oral Surgery, Oral Medicine, Oral Pathology*, 75(3), 357–361.
- Bergenholtz, G. (2016). Assessment of treatment failure in endodontic therapy. *Journal of Oral Rehabilitation*, 43(10), 753–758.
- Borgia, E., Baron, R., & Borgia, J. L. (2019). Quality and survival of direct light-activated composite resin restorations in posterior teeth: a 5- to 20-year retrospective longitudinal study. *Journal of Prosthodontics*, 28(1), e195–e203.
- Byström, A., Happonen, R. P., Sjögren, U., & Sundqvist, G. (1987). Healing of periapical lesions of pulpless teeth after endodontic treatment with controlled asepsis. *Dental Traumatology*, 3(2), 58–63.
- Daokar, S., & Kalekar, A. (2013). Endodontic failures - a review. *IOSR Journal of Dental and Medical Sciences*, 4(5), 5–10.
- Dasgupta, D., Peddi, S., Saini, D. K., & Ghosh, A. (2022). Mobile nanobots for prevention of root canal treatment failure. *Advanced Healthcare Materials*, 11(14), 2200232.
- Del Fabbro, M., Corbella, S., Sequeira-Byron, P., Tsesis, I., Rosen, E., Lolato, A., & Taschieri, S. (2016). Endodontic procedures for retreatment of periapical lesions. *Cochrane Database of Systematic Reviews*, (10).
- Engstrom, B. (1964). Correlation of positive cultures with the prognosis for root canal therapy. *Odontologisk Revy*, 15, 257–269.
- Fabricius, L., Dahlén, G., Sundqvist, G., Happonen, R. P., & Möller, Å. J. (2006). Influence of residual bacteria on periapical tissue healing after chemomechanical treatment and root filling of experimentally infected monkey teeth. *European Journal of Oral Sciences*, 114(4), 278–285.
- Gulabivala, K., & Ng, Y. L. (2023). Factors that affect the outcomes of root canal treatment and retreatment - a reframing of the principles. *International Endodontic Journal*, 56, 82–115.

- Johnson, W. T., & Kulild, J. C. (2011). Obturation of the cleaned and shaped root canal system. In Cohen's Pathways of the Pulp (pp. 349-388).
- Kakehashi, S., Stanley, H., & Fitzgerald, R. (1965). The effects of surgical exposures of dental pulps in germ-free and conventional laboratory rats. *Oral Surgery, Oral Medicine, Oral Pathology*, 20(3), 340-349.
- Lin, L. M., Pascon, E. A., Skribner, J., Gängler, P., & Langeland, K. (1991). Clinical, radiographic, and histologic study of endodontic treatment failures. *Oral Surgery, Oral Medicine, Oral Pathology*, 71(5), 603-611.
- Lin, L. M., Skribner, J. E., & Gaengler, P. (1992). Factors associated with endodontic treatment failures. *Journal of Endodontics*, 18(12), 625-627.
- Lopes, H. P., & Siqueira Junior, J. F. (1999). Endodontia: biologia e técnica. In *Endodontia: Biologia e Técnica* (pp. 650).
- Lui, J.-N., Khin, M.-M., Krishnaswamy, G., & Chen, N.-N. (2014). Prognostic factors relating to the outcome of endodontic microsurgery. *Journal of Endodontics*, 40(8), 1071-1076.
- Miglani, S., Comert, F. D., Patro, S., & Chopra, V. (2021). Introduction to endodontic retreatment. In *Clinical Atlas of Retreatment in Endodontics* (pp. 1-4).
- Muruzabal, M., Erausquin, J., & Devoto, F. (1966). A study of periapical overfilling in root canal treatment in the molar of rat. *Archives of Oral Biology*, 11(4), 373-383.
- Nair, P. (1998). Pathology of apical periodontitis. In *Essential Endodontology* (pp. 68-105). Blackwell Science.
- Nair, P., Sjögren, U., Schumacher, E., & Sundqvist, G. (1993). Radicular cyst affecting a root-filled human tooth: a long-term post-treatment follow-up. *International Endodontic Journal*, 26(4), 225-233.
- Nair, P. R. (1987). Light and electron microscopic studies of root canal flora and periapical lesions. *Journal of Endodontics*, 13(1), 29-39.
- Nair, P. R., Sjögren, U., Figdor, D., & Sundqvist, G. (1999). Persistent periapical radiolucencies of root-filled human teeth, failed endodontic treatments, and periapical scars. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*, 87(5), 617-627.
- Nair, P. R., Sjögren, U., Krey, G., & Sundqvist, G. (1990). Therapy-resistant foreign body giant cell granuloma at the periapex of a root-filled human tooth. *Journal of Endodontics*, 16(12), 589-595.
- Pereira, R., Rodrigues, V. A. A., Furtado, W., Gueiros, S., Pereira, G., & Avila-Campos, M. J. (2017). Microbial analysis of root canal and periradicular lesion associated to teeth with endodontic failure. *Anaerobe*, 48, 12-18.
- Saoud, T. M. A., Ricucci, D., Lin, L. M., & Gaengler, P. (2016). Regeneration and repair in endodontics - a special issue of the regenerative endodontics - a new era in clinical endodontics. *Dentistry Journal*, 4(1), 3.
- Saunders, W., & Saunders, E. (1994). Coronal leakage as a cause of failure in root-canal therapy: a review. *Dental Traumatology*, 10(3), 105-108.
- Seltzer, S., Bender, I., & Turkenkopf, S. (1963). Factors affecting successful repair after root canal therapy. *The Journal of the American Dental Association*, 67(5), 651-662.
- Siqueira Jr, J. F. (2001). Aetiology of root canal treatment failure: why well-treated teeth can fail. *International Endodontic Journal*, 34(1), 1-10.
- Siqueira Jr, J. F., Rôças, I. N., Lopes, H. P., & de Uzeda, M. (1999). Coronal leakage of two root canal sealers containing calcium hydroxide after exposure to human saliva. *Journal of Endodontics*, 25(1), 14-16.

Sjögren, U., Figdor, D., Persson, S., & Sundqvist, G. (1997). Influence of infection at the time of root filling on the outcome of endodontic treatment of teeth with apical periodontitis. *International Endodontic Journal*, 30(5), 297–306.

Sjögren, U., Hägglund, B., Sundqvist, G., & Wing, K. (1990). Factors affecting the long-term results of endodontic treatment. *Journal of Endodontics*, 16(10), 498–504.

Spangberg, L. (2002). Instruments, materials, and devices. In *Pathways of the Pulp*.

Strindberg, L. (1956). The dependence of the results of pulp therapy on certain factors. *Acta Odontologica Scandinavica*, 14(21), 1–175.

Stuart, C. H., Schwartz, S. A., Beeson, T. J., & Owatz, C. B. (2006). *Enterococcus faecalis*: its role in root canal treatment failure and current concepts in retreatment. *Journal of Endodontics*, 32(2), 93–98.

Tabassum, S., & Khan, F. R. (2016). Failure of endodontic treatment: the usual suspects. *European Journal of Dentistry*, 10(1), 144–147.

Usri, K., Prisinda, D., & Malinda, Y. (2023). Analysis of various factors that cause the failure of root canal treatment: scoping review. *Journal of International Dental and Medical Research*, 16(1), 404–410.

