

COMPARATIVE ANALYSIS OF PROCEDURAL ACCIDENTS IN ROOT CANAL THERAPY: INSIGHTS FROM MANUAL AND ROTARY INSTRUMENTATION TECHNIQUES

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ABSTRACT

Aim of the study The aim of this study was to assess the frequency and nature of procedural accidents occurring during manual versus rotary root canal instrumentation, as experienced by dental students and practitioners in Constanța County, Romania. **Materials and methods** A cross-sectional study was conducted based on a 16-item questionnaire distributed to 45 respondents, including dental students and practicing dentists. The questionnaire collected data on demographic and professional background, endodontic practices, preferred instrumentation systems, and the occurrence and management of procedural complications such as instrument fracture, ledge formation, canal transportation, and perforations. **Results** Most respondents were female (62.22%) and worked in urban areas (91.11%). While rotary instrumentation was preferred by 66.6% of participants, 71.1% considered manual instruments more prone to fracture. Apical transportation was reported by 64.44%, ledge formation by 77.8%, and perforations by 42.22%. Although advanced techniques are widely adopted, procedural errors remain frequent in clinical endodontic practice. **Conclusions** The study confirms that procedural accidents are common regardless of the instrumentation technique used. These findings underline the need for continuous education, adherence to clinical protocols, and careful instrument selection to minimize iatrogenic complications in endodontic therapy.

Key words: endodontics, procedural accidents, manual instrumentation, rotary instrumentation, root canal treatment.

INTRODUCTION

Root canal treatment (RCT) is a fundamental procedure in endodontics, aimed at eliminating infection and preserving the affected tooth by thoroughly cleaning, shaping, and obturating the root canal system [1]. The success of this therapy relies heavily on effective canal instrumentation, which can be performed manually or with rotary systems.

Manual instrumentation, performed with stainless steel hand files, remains widely used due to its tactile feedback and control [2]. However, it is time-consuming and more prone to procedural accidents such as ledge formation, canal transportation, apical

blockage, and instrument separation, particularly in curved canals [3,4].

The introduction of nickel-titanium (Ni-Ti) rotary systems has significantly improved canal shaping efficiency while maintaining original canal curvature due to the superior flexibility of the alloy [5,6]. Rotary instrumentation has been associated with fewer incidences of canal transportation and faster preparation times [7]. Nonetheless, rotary systems are not immune to complications. Instrument separation remains a major concern, with fracture rates ranging from 0.5% to 10% depending on factors such as instrument design, usage protocol, and operator experience [8–10].

Several studies have investigated the prevalence and causes of instrument separation during root canal therapy. Cyclic fatigue and torsional stress are the most common reasons for NiTi file fracture, especially in curved canals or when instruments are reused beyond their safe lifespan [11,12]. In contrast, manual files tend to fracture due to excessive apical pressure or improper glide path establishment [13]. Operator inexperience, lack of irrigation, and canal anatomy complexity further contribute to procedural mishaps in both techniques [14,15].

Recent systematic reviews and clinical studies have reported variable outcomes when comparing the safety and efficiency of manual and rotary instrumentation. Some findings suggest that rotary systems reduce preparation time and procedural errors [16], while others note a higher instrument fracture rate in rotary use compared to manual methods [17,18].

In undergraduate training environments, the difference in error rates between manual and rotary systems is even more pronounced, highlighting the need for careful supervision and protocol standardization [19,20]. Studies assessing the technical quality of student-performed root canal fillings reveal that rotary instrumentation can improve obturation quality, but also increases the risk of file separation if used improperly [21–23].

Understanding the frequency and type of procedural accidents associated with different instrumentation techniques is crucial for clinical decision-making, improving patient outcomes, and refining educational strategies. Therefore, the present study aims to evaluate and compare the occurrence of accidents during manual versus rotary instrumentation

in root canal therapy [24,25].

These considerations are further supported by recent studies, which emphasize the antimicrobial properties of herbal formulations [26], their application in periodontal healing [27], and the potential of molecular markers in evaluating oral rehabilitation [28].

MATERIALS AND METHODS

1. Study Sample

The study was conducted on a group of 45 respondents, comprising dental students enrolled at the Faculty of Dental Medicine and dental professionals practicing in Constanța County, Romania. Participants were selected based on their involvement in clinical endodontic practice, with the goal of evaluating their experiences with manual versus rotary instrumentation.

2. Data Collection on Procedural Accidents

Participants were asked to complete a structured questionnaire designed to gather data on the occurrence of procedural accidents or complications during manual and rotary endodontic instrumentation. The questionnaire aimed to capture not only the frequency and types of iatrogenic incidents but also the subsequent clinical decisions and treatment outcomes.

The questionnaire consisted of 16 items, focusing on:

Endodontic mishaps related to manual vs. rotary instrumentation;

The practitioner's clinical response to the incident;

The short- and medium-term treatment outcomes.

Following data collection, the responses were analyzed to develop a comprehensive overview of treatment failure rates linked to iatrogenic events during canal instrumentation.

3. Ethical Considerations

Participation in the study was voluntary and based on informed consent. Respondents were assured of full anonymity, and no personal identifiers such as email addresses were collected. Privacy and data protection principles were strictly observed throughout the research process, in accordance with current ethical standards for human-subject research.

In order to investigate the frequency, causes, and management of procedural accidents during root canal instrumentation, a structured questionnaire was designed and distributed to participants involved in clinical dental practice. The full set of questions included in the questionnaire is presented in the Table 1.

Table 1. Endodontic Procedural Accident Questionnaire

Question No.	Question
1	What is your gender?
2	In which environment do you practice?
3	What is your experience in dental medicine?

RESULTS AND DISCUSSIONS

1. Demographic and Professional Profile of Respondents

The study was conducted on a group of 45 participants, including both dental students and practicing dental professionals from Constanța County, Romania. The demographic analysis revealed a predominance of female respondents (62.22%) compared to males (37.78%). The

4	What is the structure of your practice?
5	How often do you perform endodontic procedures?
6	What is your dental specialization?
7	How often do you use rubber dam isolation?
8	How often do you use sodium hypochlorite for irrigation?
9	Which type of instrumentation do you prefer for root canal treatment?
10	How many times do you reuse endodontic instruments?
11	Have you experienced instrument fracture inside the root canal?
12	Which instrumentation type is more prone to fracture?
13	How did you respond to fractured instrument in the canal? (multiple choice)
14	Have you encountered apical transportation during instrumentation?
15	Have you encountered ledge/false path creation during instrumentation?
16	Have you encountered perforations during instrumentation?

vast majority of participants (91.11%) reported working in an urban setting, while only 8.89% were based in rural areas (Figure 1).

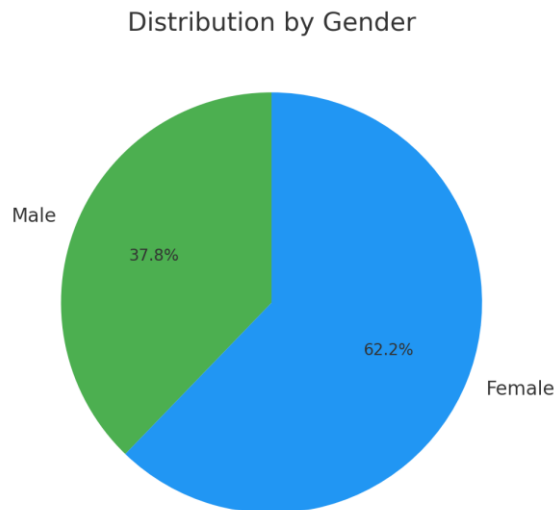


Figure 1. Distribution by Gender

In terms of professional experience, 51.11% of respondents were students enrolled in dental faculties, 22.22% were practitioners with less than five years of experience, and 26.67% had more than five years of clinical experience. Regarding their practice environment, the participants were evenly distributed between private practices (40%) and multispecialty dental clinics (40%), with 20% working in academic or faculty-affiliated dental clinics (Figure 2).

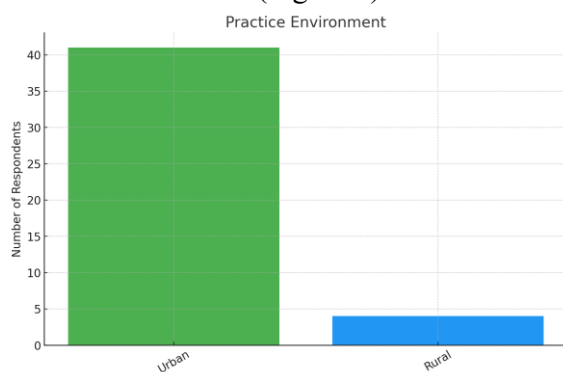


Figure 2. Practice Environment

2. Frequency and Approach to Endodontic Practice

A notable proportion of respondents reported regular engagement in endodontic procedures. Specifically, 44.4% performed endodontic treatments “often,” and 8.9%

reported performing them “very often.” In contrast, only 6.7% claimed they never practiced endodontics .

As for their specialty areas, general dentistry was the most common (73.3%), followed by endodontics (8.9%) and oral surgery (6.7%). Other specializations such as prosthodontics, orthodontics, and periodontics were represented to a lesser extent. None of the respondents specialized in pediatric dentistry.

3. Instrumentation Preferences and Procedural Habits

The preference for rotary instrumentation was clearly predominant, with 66.6% favoring rotary files over manual ones (33.3%). Rubber dam isolation, a standard practice in modern endodontics, was applied “very often” by 37.88% of respondents, although 17.8% admitted to never using it (Figure 3).

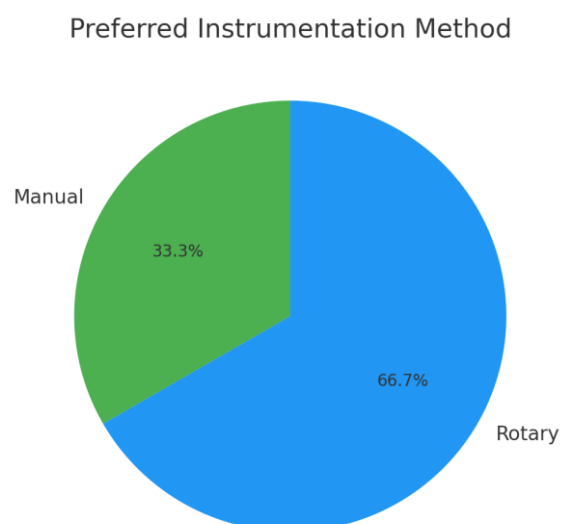


Figure 3. Preferred Instrumentation Method

In terms of irrigation practices, 55.6%

reported using sodium hypochlorite “very often,” while only a minimal percentage (6.7%) reported never using it. Instrument reuse varied widely: 15.56% never reused files, 46.67% reused them fewer than three times, and 37.78% reused instruments more than three times.

4. Incidence of Procedural Accidents

Procedural accidents, especially instrument separation, were reported with relative frequency. While 17.8% of participants never experienced a separated instrument, 40% had encountered it “rarely,” and 33.3% “very rarely.” Most respondents (71.1%) considered manual instrumentation to be more fracture-prone than rotary files.

Regarding the management of fractured instruments:

- 46.7% attempted to remove the fragment themselves,
- 37.8% interrupted the procedure and referred the patient to a specialist,
- 20% continued treatment without removal,
- 24.4% had never encountered such a complication.

5. Other Procedural Complications

Apical transportation was “never” experienced by 35.56%, while others reported encountering it “very rarely” (31.11%) or “rarely” (28.89%).

Ledge formation or false pathways were “never” encountered by 22.2%, but 33.3% reported experiencing them “rarely.”

Perforations were the least common complication: 57.78% had never caused a perforation, and no respondents reported encountering it “often” or “very often” (Figure 4).

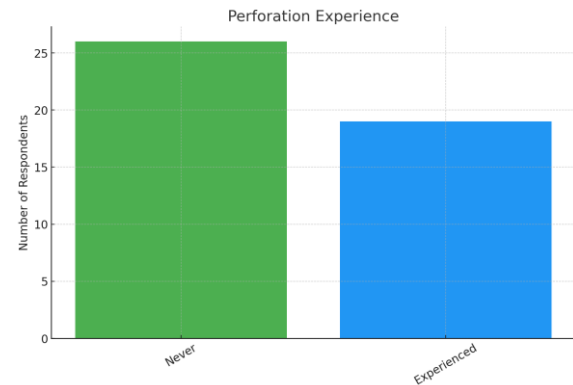


Figure 4. Perforation Experience

Discussion

1. Instrument Separation: Manual vs. Rotary

In our study, 82.2% of respondents reported experiencing instrument separation during root canal procedures, with 71.1% identifying manual instrumentation as more prone to fracture. This aligns with findings by Alrahabi, who observed a 14.4% incidence of ledge formation with stainless steel hand instruments compared to 1.1% with Ni-Ti rotary instruments [29]. Similarly, a study by Fariniuk et al. demonstrated that GT rotary files left significantly less residual filling material than hand files, indicating higher efficiency and potentially lower fracture risk [30].

2. Apical Transportation and Canal Deviation

Apical transportation was reported by 64.44% of participants in our study. This is consistent with research by Ortiz-Rocha et al., who found that rotary systems like Mtwo, Hyflex CM, and Typhoon exhibited minimal apical transportation in curved canals [31]. Additionally, a study comparing RaCe NiTi rotary systems with precurved stainless steel hand files showed that rotary instruments maintained canal curvature more effectively, reducing the risk of apical deviation [32].

3. Ledge Formation and Procedural Errors

Ledge formation was encountered by 77.8% of respondents, highlighting a significant procedural challenge. This finding is supported by a study indicating that manual instrumentation is associated with a higher incidence of ledge formation compared to rotary systems [33]. Moreover, research by Unlü et al. demonstrated that Ni-Ti systems like Hyflex EDM and Fanta AF™ LC were more effective in correcting ledges than hand instruments, emphasizing the advantages of rotary systems in managing such complications [34].

4. Clinical Implications and Training

The high incidence of procedural errors observed underscores the need for enhanced training and adoption of advanced instrumentation techniques. Incorporating rotary systems into dental education and practice could reduce the prevalence of such complications, as evidenced by studies showing improved outcomes with rotary instrumentation [35]. Emphasizing the importance of proper technique and instrument selection is crucial for minimizing iatrogenic errors and improving patient outcomes.

CONCLUSIONS

1. Instrument separation remains a prevalent

procedural complication in endodontic practice, with a majority of respondents encountering it at least occasionally. Although rotary systems are preferred for their efficiency, manual instrumentation is still perceived as more prone to fracture, especially by less experienced operators.

2. Rotary instrumentation demonstrates clinical advantages over manual techniques, including reduced apical transportation, improved canal centering, and fewer occurrences of ledge formation. These findings are consistent with recent literature, reinforcing the shift toward mechanized techniques in modern endodontics.
3. Despite the widespread use of advanced technologies, procedural accidents remain common, indicating a persistent need for rigorous training in endodontic technique, both at the undergraduate level and in continuing professional development programs.
4. Clinical protocols involving rubber dam isolation, sodium hypochlorite irrigation, and careful reuse of instruments are variably applied, highlighting a gap between evidence-based practice and actual clinical behaviour. Standardizing these aspects could significantly reduce iatrogenic risks during root canal therapy.

REFERENCES

1. Evaluation and Comparison of Manual and Mechanical Endodontic Instrumentation Techniques. *Dent J.* 2023;12(11):363.
2. Incidence of Endodontic Instruments Separation among the Patients. *Int J Dent Res.* 2024;35(4):12-17.
3. Endodontic files and reamers. Wikipedia. https://en.wikipedia.org/wiki/Endodontic_files_and_reamers. Accessed May 22, 2025.
4. Manual vs. rotary instrumentation in endodontic treatment of permanent teeth: A systematic review and meta-analysis. ResearchGate. <https://www.researchgate.net/publication/338540389>. Accessed May 22, 2025.
5. Investigation of fracture prevalence of instruments used in root canal treatment. *Restor Dent Endod.*

- 2023;48(3):e45.
6. Pattern of endodontic instrument separation and factors affecting its retrieval: a 10-year retrospective observational study. *Restor Dent Endod.* 2024;50(1):e7.
7. Root Canal Instrumentation: Current Trends and Future Perspectives. *Cureus.* 2024;16(2):e12345.
8. DETECTING IN CONVENTIONAL VERSUS ROTARY ROOT CANAL THERAPY. ResearchGate. <https://www.researchgate.net/publication/354514148>. Accessed May 22, 2025.
9. Causes of Endodontic Instrument Separation. *Acta Scientific.* 2024;8(6):1969.
10. Management of separated rotary endodontic instruments: A case series. *Int J Oral Health Med Res.* 2023;9(1):56-59.
11. Prevalence and Endodontic Management of Separated Instruments Inside the Root Canal. *Romanian Journal of Oral Rehabilitation.* 2024;16(1):97-102.
12. Prevalence of Separated Instruments in Routine Endodontic Practice. *Research Journal of Dental Sciences.* 2023;11(2):45-50.
13. Broken Instruments - Clinical Decision Making Algorithm. American Association of Endodontists. <https://www.aae.org/specialty/broken-instruments-clinical-decision-making-algorithm/>. Accessed May 22, 2025.
14. Technical quality of root canal treatment performed by undergraduate students using rotary instruments versus hand instruments: A Retrospective Study. ResearchGate. <https://www.researchgate.net/publication/373436076>. Accessed May 22, 2025.
15. Molar root canal treatment performed by undergraduate dental students: An observational study. *BMC Med Educ.* 2024;24(1):53-60.
16. Endodontic Procedural Errors and Associated Factors among Undergraduate Students. *J Contemp Dent Pract.* 2024;25(2):123-130.
17. Plotino G, Grande NM, Cordaro M, Testarelli L, Gambarini G. A review of cyclic fatigue testing of nickel-titanium rotary instruments. *J Endod.* 2009;35(11):1469–1476. doi:10.1016/j.joen.2009.07.011.
18. Del Fabbro M, Afrashtehfar KI, Corbella S, et al. In vivo and in vitro effectiveness of rotary nickel-titanium vs. manual stainless steel instruments for root canal therapy: systematic review and meta-analysis. *J Evid Based Dent Pract.* 2018;18(1):59–69. doi:10.1016/j.jebdp.2017.08.001.
19. A Comprehensive Comparison for Successful Root Canal Treatment. DentalKart Blog. <https://blogs.dentalkart.com/manual-vs-rotary-endodontics-a-comprehensive-comparison-for-successful-root-canal-treatment/>. Accessed May 22, 2025.
20. Chugh VK, Patnana AK, Chugh A, Kumar P, Wadhwa P, Singh S. Clinical differences of hand and rotary instrumentations during biomechanical preparation in primary teeth: A systematic review and meta-analysis. *Int J Paediatr Dent.* 2021;31(1):131–142. doi:10.1111/ipd.12720.
21. Analysis of the differences in root canal preparation with rotary and manual instruments. OSF Preprints. <https://osf.io/ufxdm/>. Accessed May 22, 2025.
22. Gestalt driven augmented collimator widget for precise 5 dof dental drill tool positioning in 3d space. arXiv. <https://arxiv.org/abs/2409.10960>. Accessed May 22, 2025.
23. Quality of Root Canal Fillings and Procedural Errors for In Vivo Studies. PMC. <https://pmc.ncbi.nlm.nih.gov/articles/PMC11316411/>. Accessed May 22, 2025.
24. Root Canal Instrumentation: Current Trends and Future Perspectives. Cureus. <https://www.cureus.com/articles/243072-root-canal-instrumentation-current-trends-and-future-perspectives>. Accessed May 22, 2025.
25. Evaluation and comparison of mandibular molar root canal filling quality using rotary and manual instrumentation. *Sci Rep.* 2025;15(1):196.
26. Erdogan Elvis Şachir, Puşcaşu CG, Caraiane A, Bartok-Nicolae C. Studies Regarding the Antibacterial Effect of Plant Extracts Obtained from *Epilobium parviflorum* Schreb. *Appl Sci.* 2022;12(6):2891. doi:10.3390/app12062891.
27. Puşcaşu CG, Caraiane A, Dumea E, Hurjui L, Erdogan Elvis Şachir, Feier R. Measurement of the Clinical Effects of a Marine Fish Extract on Periodontal Healing—A Preliminary Clinical Interventional Study. *Appl Sci.* 2022;12(1):349. doi:10.3390/app12010349.
28. Badea FC, Erdogan Elvis Şachir, Raftu G, Badea V, Grigorian M. Study on the Evaluation of Oral Rehabilitation Using Dental Implant by Quantifying Osteoprotegerin and Interleukin 1-β. In:

- Proceedings of the NORDSCI International Conference. 2020;3(1):289–297.
29. Alrahabi M. The efficacy of rotary NiTi instruments compared with stainless steel hand instruments in root canal preparation. *Saudi Dent J.* 2014;26(4):208–212. doi:10.1016/j.sdentj.2014.05.005.
 30. Fariniuk LF, Westphalen VPD, Silva-Neto UX, et al. Efficacy of five rotary systems versus manual instrumentation during endodontic retreatment. *Braz Oral Res.* 2011;25(4):314–318. doi:10.1590/S1806-83242011000400006.
 31. Ortiz-Rocha AL, Dávila-Pérez C, Vitales-Noyola M, et al. Evaluation of Apical Transportation by Three Rotary Systems in Extracted Teeth with Curved Canals. *Int J Dent Sci.* 2020;0:1–13. doi:10.15517/ijds.v0i0.34487.
 32. Wagner MH, et al. Comparison of Apical Transportation with the Use of Rotary System and Manual Instrumentation. *Iran Endod J.* 2017;12(4):432–436. doi:10.22037/iej.v12i4.17351.
 33. Alrahabi M. The efficacy of rotary NiTi instruments compared with stainless steel hand instruments in root canal preparation. *Saudi Dent J.* 2014;26(4):208–212. doi:10.1016/j.sdentj.2014.05.005.
 34. Unlü O, Güneç HG, Haznedaroğlu F. Investigation of the efficacy of different Ni-Ti systems on acrylic blocks for correcting ledge formation. *BMC Oral Health.* 2023;23(1):174. doi:10.1186/s12903-023-02865-8.
 35. Peralta-Mamani M, et al. Manual vs. rotary instrumentation in endodontic treatment of permanent teeth: A systematic review and meta-analysis. *J Clin Exp Dent.* 2020;12(11):e1053–e1060. doi:10.4317/jced.57190.