ORIGINAL ARTICLE

Comparative Analysis of Endodontic Instrument Separation, Secondary Errors and Retrieval Techniques in Private and Public Dental Hospitals

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ABSTRACT

Background: Endodontic instrument separation and secondary procedural errors pose significant challenges in dental clinics. The study aimed to assess and compare the frequency of endodontic instrument separation, retrieval techniques, and secondary procedural errors during retrieval in private and public dental hospitals in Punjab, Pakistan.

Methods: This cross-sectional study was conducted between June 2021 and Sept 2022 after the IRB approval of CMH Dental College, involving 298 dentists from 4 private and 2 public dental hospitals, using purposive sampling. The inclusion criteria were house officers, postgraduate trainees, demonstrators, assistant professors and above working in the endodontic clinics. A self-administered questionnaire was distributed to gather data on demographics, file separation experience, management techniques, and errors during retrieval. Data was analyzed using SPSS and compared using Chi-square test. p-values ≤ 0.05 were considered significant.

Results: A total of 69% (n=206) of respondents experienced file separation with no significant difference between private and public hospitals (p=0.475). Private hospitals reported more retrieval attempts (n=88, 53%) compared to public (n=46, 35%) (p=0.002). Instrument Retrieval Systems were more available in private hospitals (p<0.0001). Secondary procedural errors were reported by 47.6% (n=142) of the participants, with no difference between two sectors (p=0.498). Perforation was more common in public hospitals (p=0.032), and secondary file separation was more frequent in private hospitals (p = 0.007). The management strategies varied significantly (p = 0.001).

Conclusion: File separation and secondary procedural error are common challenge across both sectors, with private hospitals exhibiting more proactive retrieval attempts and utilizing more advanced techniques.

Keywords: Endodontic Procedures, File Retrieval Techniques, Instrument Separation, Pakistan, Root Canal Treatment.

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INTRODUCTION

Endodontics is a specialized branch of dentistry that primarily focuses on the diagnosis, prevention, and treatment of diseases affecting the dental pulp and surrounding tissues[1]. Root canal therapy, a common procedure in endodontics, involves the careful cleaning, shaping, and filling of the root canals to save a tooth that might otherwise need extraction[2]. Endodontic procedures require the use of various instruments, including files, reamers, and rotary instruments, to achieve optimal results. However, despite the advancements in dental technology and instrumentation, instrument separation remains a challenging and prevalent issue in endodontic practice[3].

Instrument separation refers to the unintentional fracture or breakage of endodontic instruments during root canal treatment. This complication can occur at any stage of the procedure and poses significant clinical and economic consequences for both patients and practitioners[2]. The management of instrument separation demands skill, experience, and access to appropriate resources, including specialized retrieval tools and techniques[4]. The management of instrument separation is crucial to ensure the success of endodontic treatments[5]. In Punjab, Pakistan, both private and public dental hospitals play a critical role in providing endodontic care[2].

Endodontic instrument separation involves the breakage of endodontic files, typically made of stainless steel or nickel-titanium (NiTi), during root canal procedures[6]. Studies have reported varying prevalence rates of instrument separation, with NiTi instruments being more prone to breakage due to their greater flexibility and cyclic fatigue[7,8,9]. Common causes include excessive torque, inadequate lubrication, curved canals, and instrument design flaws[3].

Advanced endodontic file retrieval systems have evolved to address the challenges associated with retrieving broken or separated endodontic instruments from root canals. These systems incorporate innovative techniques and technologies to enhance the success rates of file retrieval procedures, reduce patient discomfort, and improve overall treatment outcomes[10,11]. These advanced systems and innovations include ultrasonic file retrieval, electrochemical file retrieval, microscope-assisted retrieval, CBCT-guided retrieval, and customized retrieval tools, such as advanced NiTi rotary systems, laser-assisted retrieval, and chemomechanical solutions[12,13,14].

Private dental hospitals often have access to advanced technology and materials, enabling them to employ a wide range of management strategies like ultrasonic retrieval, microscope-assisted retrieval, and advanced NiTi systems[1,2]. Public dental hospitals in Pakistan, especially in Punjab, face resource constraints, impacting their ability to adopt advanced techniques. Management strategies in public hospitals mostly include traditional hand files and surgical approaches[3].

Despite the availability of various management strategies, challenges persist in both private and public dental hospitals in Punjab. These challenges include limited training and expertise, financial constraints, and access to technology and materials. The study aimed to assess and compare the frequency of endodontic instrument separation, retrieval techniques, and secondary procedural errors during retrieval in private and public dental hospitals in Punjab, Pakistan.

METHODS

This cross-sectional survey was conducted after the approval of the ethical review board of the Institute of Dentistry, Combined Military Hospital Lahore Medical College (Case No: 649/ERC/CMH-LMC) from 21st June 2021 to 29th September 2022. Moreover, this is a follow-up secondary study that not only provides the in-depth comparisons of the private and public sectors, but also the secondary procedural errors and retrieval techniques, which have not been previously investigated. This study used more recent data and includes a larger, more diverse sample. The inclusion criteria were dental house officers, postgraduate trainees, demonstrators, assistant professors, and above faculty members working in the endodontic clinics of four private and two public dental hospitals in Punjab, Pakistan. The exclusion criteria were dental professionals not working in the endodontic department, final year students, and those who did not complete the survey or refused to be the part in the study. The private colleges included the Institute

of Dentistry, CMH Lahore Medical College, University College of Medicine and Dentistry, Azra Naheed Dental College, and Lahore Medical and Dental College, while the public dental hospitals were de' Montmorency College of Dentistry and University Medical and Dental College, Faisalabad.

The non-probability purposive sampling technique was employed, and a minimum sample size of 232 participants was calculated using a 90% confidence interval, 5% level of significance, and an anticipated frequency of instrument separation of 69%[3]. The sample size was raised to 350 to ensure better participation.

The data was collected using a self-administered questionnaire developed by the authors after a literature review. The questionnaire was developed using Google Forms (Google Inc.), and a weblink was generated, and forms were distributed via hospital WhatsApp groups through their administrators. The questionnaire consisted of 16 closed-ended questions and was divided into two sections. The consent and confidentiality statement were mentioned in the questionnaire. The first section targeted demographics, while the second part included questions regarding the experience of file separation, its management, and errors experienced during the management of the separated instrument. The initial draft of the questionnaire was reviewed by two research experts to assess the face and content validity, and required changes were made. Later, it was pilot tested on 30 subjects to identify the appropriateness of the questions, and slight modifications were made. The reliability analysis was performed on the responses collected during the pilot study using Cronbach's alpha analysis, which was found to be 0.72, falling within the acceptable limits.

The data was entered and analyzed using the Statistical Package for Social Sciences software for Windows (SPSS, version 24, IBM Corporation). Descriptive statistics were used to exhibit frequencies and percentages. The Chi-square test was used to compare the frequencies of categorical variables, and a p-value of less than or equal to 0.05 was taken as significant.

RESULTS

Table 1: Demographic details of the Participants

Demographics		n	%
Gender	Male	118	39.6
	Female	180	60.4
Institute	Private	166	55.7
	Public	132	44.3
Designation	House Officer	92	30.9
	Post Graduate Trainee	94	31.5
	Demonstrator	54	18.1
	Assistant Professor and above	58	19.5
Years of Experience	Less than 2 years	110	36.9
	2 to 5 years	112	37.6
	More than 5 years	76	25.5

A total of 350 people were approached, out of whom 298 responded. The response rate was 85.1%. The mean age of the respondents was 28.2±5.6 years. The demographic details of the participants are tabulated in **Table 1.**

File separation was a common occurrence among the respondents, with 69% reporting experiencing it during endodontic procedures. There was no significant difference in the experience of file separation between private and public institutions.

The most common cause of instrument fracture was older, fatigued files (57.7%) and excessive pressure/improper motion (19.5%) of files **Figure 1.**

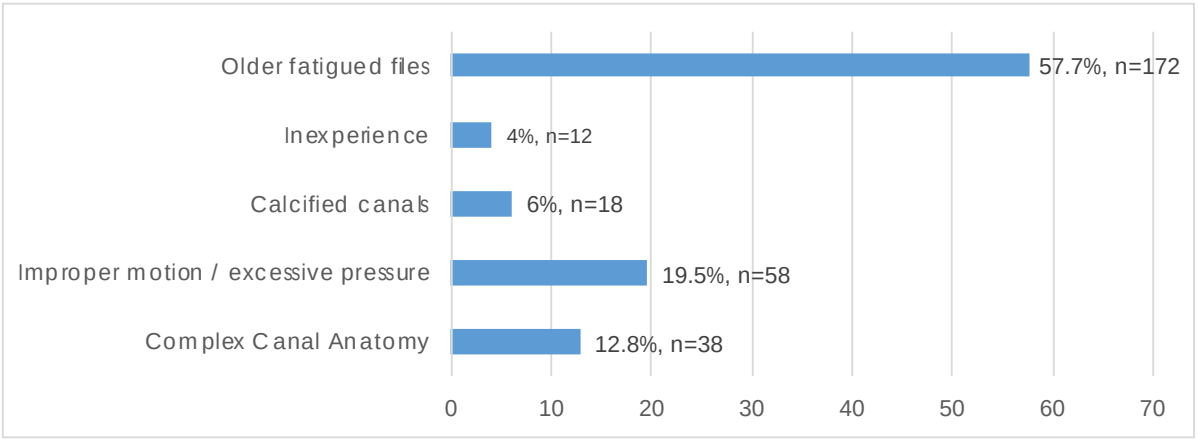

Figure 1: The Frequency of Causes of File Separation During Endodontic Treatment

A significant difference was observed in the type of endodontic files that broke during procedures, with manual files breaking more frequently in public hospitals and rotary files in private ($X^2 = 16.24$, $p = 0.001$). However, no significant difference was found in the manufacturing type of the broken files ($X^2 = 1.15$, $p = 0.178$), **Figure 2.**

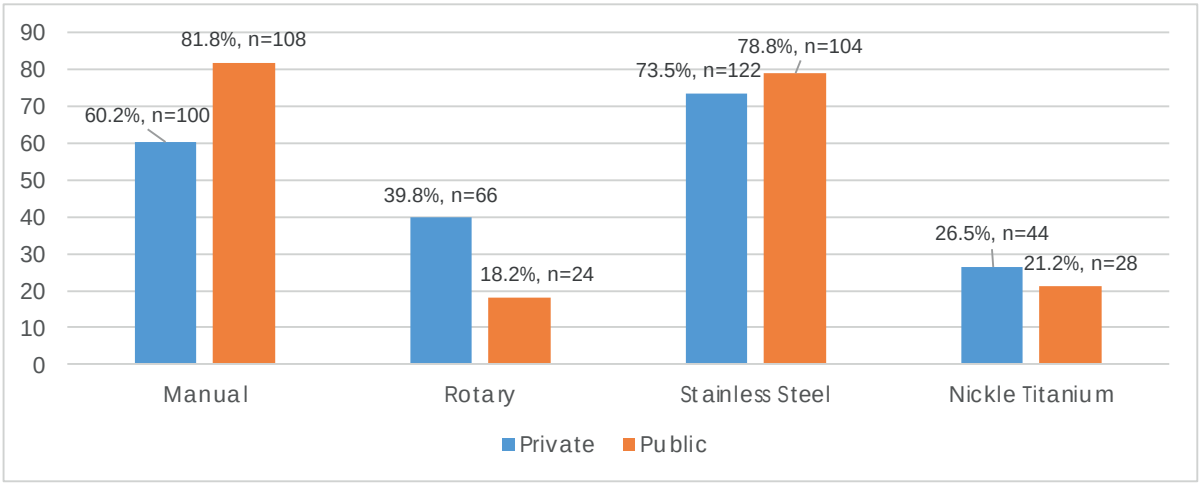

Figure 2: The Comparison of The Frequency of Type of Instrument Fracture Between Private and Public Dental Hospitals

Table 2: Comparison of File Separation and Retrieval Practices between Private and Public Dental Hospitals

Variables	n(%)	Private n(%)	Public n(%)	X^2	p
Experienced File Separation	206(69.1)	114(68.6)	92(69.6)	0.036	0.475
Bypass Attempt of the Broken Instrument	202(67.7)	112(68.0)	92(75.0)	1.733	0.188
Retrieval Attempt of Broken File	134(44.9)	88(53.0)	46(35.0)	9.803	0.002
Presence of an IR System in the Department	142(47.6)	92(55.4)	50(37.8)	18.206	0.000
Secondary Procedural Error During Retrieval	142(47.6)	82(49.0)	60(45.0)	0.458	0.498

p-values were obtained using the Chi-square test

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Most participants reported attempting to bypass the broken instrument (67.7%), the retrieval attempts were significantly more common in private hospitals (53%) than in public hospitals (35%) (p=0.002). A significant difference was found in the availability of Instrument Retrieval Systems, with 55.4% of private hospital departments having access to these systems compared to only 37.8% in public hospitals. Despite these differences in technology, secondary procedural errors during retrieval occurred in 47.6% of the cases, with no significant difference between the private (49%) and public (45%) hospitals (p=0.498) **Table 2.**

Table 3: Techniques Used for File Retrieval in Private and Public Dental Hospitals

Technique Used for Retrieval	n(%)	Private n(%)	Public n(%)	X^2	p
Ultrasonics	92(30.8)	58(35.0)	34(26.0)	9.406	0.024
Instrument Retrieval Kit	12(4.0)	8(4.8)	4(3.0)		
Wire-loop Technique	38(12.7)	26(15.6)	12(9.0)		
Other	156(52.3)	74(44.5)	82(62.1)		

p-value was obtained using the Chi-square test

There was a significant difference between the private and public institutes regarding the technique used for the retrieval of the broken instrument. (p=0.024) The use of ultrasonic devices for retrieval was more common in private hospitals, **Table 3.**

Table 4: Types of Secondary Procedural Errors during File Retrieval in Private and Public Dental Hospitals

Type of Secondary Procedural Error During Retrieval	n(%)	Private n(%)	Public n(%)	X^2	p
Over-enlargement of canal	80(26.8)	44(27)	36(27)	0.022	0.882
Ledge formation	144(48.3)	80(48)	64(49)	0.003	0.960
Apical transportation	34(11.4)	16(10)	18(14)	1.163	0.281
Perforation	52(17.4)	22(13)	30(23)	4.582	0.032
Secondary file separation	72(24.1)	50(30)	22(17)	7.264	0.007
Root Fracture	8(2.6)	0(0)	8(6)	10.338	0.001

p-values were obtained using the Chi-square test

Secondary procedural errors during retrieval included ledge formation, over-enlargement of the canal, apical transportation, perforation, and secondary file separation. Perforation was more common in public hospitals (p=0.032). Secondary file separation was more prevalent in private hospitals (30%) than in public hospitals (17%) (p=0.007). Root fractures were only reported by participants in public hospitals, with no instances found in private hospitals (p=0.001) **Table 4.**

Table 5: Management of Secondary Procedural Errors in Private and Public Dental Hospitals

Management of Secondary Procedural Error	n(%)	Private n(%)	Public n(%)	X^2	p
Repair the error and continue retrieval	82(27.5)	36(22)	46(35)	22.609	0.001
Repair the error, stop retrieval, and refer	46(15.4)	18(10.8)	28(21.2)		
Refer to Senior Endodontist	120(40.2)	72(43.3)	48(36.3)		
Refer to Surgery Department	50(16.7)	40(24)	10(7.5)		

p-value was obtained using the Chi-square test

Management of secondary procedural errors also differed between institutions (p=0.001). Both private and public hospitals referred cases to senior endodontists; public hospitals were more likely to repair the error, stop retrieval, and refer (21.2%), whereas private hospitals had a higher rate of referral to surgery departments (24%),**Table 5.**

DISCUSSION

The present study aimed to explore the prevalence and endodontic instrument separation, the occurrence of secondary procedural errors, and the retrieval techniques employed in private and public dental hospitals. There is a significant disparity between private and public dental institutions in Pakistan, with private institutes and hospitals benefiting from better resources, superior equipment, and greater funding[1,2]. In contrast, the public sector is underfunded, equipped with fewer resources, and faces a higher patient burden in both medical and dental services. This disparity may impact the management of procedural errors, such as instrument separation in private and public sector dental hospitals.

File separation is a common occurrence in both private and public dental hospitals. In the current study, 69% of the respondents reportedly experienced file separation during endodontic procedures. Previous studies have reported a similar prevalence of instrument separation, citing rates of 50% to 75%[3,15,16]. The occurrence of file separation was not significantly different between private and public institutions, suggesting that file separation remains a frequent issue regardless of institution. This finding aligns with previous literature, which reported that advanced technologies may reduce some procedural risks, but the issue of file separation remains consistent across different hospital settings[2,17]. In the current study, the retrieval attempts were significantly more common in private hospitals compared to public hospitals, which might reflect a greater reliance on advanced retrieval systems and techniques in private institutions, which have better resources and funding. This is consistent with findings of the previous studies, which highlighted those private institutions often have better access to advanced endodontic equipment, which may encourage more proactive retrieval attempts[2,18].

A significant difference was observed in the availability of Instrument Retrieval (IR) systems, with more availability in private hospitals compared to public hospitals, which may be due to the technological gap between the two sectors, with private institutions more likely to have better resources and funding. According to previous studies, access to advanced technologies like IR systems has been shown to improve the success rates of instrument retrieval and reduce the occurrence of secondary procedural errors[2,19]. The differences observed in this study may therefore have implications for the management and outcomes of endodontic procedures, suggesting that greater access to technology in private hospitals may enhance the efficiency of instrument retrieval[3].

A significant difference was found regarding the type of endodontic files that broke, with manual files breaking more frequently in public hospitals and rotary files in private hospitals. This finding was inconsistent with the findings of the previous studies reporting a higher frequency of breakage in rotary files[15,20]. This difference in file breakage may reflect not only the choice of instruments but also the varying levels of training and experience between the institutions[1]. It is possible that private hospitals, with more experienced staff and access to better-quality instruments, are less likely to experience breakage of rotary files, which are generally considered more flexible and durable than manual files[3, 21]. This finding suggests that both the choice of file type and the training of clinicians play significant roles in minimizing the risk of file separation.

The occurrence of secondary procedural errors during retrieval was reported in 47.6% of cases in this study, with no significant difference between private and public hospitals. This finding is consistent with the literature that suggests procedural errors such as ledge formation, perforation, and canal over-enlargement are common in endodontic treatments[1,3,22]. Although no significant difference was found between the hospital types, it is important to note that certain specific errors were more common in different settings like perforations were more common in public hospitals compared to private hospitals, which may reflect differences in training, experience, and resources[2,23]. Public hospitals may face higher patient load and more complex cases, which could increase the likelihood of such errors[1,3].

There was a significant difference in the techniques used for retrieval between private and public hospitals, with ultrasonic devices being more commonly employed in private hospitals as they are better equipped and funded. The use of ultrasonic devices for retrieval is known to be more effective in loosening and removing separated instruments[24].

The management of secondary procedural errors was another area where significant differences between private and public hospitals were reported in this study. Public hospitals were more likely to repair the error and stop retrieval, while private hospitals had a higher rate of referral to surgery departments. This finding aligns with previous research in Pakistan, which reported that referrals to senior endodontists and surgery departments are more common in cases with complex procedural errors[1,2,25]. The preference for referral in private hospitals may be due to better access to resources and trained staff, allowing for more comprehensive management of complicated cases. The differing management strategies between hospital types also reflect the importance of institutional resources in

determining treatment approaches and outcomes. The cross-sectional design is one of the limitations of the study; moreover, the study relied on self-reported data and a purposive sampling technique. The sample size was sufficient but was drawn from a limited number of private and public dental hospitals in Punjab, limiting the generalizability of the findings. Future research exploring longitudinal studies with a larger sample size and a wide range of institutions is recommended to better understand the outcomes of different retrieval techniques at various settings. Enhancing training programs for clinicians in public hospitals and improving access to advanced endodontic technologies could help reduce procedural errors and improve outcomes.

CONCLUSION

File separation was a common challenge across both sectors, with private hospitals exhibiting more proactive retrieval attempts and utilizing more advanced techniques. The occurrence of secondary procedural errors was similar between the two sectors, but management strategies differed, with private hospitals showing a greater tendency to refer complex cases to surgery departments and senior endodontists. Improving the funding and as well as training in public hospitals could help reduce procedural errors and enhance treatment outcomes.

LIST OF ABBREVIATIONS

NiTi: Nickel-Titanium
CBCT: Cone Beam Computed Tomography
IR System: Instrument Retrieval System

FUNDING

None

CONFLICT OF INTEREST

None

ETHICAL APPROVAL

Ethical approval was obtained from the institutional ethics review committee of Combined Military Hospital Lahore Medical College under reference number (Ref #: 649/ERC/CMH-LMC).

AUTHORS' CONTRIBUTIONS

H.H. and M.A. led the study's conception, design, data analysis, investigation, and manuscript drafting, with **H.H.** also providing statistical expertise. **M.S.** contributed to study design, manuscript drafting, and critical revision. **K.I.** handled data collection, analysis, and interpretation. **M.Ha. and M.Ha.s** conducted literature searches, critically revised the manuscript, and contributed to drafting and data interpretation.

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