



Analyzing the Effectiveness of Different Methods for Instrument Retrieval: A Comprehensive Systematic Review

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KEYWORDS

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ABSTRACT:

Introduction: The rate of success of retrieval of instruments that have been fractured differs because it depends upon several variables, such as the visibility of the broken instrument, the size of the broken instrument relative to the canal's curvature, and the methods used in every instance. The separation of endodontic instruments in the intracanal area can hinder shaping and cleaning processes in the canal and could negatively affect the procedure results. This descriptive analysis of distinct instruments set out to (1) look over the research concerning treatment options, influences aspects, and complications. (2) propose the best method for the management of these instruments..

Methods: Research was conducted through peer-reviewed journals in PubMed, Lialac, Ebsco, ProQuest, open gray, and J gate to locate experiments and clinical studies and reviews, by utilizing the key phrases Instruments, Files obstructions, fractured or broken instruments, separation removal, retrieval treatment, bypassing, as well as problems with or without the endodontic canal or root canal.

Results: The results show an absence of evidence at a higher level about properly managing separate instruments. The conventional conservative treatment includes eliminating or avoiding the fracture or filling the root canal system to an extent that is coronal to the fragment. The surgical procedure is an option. This is influenced by several aspects and could be linked with issues. Based on recent clinical research an approach to decision-making for treatment is recommended.

Conclusions: This comprehensive review provides insights from laboratory studies that examine the correlation between the curvature of root canals and the specific location where instrument fractures occur, offering valuable insights into their impact on overall treatment success. Significantly, the ultrasonic approach demonstrated the most favorable outcomes. It underscores the importance of anchoring clinical practice in rigorously conducted clinical trials

1. Introduction

Separation of the instrument in the root canal is unavoidable and can delay the procedure and alter the results. 1 Although this issue has been an ongoing issue for endodontics, the advent of the nickel-titanium (NiTi) file marked an important technological advancement in the area. But, the frequency of file fractures within the root canals has become a major problem for dentists. 2,3 It has been found that the stainless steel (SS) instruments' separation rates range

from 0.25 to 6.6%.4, 5, 6, 7. It has been discovered that the separation rate of NiTi instruments with rotating functions ranges from 1.3% to 10.0%.5,6

Although it is obvious that a variety of factors, such as flexural failure, cyclic torsional fatigue, or a combination that can cause the instrument to fracture, influence the process of separation, the precise mechanism of separation is still not entirely understood. 8. The instrument's design, the quality of the files it contains, the fabrication process, the dynamics of its use, the number



of times it has been used, the instrument's cleaning and sterilization are all factors that can lead to instrument separation. Furthermore, during endodontic canal retreatment, fractures occur far more frequently.^{9,10}

The removal of fractured endodontics files from the root canal is crucial in order to guarantee the effectiveness of treatment, avoid complications and infections, reduce the discomfort of patients, and enhance the overall outcomes of the treatment. Removing broken instruments from the root canal the majority of cases is challenging and sometimes ineffective.¹⁰ There is no standard procedure for instrument removal is in place. Numerous techniques and tools have been suggested for instrument retrieval.⁹ Certain practitioners have employed chairs side methods to retrieve broken instruments, such as the loop technique, braided technique and hypodermic needle technique. miniature forceps and glue techniques.¹¹

With the difficulty of retrieving fractured files from the root canal and the importance of maximizing the treatment for root canals Researchers have taken on the challenge of evaluating new techniques and methods for successful removal of instruments. The forthcoming systematic review is designed to review the existing research and highlight new developments in the treatment of the issue of damaged files in root canals.

2. Methods

A comprehensive review protocol was developed and an outline of the PRISMA checklist [Downs & Black (2008)] used in the process of planning and conducting the study. The link to the international open scientific framework registry is <https://doi.org/10.17605/OSF.IO/FBACN>.

Focused question: Does the instrument retrieval technique helps in retrieving broken instrument in all cases where the file is fractured in apical, middle, and coronal third?

The PICO outline was as follows. – Population: human teeth with separated instrument - Intervention: instrument retrieval - Comparisons: human teeth with separated instrument where a treatment with a different instrument retrieval techniques, or a different treatment approach was used. - Outcomes: accuracy, iatrogenic errors, time taken, advantages and limitation

Eligibility criteria:

The following were the requirements for inclusion: The criteria for inclusion were satisfied by in vitro studies that used techniques for handling broken tools in the apical, middle, or coronal third of the root canals of permanent human teeth.

The exclusion criteria were as follows: retreatment, research reviews and case reports, clinical studies cases, series of case studies, conference journals, editorials, and pilot studies were not included, nor were studies that offered treatment strategies for fractured instruments inside the root canal, research that assessed surgical techniques to remove fractured instruments, studies that investigated apicectomy

Literature search:

The searches were performed using these databases: PubMed, LILACS, and Ebsco, as well as Open Grey, ProQuest, and J gate. To locate other potentially pertinent publications, hand searches of the reference lists of the articles submitted for full-text analysis were also conducted. From August 2009 to August of 2023, searches were carried out for appropriate articles using combinations of the following search terms: (ENDODONTIC TREATMENT) OR (ROOT CANAL TREATMENT) AND (INSTRUMENT SEPARATION) OR (BROKEN FILE) AND (FILE REMOVAL)) OR (FILE RETRIEVAL)

Data extraction:

The details that were gleaned from the research studies in this study: the authors, dates of publication, study designs the country, sample size intervention, the method used to treat broken instruments within the root canals, as well as the results of the technique used. The authors were reached via email to supply additional information for articles that contained insufficient information.

Synthesis of data

The results were classified by the technique used in retrieving a broken instrument. Results were compared and the outcomes were presented by examining the thirds and tooth groups of the root

RISK OF BIAS :

Two reviewers (JP and PR) assessed the bias risk independently. The risk of bias in in-vitro experiments could not be evaluated using a standardized approach.



Customized tools have been utilized in earlier investigations. A unique tool that was modified from another investigation was also used in the current study. (AlShwaimi et al., 2016) The following parameters were assessed and graded for calculating the risk of bias:

- study design and methodology
- Description of sample size calculation
- definition of success
- intervention methods
- Blinding of outcome assessor.

The possibility for bias in the research was evaluated independently by two reviewers. Among other things, we examined the abstract, introduction, methods, results, and discussion of the paper. Every criteria that was accurately satisfied received a "yes," whereas those that weren't satisfied enough received a "no."

Results

The search resulted in a total of 1329 records, of which 411 duplicates were removed (Figure 1).

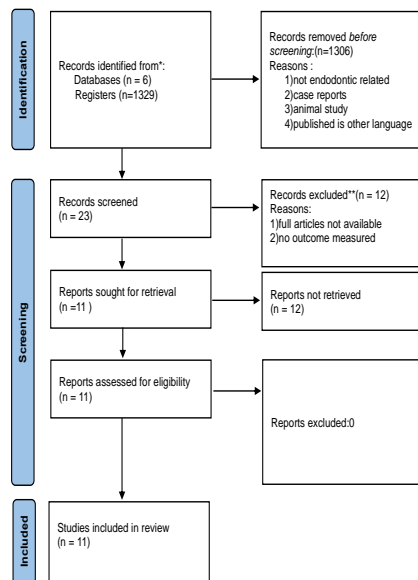


FIGURE 1: PRISMA FLOWCHART

After the assessment of titles and abstracts, 23 records were selected for full-text evaluation, of which 11 records for systematic reviews were selected for inclusion (Table 1)

TABLE 1 : RESULTS

Author	Sample size and tooth	Separation Fragment	Intervention	Time (median)	Definition of success	Success rate
Shahbainejad H et al (2013) ¹⁷	N=70 Maxillary premolars	#30/ O4 taper Metro file	ultrasonic	36.3 ± 7.15 minutes	Retrieval	Overall success rate =80%
Cuñil B. et al (2014) ¹⁸	N=33 mandibular central and lateral incisors and premolars	Stainless steel files	no VAG laser-mediated connecting of a brass tube to a fractured endodontic retractor	N/A	RETRIEVAL	OVERALL:77.3%
Aboud LR et al (2014) ¹⁹	EX-VIVO	K3, ProTaper and MTwo-RTI endodontic rotary instruments	intracanal fragment ablation and bypass	N/A	bypass	N/A
Cheung GS et al (2015) ²⁰	N=36 maxillary first molars	#40, #50/OK Sim-ling segment in apical third	Ultrasonic tips	N/A	Retrieval	N/A
Genik et al (2015) ²¹	N=39 Mandibular incisors	Size 30 K file	Ultrasonic and Maxon mm KJ,	N/A	Retrieval	N/A
Wahlgrenmuth et al (2015) ²²	N=36 Human molars	#10K, #15K, #20 K file	OvertrixWave System	10.4 min	Retrieval	Apical: 61.32% Middle: 83.33% Overall: 72%
Adri et al (2017) ²³	N=60 Mandibular 1 st molar	#30/ O4 taper	bypass	2.8 min	bypass	Overall success 83.3%

Yong Q. et al (2017) ²⁴	N= 21 mandibular molars	K3 25/06%	Ultrasonics and trephine bur	Trephine group (n=9) 3.5 min ultrasonic group (n=12) 11.9 min	Retrieval	Overall success 300%
Fu M et al (2019) ²⁵	N=18 Mandibular incisors	K files were fractured in the middle third of canals	ultrasonic	N/A	Retrieval	N/A
Meng et al (2020) ²⁶	N=34 Mandibular incisors	5 mm apical 25.06% K3 rotary file	Trepan bur/ministubule technique	8.55 ± 5.83 min	Retrieval	Overall success rate 76.47%
Pruthi P et al (2020) ²⁷	N= 80 Mandibular molars	ProTaper F3 in the middle third and coronal third	Comparing Terauchi file retrieval kits (TRFK) with ProUltra ultrasonic tips	TRFK took a shorter average time than ultrasonic tips.	Retrieval	90% for the ultrasonics group and 55% for the TRFK group overall success

TABLE LEGENDS: #= NUMBERS

The entire assessment produced one study with a high risk of bias, four papers with a medium risk, and six studies with a low risk of bias after taking the criteria for risk of bias into consideration. The study's participant count was found to be the domain with the highest risk of bias, while the safety and effectiveness of the methods used to remove fragments from endodontic instruments was found to be the area with a medium risk of bias.(Table 2)

TABLE 2 RISK OF BIAS

Study	Sample Size	Study Design & Methodology	Definition of Success	Intervention Methods	Publication Bias	OVERALL RISK OF BIAS
Shahbainejad H et al (2013)	✓	✓	✓	✓	✓	LOW
Cuñil B et al (2014)	✓	✓	✓	✗	✓	MEDIUM
Aboud LR et al (2014)	✗	✗	✓	✓	✓	HIGH
Cheung GS et al (2015)	✓	✓	✓	✓	✓	LOW
Genik et al (2015)	✓	✗	✓	✓	✓	MEDIUM
Wahlgrenmuth et al (2015)	✓	✓	✓	✓	✓	LOW
Adri et al (2017)	✓	✓	✗	✓	✓	MEDIUM
Yong Q. et al (2017)	✓	✓	✓	✓	✓	LOW
Fu M et al (2019)	✓	✓	✓	✓	✗	MEDIUM
Meng et al (2020)	✓	✓	✓	✓	✓	LOW
Pruthi P et al (2020)	✓	✓	✓	✓	✓	LOW

Entry criteria that was accurately satisfied received a "yes," whereas those that weren't satisfied enough received a "no."

✓ = YES, ✗ = NO



Discussion

Instrument fractures are a major issue in endodontic treatment because they restrict an apex's access hindering an efficient cleaning, shaping, and sealing of the root canals. This issue can cause frustration for both the dentist as well the patient. Several factors need to be considered before trying to remove the broken instrument. Chances of success must be weighed against the potential for difficulties. There is no standard process for removing instruments that have fractures.

The method that garnered the most attention in this review was ultrasonic technology, which proved an extremely high proportion of efficacy. Due to its widespread application in daily clinical practice throughout a range of surgical procedures and specific areas, this technique has an excellent ratio of advantages compared to the cost. The average success rate for instrument retrieval using ultrasonic techniques is around 90 % 12,15,16,19,20,22. The efficacy and safety of using ultrasonic for the removal of files have been widely acknowledged in prior research. But, given the necessity for dentin removal, the technique raises the chance of root fracture.

Ultrasonic approaches outperform the microtube instrument (iRS) 21. The overall success rate for instrument retrieval using the Microtube instrument retrieval technique is 76.47% When compared with the Masserann kit, as well as hand files used for removal or bypass, the ultrasonic method has a higher success rate when it came to removing broken instruments from straight and curving canals 24. Furthermore, more force was needed to fracture the roots 16 when comparing teeth treated with the Masserann kit vs teeth treated with ultrasonic technology. Additionally, in curved canals there are restrictions on the use of ultrasonic tips and the Masserann kit 26, 27, 28. The volume of the root canal dentin and the average canal diameter were larger after the removal of ultrasonic technology as compared to the micro-retrieval and restoration method using ultrasonic. Furthermore, the ultrasonic removal method required 25 minutes, whereas the micro-retrieve repair method just required 9 minutes.

Despite having a shorter mean operating time, the bypass approach's overall success rate was identical to that of the ultrasonic procedure 18. This study showed that using the bypass technique to remove fragments was extremely

effective, however in one clinical study just 37.5 percent of broken files could be bypassed successfully 29. Another clinical research in the field of dentistry discovered that bypassing or recovering the fracture was effective in 53% of the cases. The rate of success is influenced by the tooth type as well as the location of the broken instrument in the canal, the amount of curvature and size of the piece, as well as the kind of broken instruments 30. The study's structure may have influenced the extremely high success rate for bypass during this research.

A method called the Gentle Wave System has less success around 72 % as compared to the ultrasonic method of removal of broken instruments 17. Conversely, the Gentle Wave method does not in modeling or instrumentation and does not remove any excess dentin 27. Therefore, this method is advised when little dentin remains in a tooth in which the file gets separated. In light of the requirement to use expensive and specialized equipment and the lower success rate of around 77.3% using laser Nd: YAG 13, 21. This method has been considered to be the most ineffective contrasted with other techniques examined.

When the ultrasonic tip is compared with TFRK, the total performance in the removal of the instrument that was separated was 95% in group P, and 95% for group T ($p > 0.05$) The average time to remove the instrument was greater when using ultrasonic tips compared when using the TFRK ($p > 0.05$). Both methods are suitable instruments for use in clinical practice however the loop system that is in the TFRK needs some more dexterity than that required by the ProUltra tips. 22

In a detailed study of this research, it was discovered that the likelihood of successful removal of a broken instrument can range from 53-95 percent. The apical region has the lowest rate of success for the retrieval of the broken instrument as compared to the coronal and middle third. In addition, success in removal was different concerning the location where the broken instrument was located in relation to the curvature of the canal

Further clinical studies regarding this subject are required and the choice to implement a technique should always be determined by the outcomes of clinical trials that are randomized. Future studies should concentrate on methods and approaches to lessen dentin loss from the



root canal and lower the risk of vertical plane fractures.. A set of guidelines on the treatment of broken instruments are required and studies into the best solutions in situations in which instruments separated can't be recovered. In addition, dentists need to be aware of ways to prevent fractures of instruments in the inner canals of the canals for root healing by disposing of instruments within the manufacturer's prescribed duration and also understanding the limits of their instruments as well as technique. In the event of a fracture, it's important to know the methods employed to treat the issue.

Conclusion:

In conclusion, this systematic review underscores the challenges and potential solutions associated with the retrieval of fractured instruments in endodontic practice. While ultrasonic technology stands out as a highly effective and widely applicable method, the choice of retrieval technique should be made with careful consideration of factors such as tooth type, instrument location, and the need to preserve dentinal integrity. Bypass techniques also show promise, and the Gentle Wave System may be preferable in cases where minimal dentin removal is essential. The Nd:YAG laser method appears less effective and cost-prohibitive. The Terauchi File Retrieval Kit (TFRK) and ProUltra tips offer viable options, with the TFRK showing a slight advantage, but operator dexterity plays a role in the choice.

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