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Considerations for removal of fractured files in root canals: a concise systematic review

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Abstract

Introduction: Fracture of endodontic instruments is a challenge and deserves the spotlight in endodontics. Fracture rates for stainless steel instruments can reach 6%, while nickel-titanium rotary instruments can have a 10% fracture rate. Fractured files can be removed using bypass and ultrasound techniques, for example. **Objective:** The present study developed a concise systematic review to present the main considerations for removing file fractures in root canals, in order to inform the current state of the art in techniques. **Methods:** The systematic review rules of the PRISMA Platform were followed. The research was carried out from March to April 2025 in Scopus, Embase, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** A total of 138 articles were found, 34 articles were evaluated in full and 16 were included and developed in this systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 22 studies with a high risk of bias and 26 studies that did not meet GRADE and AMSTAR-2. It was concluded that fracture can occur for various reasons, such as factors related to the experience and capacity of the operator, anatomical characteristics of the tooth, and also the instrument used. The first approach to use is the bypass system in order to bypass the instrument, which is less invasive and more accessible to operators. Another possible technique is the use of ultrasound, but with care to avoid dentin wear. And finally, there are microtube systems that in turn also wear away the dentin and can weaken the tooth.

Keywords: Fracture of instruments. Endodontic treatment. Root canal. Bypass system. Ultrasound.

Introduction

Fracture of endodontic instruments is a challenge and deserves the spotlight in endodontics. Fracture rates for stainless steel instruments can reach 6%, while nickel-titanium rotary instruments can have a 10.0% fracture rate. To prevent fracture of stainless steel instruments, they should be discarded whenever they show the slightest evidence of metal fatigue. However, fracture of nickel-titanium instruments can occur even when there are no signs of fatigue [1,2].

In this sense, accidents such as instrument fracture can occur, whether due to torsion, bending, fatigue, lack of knowledge on the part of the professional, or a combination of all these hypotheses [3,4]. The endodontist must be prepared to resolve this complication, either by removing the fragment with conventional or unconventional devices and methods. He or she must also be prepared for the fractured file not to be removed and to use the bypass technique to bypass the file to continue the treatment until the end, always prioritizing the correct prognosis. It is always recommended that dentists take precautions to ensure that no problems occur during the procedure. Therefore, understanding and knowing the limits of their equipment and instruments is essential for correct prevention, avoiding instrument fracture and stress for the professional and patient [5].

Planning and skill are required by dentists who aim to remove the fractured file from the root canal, as several factors such as fragment size, canal anatomy

and location of the fracture influence this decision. Several methods are proposed for removing this artifact. It is essential that the clinician correctly evaluates each case to the anatomy of the canal and the working technique to be used before carrying out the treatment [3,6].

The lack of technique and knowledge of internal anatomy together with cyclic instrument fatigue (instrument wear caused by excessive use) increases the chance of the inconvenience of instrument fracture occurring. There are various types of instruments, which are known to have different cutting capacities, resistance, and flexibility. Therefore, dentists should choose the instrument system for which they have the greatest knowledge and affinity [3,7,8].

Although it increases the difficulty of the treatment, there are several ways to continue the procedure effectively. It is possible to use the technique of bypassing the fragment, a strategy that consists of using another instrument of smaller caliber to pass through the fractured equipment – in this way, the particle can be incorporated into the filling material. It is also possible to intervene surgically, through endodontic surgery, or even to remove the fragment, as was done in the case presented in this study [3,8,9].

In this regard, the probability of successful removal depends on the level of the fracture (coronal, middle, or apical third); location concerning the curvature of the root canal; the type of fractured instrument; its length; the degree of curvature of the canal and the type of tooth. The prognosis for a tooth that retains a fractured instrument depends on the presence of a periapical lesion, the microbial load of the root canal during the time of the fracture, and the quality of the filling [3].

Fracture of endodontic instruments within a root canal can negatively affect the success of a treatment. If this failure occurs, one option is to remove the fragment or keep it inside the canal. However, it is necessary to analyze the moment in which the material was fractured due to the risk of contamination [3,10]. The ideal is always to remove it from inside the root canal, but when this is not possible, keeping it inside a tooth with necrotic pulp is uncertain. The procedure is more complicated in apical thirds, as it has a more atretic shape and the difficulty assumes greater proportions. When the fracture occurs in the middle and cervical thirds, it is easier to remove it [8,11].

Given this, the present study developed a concise systematic review to present the main considerations for removing file fractures in root canals, in order to inform the current state of the art in techniques.

Methods

Study Design

This study followed the international systematic review model, following the PRISMA (preferred reporting items for systematic reviews and meta-analysis) rules. Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. It was accessed on: 04/15/2025. The AMSTAR-2 (Assessing the methodological quality of systematic reviews) methodological quality standards were also followed. Available at: https://amstar.ca/. It was accessed on: 04/15/2025.

Data Sources and Search Strategy

The literature search process was carried out from March to April 2025 and developed based on Web of Science, Scopus, Embase, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various periods to the present day. The descriptors (DeCS/MeSH Terms. Available on: https://decs.bvsalud.org/) were used: *"Fracture of instruments. Endodontic treatment. Root canal. Bypass system. Ultrasound"*, and using the Boolean "and" between MeSH terms and "or" between historical findings.

Study Quality and Risk of Bias

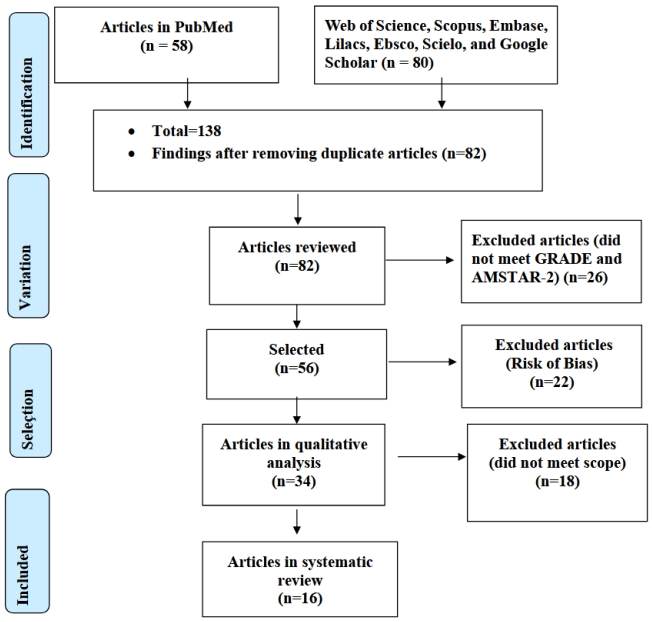
The quality was classified as high, moderate, low, or very low regarding the risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analysis of randomized clinical trials, followed by randomized clinical trials. Low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument by analyzing the Funnel Plot graph (Sample size versus Effect size), using Cohen's d test.

Results and Discussion

Summary of Findings

A total of 138 articles were found. Initially, duplicate articles were excluded. After this process, the abstracts were evaluated, and a new exclusion was performed, removing the articles that did not include the topic of this article, resulting in 82 articles. A total of 34 articles were evaluated in full, and 16 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 22 studies with high risk of bias and 26 studies that did not meet GRADE and AMSTAR-2, according to Figure 1.

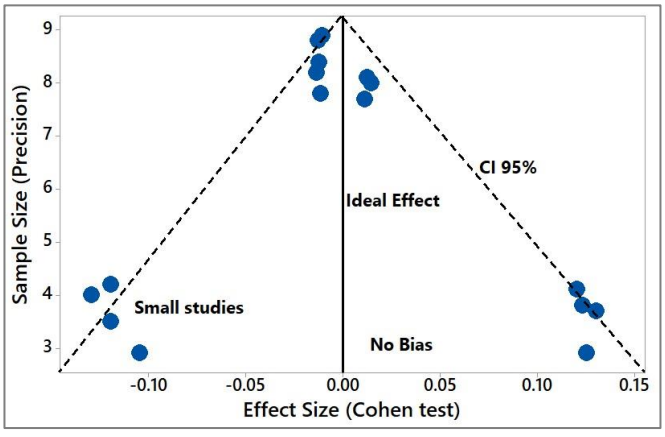
Figure 1. Selection of the articles.



Source: Own Authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using Cohen's Test (d). The sample size was determined indirectly by the inverse of the standard error (1/Standard Error). This graph showed symmetrical behavior, not suggesting a significant risk of bias, both among studies with small sample size (lower precision) that are shown at the base of the graph and in studies with large sample size that are shown in the upper region.

Figure 2. The symmetrical funnel plot suggests no risk of bias among the studies with small sample size that are shown at the bottom of the graph. High confidence and high recommendation studies are shown above the graph (NTotal = 16 studies evaluated in full in the systematic review).



Source: Own Authorship.

Major Findings

Fracture of endodontic instruments inside a root canal is always undesirable and most of the time it happens due to carelessness on the part of the operator. This occurrence can negatively affect the success of the endodontic treatment, and it is also important to keep in mind that if the endodontic file fractures, one option is to remove the fragment or leave it inside the root canal, making it necessary to analyze the moment when the fracture occurred due to the risk of contamination. However, the potential for removing the instrument from inside the root canal must always be considered, since if removal is not possible, keeping it inside a tooth with necrotic pulp becomes uncertain [1-3].

Stainless steel and nickel-titanium endodontic instruments, whether manually or mechanically operated, can fracture. However, studies show that when rotary instruments are used, they can become screwed and/or stuck in the root canal during instrumentation, causing deformation or fracture of the instrument. It is also important to control the torque of the endodontic motor and the force used in instrumentation. It is important to emphasize that although nickel-titanium files have a low failure rate, as long as they are handled correctly, they are a metal alloy that will break when pushed to their elastic limit [3-5].

Endodontic instruments are manufactured to follow the curvatures of the canals, having a certain flexibility and thus increasing the risk of fracture. In cases where the instrument is divided into small fragments in apical regions after a curvature and in atretic canals, removal becomes more complex, creating an enormous challenge for the operator who needs to have good skills and experience for the removal to be effective and satisfactory [5-7].

The fracture of an endodontic instrument inside the root canal is an accident that can happen to any dental surgeon, altering the treatment plan, and causing some disappointment and anguish to the surgeon. This accident can be related to several factors, such as the inexperience of the dental surgeon or even the anatomy of the canal itself (atretic and curved canals). The fracture of the instrument can be caused by bending or torsion. Bending follows cyclic fatigue and in the flexion region of the endodontic instrument, stresses are generated that vary between compression and traction when the bending is repeated a few times, it can promote small cracks that propagate until the fracture due to cyclic fatigue such instrument [8,9].

A torsion fracture occurs when the instrument is immobile and a force is applied that the instrument is unable to withstand, leading to its fracture. When a file is fractured, it does not always negatively affect the prognosis, since the file itself is not capable of directly

causing an infection. However, depending on the stage at which the file was fractured, it can interfere with the cleaning sequence, making the chemical-mechanical preparation of the canal system and also the obturation more difficult. It is necessary to know at what stage of disinfection the file was broken to be able to obtain the correct conduct for the case. The most favorable prognosis when the fracture occurs is in the final phase of instrumentation [8,10].

In this sense, authors argue that there should be at least an attempt to remove the fractured fragment [1-4]. There are some factors that influence the probability of removing the instrument, such as location, since once the file is fractured in a straighter part, it is more likely to be removed than compared to those located more apically to the curvature of the canal. Another factor is the length of the file; the longer the fragment is left, the greater the chance of it being removed. The material of the instrument also influences this removal; stainless steel files are easier to remove than Nickel-Titanium (Ni-Ti) files, and this is due to the fact that Ni-Ti rotary files "lock" inside the canal during rotation, which tends to fracture [3-5].

There are different ideas regarding the influence of an instrument fracturing on the degree of curvature of a canal. Some argue that there is a relationship and that the vestibular canals of the upper molars and the mesial canals of the lower molars are more likely to fracture a file [11,12]. Others disagree with this idea and report that it is an almost insignificant concern. If the operator chooses to remove the fragment, there is a wide range of methods to make this possible. One widely used device is ultrasound, which promotes the displacement of the instrument through vibrations. However, the use of ultrasound without proper water cooling can cause heat and future periodontal damage [13-15].

Furthermore, the use of ultrasound can cause excessive wear of dentin, resulting in vertical fracture of the roots. The bypass system should always be the first attempt when trying to bypass a fractured instrument and consists of using a small-caliber K-file (#8 or #10) between the root canal wall and the fragment, to create a space between them. Although it is considered a conservative technique, in atretic canals it can lead to excessive wear of the dentin [8].

Finally, it is also possible to use the Masserann Kit, which consists of using trephine-type tips to create a space and expose a fragment, followed by the use of extractors to grasp and remove the instrument. However, for exposure to occur, significant dentin wear is necessary, thus weakening the root. Some authors advocate the use of cyanoacrylate glue that helps to join the tube to the fragment, allowing its removal [3,16].

Conclusion

It was concluded that fracture can occur for various reasons, such as factors related to the experience and capacity of the operator, anatomical characteristics of the tooth, and also the instrument used. The first approach to use is the bypass system in order to bypass the instrument, which is less invasive and more accessible to operators. Another possible technique is the use of ultrasound, but with care to avoid dentin wear. And finally, there are microtube systems that in turn also wear away the dentin and can weaken the tooth.

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Similarity Check

It was applied by Ithenticate®.

Application of Artificial Intelligence (AI)

Not applicable.

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