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Analysis of methods for removing the fragments of instruments from the root canal system

Alexander V. Mitronin, Kirill A. Archakov, Diana A. Ostanina ✉, Yuriy A. Mitronin
Russian University of Medicine, Moscow, Russian Federation
✉ dianaostanina@mail.ru

Abstract
INTRODUCTION. Endodontics is a constantly developing area of dentistry. Every year new systems of machine rotating nickel-titanium instruments appear on the dental market which is accompanied by an increase in the incidence of such a complication of endodontic treatment as fragmentation of files in the root canal system. The frequency of this complication, which many dentists encounter, varies from 0.4% to 23%. That is why it is important to know the principles and methods of the safest possible extraction of broken instruments from the root canal system.
AIM. To systematize the analysis of methods of therapeutic and surgical extraction of fragmented instruments as well as summarize the indications for their use.
MATERIALS AND METHODS. A search of literature sources was carried out in the PubMed, dissercat.com, elibrary.ru, database.ru, cyberleninka.ru by keywords “endodontic treatment”, “iatrogenic events”, “fracture of endodontic instruments”, “methods for removing the fragments of instruments” with a choice of article types “Clinical Trial”, “Meta-Analysis”, “Review”, “Systematic Review”.
RESULTS. After analyzing the literature review an idea was obtained about the methods and indications for therapeutic and surgical methods of removing broken files from the root canal system. A protocol for the preparatory and main stages of extracting fragmented instruments using ultrasonic tips is described depending on the degree of visualization of the endodontic instrument.
CONCLUSIONS. The tactics of extracting fragmented endodontic instruments are individual in each individual clinical case and depend on a number of factors: the level of file fragmentation, the degree of its visualization, the anatomy of the root canal, and the manual skills of the dentist.

Keywords: endodontic treatment, iatrogenic events, fracture of endodontic instruments, methods for removing the fragments of instruments

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Анализ методик извлечения фрагментированных инструментов из системы корневых каналов

А.В. Митронин, К.А. Арчаков, Д.А. Останина ✉, Ю.А. Митронин
Российский университет медицины, г. Москва, Российская Федерация
✉ dianaostanina@mail.ru

Резюме
ВВЕДЕНИЕ. Эндодонтия является постоянно развивающимся направлением стоматологии. Ежегодно на стоматологическом рынке появляются новые системы машинных вращающихся никель-титановых инструментов, что сопровождается увеличением встречаемости такого осложнения эндодонтического лечения, как фрагментация файлов в системе корневых каналов. Именно поэтому важно знать принципы и способы максимально безопасного извлечения сломанных инструментов их системы корневых каналов.
ЦЕЛЬ ИССЛЕДОВАНИЯ. Систематизировать анализ методов терапевтического и хирургического извлечения фрагментированных инструментах, а также обобщить показания к их применению.
МАТЕРИАЛЫ И МЕТОДЫ. Проведен поиск литературных источников в базе данных PubMed, elibrary.ru, cyberleninka.ru, по ключевым словам, «эндодонтическое лечение», «ятрогенные ошибки», «фрагментация файлов», «способы извлечения инструментов» с выбором типов статей «Clinical Trial», «Meta-Analysis», «Review», «Systematic Review».
РЕЗУЛЬТАТЫ. После анализа обзора литературы, получено представление о методах и показаниях к терапевтическому и хирургическому способам удаления сломанных файлов из системы корневых каналов. Описан протокол подготовительного и основного этапов извлечения фрагментированных

инструментов с использованием ультразвуковых насадок в зависимости от степени визуализации эндодонтического инструмента.
ВЫВОДЫ. Тактика извлечения фрагментированных эндодонтических инструментов индивидуальна в каждом отдельном клиническом случае и зависит от ряда факторов: уровня фрагментации файла, степени его визуализации, анатомии корневого канала, мануальных навыков врача-стоматолога.

Ключевые слова: эндодонтическое лечение, ятрогенные ошибки, фрагментация файлов, способы извлечения инструментов

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INTRODUCTION

Endodontics is a continuously evolving field within dentistry [1]. Each year, new instrumentation systems for primary and secondary mechanical preparation of the root canal system are introduced to the dental market. Rotary nickel-titanium (Ni-Ti) endodontic instruments have gained particular popularity among clinicians due to their ease of use, the wide variety of available systems, and their ability to reduce the time required for root canal preparation [2]. However, the prevalence of one significant complication – instrument fracture within the root canal system – has also increased. The reported incidence of fragmentation ranges from 0.25% to 6% for stainless steel hand files and from 1.3% to 10% for rotary Ni-Ti instruments, representing a substantial proportion of iatrogenic errors in endodontic treatment [3].

When this complication arises, the prognosis of treatment worsens, and the presence of necrotic tissue within the root canal system can provoke inflammation of the periapical tissues. In most clinical cases, the inability to retrieve the fractured instrument ultimately necessitates tooth extraction [4].

Therefore, instrument separation remains a frequent and challenging problem in modern endodontics, encountered by many practitioners in clinical practice. The variability in the types of instrument fractures requires an individualized management strategy in each case [5]. Consequently, a wide range of techniques for the retrieval of separated instruments from the root canal system has been developed.

AIM

To systematize the information presented in scientific publications regarding the existing techniques for the retrieval of fractured instrument fragments from the root canal system.

MATERIALS AND METHODS

A literature search was conducted in the PubMed, dissercat.com, eLibrary.ru, and CyberLeninka.ru databases using the keywords “endodontic treatment”, “instrument separation”, and “instrument retrieval”, with article type filters set to “Clinical Trial”, “Meta-Analysis”, “Review”, and “Systematic Review”.

RESULTS

The management of separated instruments can be approached using either nonsurgical or surgical methods [6]. Surgical interventions include apical resection, hemisection, or intentional replantation of the tooth. However, primary emphasis is placed on nonsurgical techniques aimed at retrieving the fragment while preserving the integrity of the root.

If instrument separation occurs at the canal orifice, it may be possible to remove the fragment using a hemostat or needle holder to grasp and unscrew the freely exposed portion [7]. The “braiding technique” has also been described, which involves inserting two H-files on either side of the fractured fragment and simultaneously withdrawing them with a rotational movement. This technique allows for the removal of the H-files and the fragment as a single unit [8].

Instrument separation most commonly occurs in the middle or apical third of the canal. The determining factor for the subsequent treatment approach is the degree of instrument visualization. Therefore, the use of magnification, particularly with an operating dental microscope, is highly recommended in these cases [9].

When the fractured file is visible, the first step is to create a straight-line coronal access using Gates-Glidden drills or orifice shaping rotary files. This coronal enlargement facilitates the use of the primary retrieval tool–an ultrasonic tip with a fine working end. The tip is positioned between the fractured instrument and the canal wall, generating a counterclockwise vibration intended to loosen and dislodge the fragment. A critical technique involves operating along the inner curvature of the canal to encourage coronal displacement of the fragment [10]. Prolonged ultrasonic activation along the outer canal wall may result in apical migration of the fragment into the periapical tissues.

The use of ultrasonic tips inevitably leads to the removal of internal root dentin, which is continued until visible movement of the fragment is achieved. It is recommended to initiate preparation at a 90° angle relative to the cross-section of the canal to a depth of approximately one-third of the fragment’s length. This is followed by widening the preparation circumferentially to 180°, thus freeing the fragment from the

surrounding dentin. The appearance of fragment mobility is the main indicator of successful preparation. If the fragment remains immobile, further apical enlargement should be performed along the inner curvature of the canal.

Following this stage, the smoothness of the outer canal wall must be verified. Any irregularities or ledges that may obstruct fragment removal should be eliminated using rotary Ni-Ti files or additional ultrasonic activation.

Instrument retrieval can be performed under two conditions: in a dry or wet environment [11]. A dry field provides superior visibility, whereas a wet field enhances cavitation, reduces the risk of secondary fragmentation, and prevents thermal damage to periapical tissues by limiting temperature increases to under 10°C [12]. Therefore, optimal safety and efficacy are achieved under wet conditions. For straight canals with curvature less than 15°, it is advisable to use low-viscosity, high-surface-tension solutions such as EDTA to remove dentin debris and enhance acoustic streaming. In canals with curvatures exceeding 15°, high-viscosity lubricants like soybean or corn oil are recommended to facilitate fragment retrieval by improving lubrication [13].

Once the canal is filled with the chosen solution, ultrasonic retrieval is initiated. The ultrasonic tip is applied along the previously prepared inner curvature of the canal with a higher power setting than previously used. Ideally, the separated fragment should be retrieved within 10 seconds; if not, additional space between the canal wall and the file must be created [14]. Figure 1 illustrates the general scheme for the removal of a visible fractured instrument.

The retrieval of non-visible separated instruments presents additional challenges. Initially, a radiograph should be obtained using contact intraoral periapical radiography with a pre-bent microexplorer inserted into the canal to locate the space between the canal wall and the fragment. Subsequently, the canal should be enlarged up to its curvature using large-curvature rotary Ni-Ti files, such as the HyFlex EDM #60.02 system (Coltene/Whaledent, Switzerland). A major difficulty lies in the inability to directly assess the amount of dentin removed from the canal wall. Therefore, the detection of subtle mobility of the fragment beyond the curvature becomes the primary indicator for proceeding to the next stage of retrieval. Figure 2 presents a schematic illustration of the removal of a non-visible fractured file located within a canal curvature.

If ultrasonic techniques prove ineffective, loop-based systems such as the Yoshi Loop (DE Labs) and BTR Pen System (CERKAMED) can be employed. These systems operate by grasping and extracting the fractured instrument fragment [15]. Successful placement of the loop requires the canal diameter to be at least 0.04 mm, which is achieved by preliminary enlargement of the canal using rotary Ni-Ti files. Once the desired diameter is verified with a size 40 plugger, the loop is inserted and adjusted around the fragment using a fine endodontic explorer. The loop is then tightened around the instrument and gently pulled to facilitate removal. It is important to note that this technique requires the root canal and pulp chamber to be thoroughly dried to optimize visibility of the working field [16].

Surgical intervention should be considered when conservative approaches fail or when there is an initial risk of excessive dentin removal that would compromise the structural integrity of the tooth. This situation often arises when the fragment is located beyond the apical foramen. A clinical case reported by S. Mokal and S. Shenvi describes the surgical removal of a separated Ni-Ti instrument from the maxillary lateral incisor of a 52-year-old female patient [17]. Preopera-

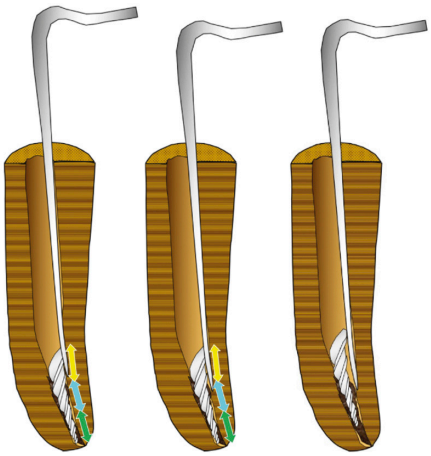

Fig. 1. General outline for removing a visualizable fragment of a endodontic tool
Source: [3]

Рис. 1. Общая схема удаления доступного для визуализации фрагмента эндодонтического инструмента
Источник: [3]

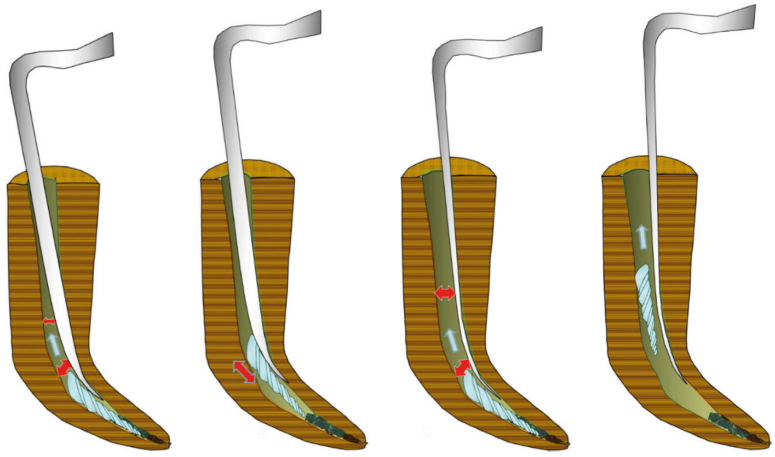

Fig. 2. General outline for removing a non-visualizable fragment of a endodontic tool located in a curvature of the root canal
Source: [3]

Рис. 2. Общая схема удаления трудновизуализируемого фрагмента эндодонтического инструмента, расположенного в изгибе корневого канала
Источник: [3]

tive intraoral periapical radiography (Fig. 3) showed a small periapical radiolucency into which the fractured instrument extended. The fragment was retrieved using a mosquito-type hemostat following reflection of a mucoperiosteal flap and creation of a bony window. Follow-up radiography one year postoperatively confirmed complete healing of the periapical lesion (Fig. 4). This case illustrates the rationale for surgical management of fractured instruments when conservative ultrasonic removal attempts would result in significant loss of root dentin.

CONCLUSION

Thus, the strategy for the retrieval of fractured endodontic instruments must be individualized for each clinical case and depends on several factors, including the level of instrument separation, the degree of its radiographic and clinical visibility, the anatomy of the root canal, and the clinician's technical skills. When choosing between nonsurgical and surgical retrieval methods, it is recommended to consider the position of the fragment within the canal and to minimize procedural invasiveness to preserve as much of the root dentin as possible.

Fig. 3. Preoperative postoperative intraoral radiograph of the tooth 2.2
Source: [17]

Рис. 3. Дооперационная прицельная внутриротовая контактная рентгенография зуба 2.2
Источник: [17]

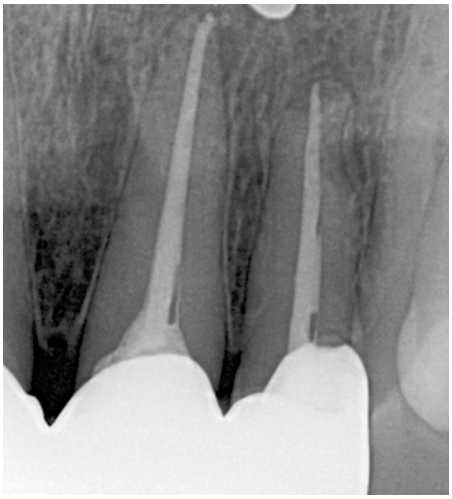

Fig. 4. Postoperative intraoral radiograph of the tooth 2.2
Source: [17]

Рис. **4.** Послеоперационная прицельная внутриротовая контактная рентгенография зуба 2.2
Источник: [17]

REFERENCES / СПИСОК ЛИТЕРАТУРЫ

1. Yanushevich O.O. (ed.). *Therapeutic dentistry. National guide*. 3rd ed. Moscow: GEOTAR-Media; 2024. 1024 p. (In Russ.)
   Янушевич О.О. (ред.) *Терапевтическая стоматология. Национальное руководство.* 3-е изд. перераб. и доп. М.: ГЭОТАР-Медиа; 2024. 1024 с.
2. Maximovsky_Yu.M., Mitronin A.V. *Therapeutic dentistry. A guide to practical exercises*. Moscow: GEOTAR-Media; 2011. 432 p. (In Russ.)
   Максимовский Ю.М., Митронин А.В. Терапевтическая стоматология: *руководство к практическим занятиям*. М.: ГЭОТАР-Медиа; 2011. 432 с.
3. Terauchi Y., Ali W.T., Abielhassan M.M. Present status and future directions: Removal of fractured instruments. *Int Endod J*. 2022;55(Suppl. 3):685–709. https://doi.org/10.1111/iej.13743
4. Madarati A.A., Hunter M.J., Dummer P.M. Management of intracanal separated instruments. *J Endod*. 2013;39(5):569–581. https://doi.org/10.1016/j.joen.2012.12.033
5. Amza O., Dimitriu B., Suciu I., Bartok R., Chirila M. Etiology and prevention of an endodontic iatrogenic event: Instrument fracture. *J Med Life*. 2020;13(3):378–381. https://doi.org/10.25122/jml-2020-0137
6. Lima T.O., Rocha A.O., Dos Anjos L.M., Meneses Júnior N.S., Hungaro Duarte M.A., Alcalde M.P. et al. A Global overview of guided endodontics: A bibliometric analysis. *J Endod*. 2024;50(1):10–16. https://doi.org/10.1016/j.joen.2023.10.002
7. Chaniotis A., Ordinola-Zapata R. Present status and future directions: Management of curved and calcified root canals. *Int Endod J*. 2022;55(Suppl. 3):656–684. https://doi.org/10.1111/iej.13685
8. Hargreaves K.M., Berman L.H. *Endodontics.* Moscow: GEOTAR-Media; 2019. 1040 p. (In Russ.)
   Харгривз К.М., Берман Л.Г. *Эндодонтия*. М.: ГЭОТАР-Медиа; 2019. 1040 с.
9. McGuigan M.B., Louca C., Duncan H.F. The impact of fractured endodontic instruments on treatment outcome. *Br Dent J*. 2013;214(6):285–289. https://doi.org/10.1038/sj.bdj.2013.271
10. Rzhanov E.A., Kopyev D.A. Method for estimating the probability of the nickel- titanium instrument failure depending on the duration of its work in a curved channel.

Endodontics Today. 2011;9(2):66–72. (In Russ.) Available at: https://www.endodont.ru/jour/article/view/759 (accessed: 14.03.2025).
Ржанов Е.А., Копьев Д.А. Метод оценки вероятности поломки никель-титанового инструмента в зависимости от продолжительности его работы в условиях искривленного канала. *Эндодонтия Today*. 2011;9(2):66–72. Режим доступа: https://www.endodont.ru/jour/article/view/759 (дата обращения: 14.03.2025).

11. Tooka M.A., Manak T.N., Butvilovsky A.V. Results of application of different protocols for mechanical preparation of curved root canals. *Meditsinskie Novosti*. 2022;(3):79–82. (In Russ.)
Тоока М.А., Манак Т.Н., Бутвиловский А.В. Результаты применения разных протоколов механической обработки искривленных корневых каналов зубов. *Медицинские новости*. 2022;(3):79–82.
12. Khabadze Z.S., Balashova M.E., Zoryan A.V., Mohamed E.R., Abdulkerimova S.M., Bakaev Yu.A., Kulikova A.A. Changes in the crystal lattice of nickel-titanium endodontic instruments as a result of autoclaving. *Endodontics Today*. 2019;17(1):33–36. (In Russ.) https://doi.org/10.33925/1683-2981-2019-17-1-33-36
Хабадзе З.С., Балашова М.Е., Зорян А.В., Мохамед Э.-Х.Р.А., Абдулкеримова С.М., Бакаев Ю.А., Куликова А.А. Изменение кристаллической решетки никель-титановых эндодонтических инструментов в результате автоклавирования. *Эндодонтия Today*. 2019;17(1):33–36. https://doi.org/10.33925/1683-2981-2019-17-1-33-36
13. Terauchi Y., Sexton C., Bakland L.K., Bogen G. Factors affecting the removal time of separated instruments. *J Endod*. 2021;47(8):1245–1252. https://doi.org/10.1016/j.joen.2021.05.003
14. Portela N.N., Rech J.P., Marchionatti A.M.E., Barasuol J.C. Techniques to address fractured instruments in the middle or apical third of the root canal in human permanent teeth: a systematic review of the in vitro studies. *Clin Oral Investig.* 2022;26(1):131–139. https://doi.org/10.1007/s00784-021-04235-6
15. Malykhina O.A., Samokhina V.I., Matskieva O.V. Break off endodontic instruments in the apical third of the root canal: case report. *Endodontics Today.* 2017;15(2):48–50. (In Russ.) Available at: https://www.endodont.ru/jour/article/view/67 (accessed: 14.03.2025).
Малыхина О.А., Самохина В.И., Мацкиева О.В. Отлом эндодонтического инструмента в апикальной трети корневого канала: клинический случай. *Эндодонтия Today*. 2017;15(2):48–50. Режим доступа: https://www.endodont.ru/jour/article/view/67 (дата обращения: 14.03.2025).
16. Lakshmaiah D., Raj Kumar J., Sakthi N., Karunakaran J., Vishwanath S. The management of fractured dental instruments: A case series. *Cureus*. 2023;15(11):e49132. https://doi.org/10.7759/cureus.49132
17. Mokal S., Shenvi S. Surgical removal of a fractured endodontic instrument beyond periapex of maxillary lateral incisor using a dental operating microscope: A case report. *Endodontics Today*. 2024;22(4):373–377. https://doi.org/10.36377/ET-0052
Мокал С., Шенви С. Хирургическое удаление сломанного эндодонтического инструмента за пределами периапикального отверстия верхнего латерального резца с использованием стоматологического операционного микроскопа: клинический случай. *Эндодонтия Today*. 2024;22(4):373–377. https://doi.org/10.36377/ET-0052

INFORMATION ABOUT THE AUTHORS

Alexander V. Mitronin – Dr. Sci. (Med.), Professor, Deputy Director of the Scientific and Educational Institute of Dentistry named after A.I. Evdokimov, Head of the Department of Conservative Dentistry and Endodontics, Honored Doctor of Russian Federation, Russian University of Medicine, 4, Dolgorukovskaya St., Moscow 127006, Russian Federation; https://orcid.org/0000-0002-3561-6222

Kirill A. Archakov – Laboratory Assistant, Student, Russian University of Medicine, 4, Dolgorukovskaya St., Moscow 127006, Russian Federation; https://orcid.org/0000-0002-5181-1546

Diana A. Ostanina – Cand. Sci. (Med.), Associate Professor of the Department of Conservative Dentistry and Endodontics, Russian University of Medicine, 4, Dolgorukovskaya St., Moscow 127006, Russian Federation; https://orcid.org/0000-0002-5035-5235

Yuriy A. Mitronin – Postgraduate Student, Assistant of the Department of Propaedeutics of therapeutic dentistry, Russian University of Medicine, 4, Dolgorukovskaya St., Moscow 127006, Russian Federation; https://orcid.org/0000-0002-3118-2869

ИНФОРМАЦИЯ ОБ АВТОРАХ

Митронин Александр Валентинович – д.м.н., профессор, заместитель директора научно-образовательного института «Стоматологии им. А.И. Евдокимова», заведующий кафедрой терапевтической стоматологии и эндодонтии, заслуженный врач РФ, ФГБОУ ВО «Российский университет медицины», 127006, Российская Федерация, г. Москва, ул. Долгоруковская, д. 4; https://orcid.org/0000-0002-3561-6222

Арчаков Кирилл Андреевич – лаборант кафедры терапевтической стоматологии и эндодонтии, студент 5 курса стоматологического факультета, ФГБОУ ВО «Российский университет медицины», 127006, Российская Федерация, г. Москва, ул. Долгоруковская, д. 4; https://orcid.org/0000-0002-5181-1546

Останина Диана Альбертовна – к.м.н., доцент кафедры терапевтической стоматологии и эндодонтии, ФГБОУ ВО «Российский университет медицины», 127006, Российская Федерация, г. Москва, ул. Долгоруковская, д. 4; https://orcid.org/0000-0002-5035-5235

Митронин Юрий Александрович – аспирант, ассистент кафедры пропедевтики терапевтической стоматологии, ФГБОУ ВО «Российский университет медицины», 127006, Российская Федерация, г. Москва, ул. Долгоруковская, д. 4; https://orcid.org/0000-0002-3118-2869

AUTHOR'S CONTRIBUTION

Alexander V. Mitronin – has made a substantial contribution to the concept or design of the article; revised the article critically for important intellectual content; approved the version to be published.

Kirill A. Archakov – the acquisition, analysis, or interpretation of data for the article; drafted the article.

Diana A. Ostanina – has made a substantial contribution to the concept or design of the article; the acquisition, analysis, or interpretation of data for the article; drafted the article; revised the article critically for important intellectual content.

Yuriy A. Mitronin – the acquisition, analysis, or interpretation of data for the article; drafted the article.

ВКЛАД АВТОРОВ

А.В. Митронин – существенный вклад в замысел и дизайн исследования, критический пересмотр статьи в части значимого интеллектуального содержания; окончательное одобрение варианта статьи для опубликования.

К.А. Арчаков – сбор данных, анализ и интерпретация данных, подготовка статьи.

Д.А. Останина – существенный вклад в замысел и дизайн исследования, сбор данных, анализ и интерпретация данных, подготовка статьи, критический пересмотр статьи в части значимого интеллектуального содержания.

Ю.А. Митронин – сбор данных, анализ и интерпретация данных, подготовка статьи.