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Retrieval of Separated Endodontic Instrument

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Abstract:- Endodontic instrument fracture is a procedural error that creates a significant barrier to routine root canal therapy. A separated instrument results in insufficient cleaning and shaping of the root canals.

Inadequate biomechanical preparation has an impact on the result and outcome of root canal treatment. Therefore, retrieval of separated instruments should be considered important.

There are many instrument retrieval kits and techniques available for this purpose. In this case report, a separated rotary file was successfully retrieved using a Masserann kit .

I. INTRODUCTION

Instrument separation during endodontic therapy occurs in 2% to 6% of cases studied.[1] Occasionally, a separated instrument can obstruct access to the apical terminus during root canal treatment. While this device is usually a file or reamer, it can also include Gates-Glidden or Peeso drills, lentulo spiral paste fillers, thermomechanical gutta-percha compactors, or even the tips of hand instruments such as explorers or gutta-percha spreaders.[2]

Nickel titanium (NiTi) files are preferred in root canal procedures due to their flexibility, which allows for more efficient cleaning and shaping of the root canal system compared to stainless steel (SS) files. However, NiTi files can still break during use, often without warning signs visible to the dentist or endodontist.[3] This breakage can occur due to factors such as cyclic fatigue, torsional failure, or a combination of both. In contrast, stainless steel files typically break due to excessive torque rather than fatigue or torsional forces. Despite these risks, NiTi files remain popular due to their overall superior performance in many aspects of endodontic treatment.[4]

The retrieval of fractured instruments from root canals can indeed be challenging, and reported success rates range from 55% to 79%.

➢ *Several Devices and Techniques have been Created to Assist in Retrieving Separated Instruments, Including:*

- Masseran™ Endodontic Kit
- Ultrasonic tips

These systems often involve specialized instruments and approaches designed to safely and effectively remove the fractured instrument from the root canal.[5]

One of the several techniques for removing foreign objects from the root canal is the Masserann technique. This method works well for extracting damaged files, posts, and silver points from the root canal; overall, a 55% success rate has been reported when using this method.[6]

Gates-Glidden drills a slow-speed, contra-angle hand piece and a Masserann kit with a variety of color-coded, end-cutting trephan burs of varying sizes are the tools used. These are rotated anticlockwise to cut the root canal dentin surrounding the fragment's coronal end, thereby creating space. The extractor resembles a tube and has a stylet, or plunger rod, which when screwed inside the extractor locks the exposed coronal end of the fragment against internal embossment just short of the end of the extractor, which can be removed by anticlockwise rotation.

In addition to these systems, newly developed ultrasonic tips used with piezoelectric ultrasonic units have shown promise in aiding the conservative removal of dentin surrounding the separated instrument. The vibrations produced by these ultrasonic tips can help facilitate the removal of the fractured instrument while minimizing damage to the surrounding tooth structure.(5)

Overall, the successful retrieval of fractured instruments requires careful planning, skillful execution, and often the use of specialized tools and techniques tailored to the specific case at hand.

➢ *Factors Contributing to Fracture of Endodontic File*

The prevention of procedural errors, especially in a field as precise as endodontics, is paramount for successful outcomes and patient safety. Procedural Errors in Endodontics, can lead to complications such as instrument fracture, perforation, and canal transportation, which can compromise the success of the root canal treatment.

To prevent such errors, thorough training and continuous skill development are essential for dental practitioners. guidelines commonly suggested for preventing procedural errors in endodontics:

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- Comprehensive Training: Dental practitioners should undergo rigorous training programs that cover both theoretical knowledge and practical skills related to endodontic procedures. This includes understanding root canal anatomy, mastering instrumentation techniques, and developing proficiency in using diagnostic tools such as radiographs.
- Clinical Experience: Hands-on experience under the guidance of experienced mentors is crucial for honing endodontic skills. Dental students and young practitioners should have opportunities to observe and assist in a variety of endodontic cases before performing procedures independently.
- Use of Magnification and Illumination: Magnification tools such as dental loupes or microscopes, along with proper illumination, can significantly enhance visibility during endodontic procedures. Improved visualization reduces the likelihood of procedural errors by allowing for better identification of canal anatomy and obstacles.
- Preoperative Assessment: Thorough preoperative assessment, including diagnostic tests such as pulp vitality tests and radiographic examination, helps in understanding the morphology of the root canal system and identifying any potential challenges before initiating treatment.
- Proper Technique: Adhering to proper instrumentation techniques, such as using the appropriate file sizes, working lengths, and irrigation protocols, minimizes the risk of procedural errors like canal transportation or ledge formation.
- Continuous Education: Endodontic techniques and materials evolve over time, so it's essential for practitioners to stay updated with the latest advancements through continuous education programs, workshops, and professional conferences.

The risk of endodontic instrument breakage, known as SIF (separated instrument fragment), is significantly influenced by root canal morphology. more complex root canal systems, such as those found in molars, pose a greater risk of instrument breakage. This is particularly true for the mesial roots of mandibular molars, which are known for their intricate and challenging anatomy.

➢ *Several Factors Contribute to the Increased Risk of SIF in Certain Canal Locations:*

- **Root Canal Morphology**: The anatomy of the root canal system, including the number of canals, their curvature, and the presence of isthmuses and fins, affects the likelihood of instrument breakage. Canals with pronounced curvature or narrow passages present greater challenges during instrumentation and are more prone to instrument fatigue.
- **Location within the Canal**: The risk of SIF varies along the length of the root canal. Instruments are more susceptible to breakage in the apical third of the canal compared to the coronal and middle thirds. This may be due to factors such as increased curvature and reduced canal diameter in the apical region.
- **Fatigue and Flexure**: Instruments undergo cyclic fatigue during use, especially in curved canals where they experience increased flexure. As the curvature of the canal becomes more pronounced, the cyclic fatigue of the instrument intensifies, leading to a shorter lifespan of the instrument and an elevated risk of breakage.
- **Contact Surface with Dentinal Walls**: In curved canals, the contact surface between the instrument and the dentinal walls is greater, leading to increased friction and stress on the instrument. This can contribute to instrument wear and fatigue, ultimately predisposing it to breakage.[7,8]

➢ *The Radius of Canal Curvature*

The relationship between the angle and radius of curvature in root canals is crucial to understand, as it significantly impacts the risk of rotary file failure, particularly in endodontic procedures. While two canals may have the same angle of curvature, their radii of curvature can differ, indicating variations in the sharpness of the curves.

Research has shown that the radius of canal curvature plays a more significant role in rotary file failure than the curvature angle itself. Even if two canals have similar angles of curvature, differences in the radius of curvature can affect the stress and strain experienced by rotary files during instrumentation.

Specifically, as the radius of curvature decreases, the rate of rotary file separation or failure increases. This means that sharper curves, characterized by smaller radii of curvature, pose a greater risk of file separation during endodontic procedures.

When considering various factors influencing rotary file failure, including root canal anatomy and instrumentation techniques, the radius of curvature emerges as the most significant factor. Practitioners must be mindful of this when selecting instruments and employing instrumentation techniques, especially in cases with sharp or tight curves, to minimize the risk of file separation and ensure successful treatment outcomes.[9,10,11]

II. METAL ALLOY

Understanding the characteristics of endodontic file materials is crucial when considering the potential for instrument failure during root canal procedures. The properties of endodontic instruments, such as their strength, flexibility, and cutting efficiency, vary depending on their metallic composition.

Stainless steel and nickel-titanium (NiTi) are two common materials used for endodontic instruments, each with its advantages and limitations:

- **Stainless Steel**: Stainless steel files and reamers have been traditionally used in endodontics. They are known for their durability, resistance to deformation, and cutting efficiency. Compared to carbon steel instruments, stainless steel files exhibit better resistance to defect

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formation and fracture, making them preferable in certain clinical scenarios.

- **Nickel-Titanium (NiTi)**: NiTi files have gained popularity in recent years due to their unique properties. NiTi alloys offer significantly greater flexibility and resistance to cyclic fatigue compared to stainless steel. This enhanced flexibility allows NiTi files to navigate curved root canals more effectively while reducing the risk of instrument separation. Additionally, NiTi files have been reported to be three times stronger than stainless steel files, further contributing to their superior performance and longevity.

While NiTi files offer several advantages over stainless steel, such as increased flexibility and strength, they also have limitations. NiTi files are more expensive than stainless steel, and they require careful handling to prevent distortion or breakage during use. Additionally, the cutting efficiency of NiTi files may vary depending on the specific alloy and manufacturing process.

Both stainless steel and NiTi files have their place in endodontic practice, with each offering unique advantages. Stainless steel instruments are durable and efficient, while NiTi files provide greater flexibility and resistance to fatigue. [12]

III. FREQUENCY OF USE

➢ *It's Challenging to Recommend a Specific Number of Uses for Endodontic Files Due to the Multifactorial Nature of the Problem.*

- **Recommendations on Reuse**: Guidelines regarding the reuse of endodontic files vary. While some suggest that small hand instruments should not be used more than twice, the situation differs for rotary instruments. Studies have indicated that certain rotary files, such as Profile instruments, can be reused multiple times without fracturing, up to ten times in simulated canals and up to four times in molars.
- **Clinical Versus Simulated Conditions**: It's important to note that the frequency of use in simulated canals may not directly correlate with real clinical scenarios. Clinical studies have suggested that rotary files like ProTaper can be safely reused at least four times. However, the anatomical variations of individual canals and other factors make it challenging to determine a specific number of uses clinically.
- **Safety Concerns**: While some studies have shown that endodontic files can be reused without fracturing, there are still concerns about safety. Even with single use, a percentage of files may exhibit defects, and a small percentage may fracture. Microstructural defects, not always visible at lower magnifications, can serve as stress concentration points, leading to file separation.
- **Importance of Technique**: Ultimately, it's not just the number of times an instrument is used that determines the risk of fracture but also how it is used. Factors such as canal anatomy, instrumentation technique, and operator skill play significant roles in the longevity and safety of endodontic files.

Given these complexities, some advocate for single-use approaches for absolute safety. However, even with single use, the risk of file defects and fracture exists. Further research, particularly using advanced imaging techniques like scanning electron microscopy (SEM), is needed to better understand the factors contributing to endodontic file fracture and to assess the clinical usability of rotary NiTi files. In the meantime, careful handling, adherence to best practices, and regular inspection of instruments remain crucial for minimizing the risk of SIF in endodontic procedures.[13,14,]

➢ *Torque*

- Torque plays a significant role in endodontic instrumentation, influencing the likelihood of instrument locking, deformation, and ultimately, fracture. Here's how torque impacts the behavior of endodontic files:
- Engagement and Locking: During instrumentation, endodontic files may engage portions of the canal walls smaller than their diameter. This can lead to the file locking or screwing into the canal walls, causing torque to rise rapidly. As a result, the file experiences high levels of stress, increasing the risk of structural failure and separation.
- Canal Size and File Diameter: Torque levels during instrumentation are influenced by canal size and file diameter. In smaller canals, the torque required to navigate the canal is higher compared to larger canals. Additionally, as the diameter of the file increases, the torque needed to initiate unwinding or fracture also increases.
- Effect of Motor Torque: The torque applied during instrumentation is influenced by the motor settings. Instruments used with low-torque motors (set at <1N/cm) are found to be more resistant to fracture compared to those used with high-torque motors (set at >3N/cm). Therefore, practitioners are advised to use electric motors set at low torque levels during root canal preparation to minimize the risk of instrument fracture.
- Curvature and File Failure: Smaller files and files used in more acutely curved canals are prone to failure at lower torque levels. The curvature of the root canal impacts the behavior of the file, with more pronounced curves increasing the risk of file deformation and separation.
- Impact of Instrument Design and Material: Factors such as instrument design and material composition also influence the response of files to torque. For example, certain surface treatments like electro-polishing have been reported to decrease the work-hardening effects of the alloy, potentially reducing the risk of instrument fracture.

The role of torque in endodontic instrumentation is crucial for optimizing procedural outcomes and minimizing the risk of file separation. Practitioners should carefully adjust motor settings, select appropriate file sizes, and consider canal anatomy to mitigate the effects of torque on instrument performance and longevity.[13,15,16]

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➢ *Speed of Rotation:*

- The speed of rotation is a critical parameter in the use of rotary files during endodontic procedures, influencing both the efficiency of instrumentation and the risk of instrument failure, particularly separated instrument fragment (SIF).
- Manufacturer Recommendations: Most manufacturers provide guidelines for the recommended speed of rotation for their rotary files, typically ranging from 150 to 350 rpm (revolutions per minute). These recommendations are based on considerations such as file design, material composition, and intended clinical application.
- Effect on SIF: Studies have shown that a higher rate of SIF occurs when rotary files are rotated at high speeds, particularly in the range of 300 to 350 rpm. Higher speeds can increase the stress and strain experienced by the files, leading to a greater risk of fatigue failure and SIF. Additionally, the time for rotary instruments to fail significantly decreases as rotation speed increases.
- Inconsistencies in Research Findings: Some studies have reported no significant effect of different rotation speeds on the incidence of rotary file fracture. However, it's important to note that the definition of instrument failure varies across studies, with some considering only fracture as failure while others include instrument deformation as well. Methodological differences among studies may also contribute to inconsistent findings.
- Adherence to Manufacturer Recommendations: Despite variations in research findings, it is imperative for clinicians to adhere to the speed recommended by the manufacturer for each rotary system and, in some cases, for each specific file. Deviating from manufacturer recommendations may increase the risk of instrument failure and compromise treatment outcomes.

While the speed of rotation influences rotary file performance and the risk of SIF, adherence to manufacturer recommendations is crucial for ensuring safe and effective instrumentation during endodontic procedures. Clinicians should carefully follow manufacturer guidelines and consider individual patient factors when selecting rotation speeds for rotary file use.[17,18,19]

➢ *Instrumentation Sequence:*

- The instrumentation sequence in endodontic procedures is crucial for achieving successful outcomes and minimizing the risk of instrument failure, such as separated instrument fragments (SIF).
- Safety and Effectiveness: Following a specific instrumentation sequence ensures that each stage of the root canal preparation process is completed systematically and effectively. A sequence that includes various taper sizes is generally considered safer compared to using a single taper throughout. This approach distributes the workload across multiple files, reducing the stress on each individual file and extending its lifespan.
- Reduced Stress on Files: By utilizing a sequence with multiple tapers, each file encounters less stress during instrumentation. This reduces the likelihood of fatigue and deformation, ultimately enhancing the durability of the instruments.
- Hybrid Instrumentation: The concept of hybrid instrumentation involves using a combination of files from different systems and employing various instrumentation techniques to address specific clinical challenges. This approach recognizes that every root canal presents unique anatomical characteristics and complexities. By combining files and techniques, clinicians can tailor the instrumentation process to meet the individual needs of each case, potentially reducing the risk of file separation.

Adhering to a well-defined instrumentation sequence, preferably one that incorporates multiple taper sizes, promotes safety, efficiency, and longevity of endodontic instruments. Additionally, the concept of hybrid instrumentation offers flexibility and customization to manage the diverse clinical scenarios encountered in endodontic practice, potentially minimizing the risk of instrument failure while optimizing treatment outcomes.[20,21]

The case reports discussed here detail the successful retrieval of a file that was tightly wedged in the root canal dentin of a right mandibular first molar.

IV. CASE REPORT

A. *Case 1*

A 22-year-old male patient was referred to the Department of Conservative Dentistry and Endodontics with acute pain in the lower right back region of the jaw that had persisted for 5 days. Radiographic examination revealed dental caries in tooth 46. After a thorough clinical examination and detailed history, the diagnosis was dental caries with chronic irreversible pulpitis in tooth 46, and root canal treatment was planned.

An access opening was performed under a rubber dam on tooth 46, where four canals were located. The working length was determined, but it was noted that the distolingual canal was calcified. This canal was negotiated using a #6 K-file until the working length was reached [Fig. 1a]. During cleaning and shaping, a #20.04 file separated in the distolingual canal. A radiograph confirmed the level of separation of the instrument [Fig. 1b], which was found at the junction of the coronal and middle thirds of the root canal.

The Masserann technique was employed to retrieve the separated instrument. Radicular access to the coronal end of the fragment was achieved by funneling the root canal with sequential Gates-Glidden drills. The remaining part of the separated instrument was examined, and the distance from the tip of the fractured file to the reference point D16 (11 mm) was measured. This distance was subtracted from the original file length of 16 mm to determine the length of the fragment remaining in the canal (5 mm).

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A pre-selected trephan with a diameter of 1.2 mm was attached to a contra-angle handpiece and used in an anticlockwise direction to create a trough around the coronal end of the fragment by removing dentin. Radiographic confirmation ensured proper centering of the trephan over the fragment. An extractor tube with a diameter of 1.2 mm was then slid into the trough to sleeve the fragment [Fig. 1c]. After radiographic confirmation, a plunger rod was turned manually inside the extractor tube in a clockwise direction to grip the fragment against its wall. When a tight grip was achieved, the entire assembly was rotated anticlockwise to unscrew and withdraw the fragment [Fig. 1d and 1e]. After several attempts, the instrument was successfully retrieved.

Cleaning and shaping of tooth 46 were completed using rotary instruments, and the canal was obturated with gutta-percha and bioceramic sealer [Fig. 1f].

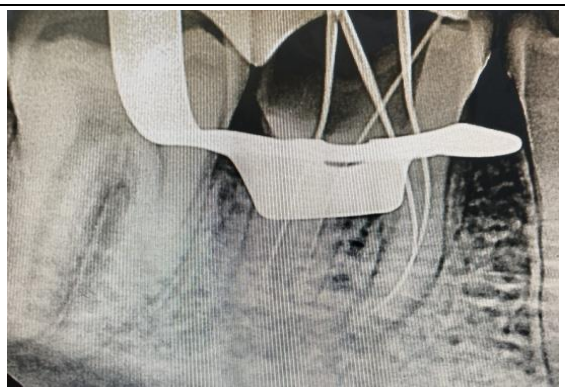

Fig 1 A canal negotiated with 6 k hand file

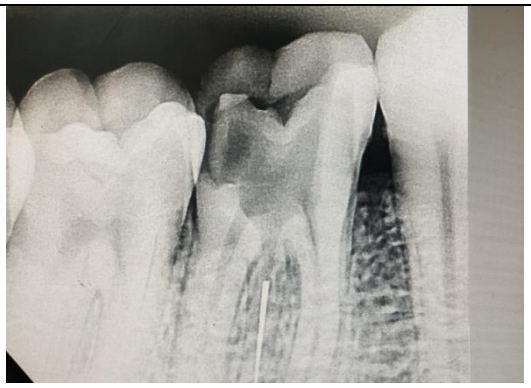

Fig 1 B #20.4 % The File Became Separated in the Distolingual Canal

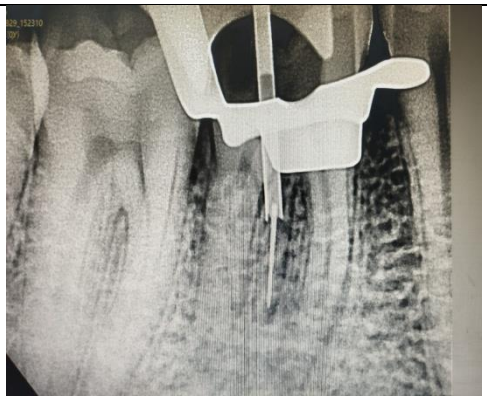

Fig 1C extractor tube

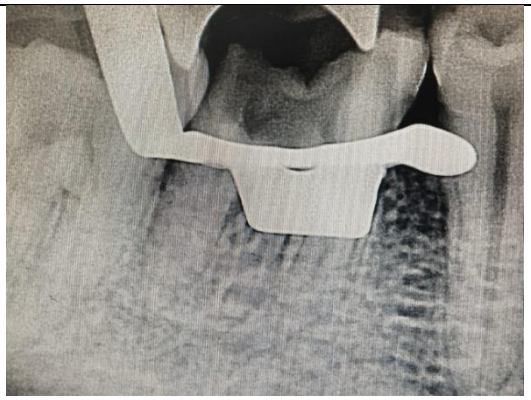

Fig 1D Retrieved fragment

Fig1E Retrieved fragment

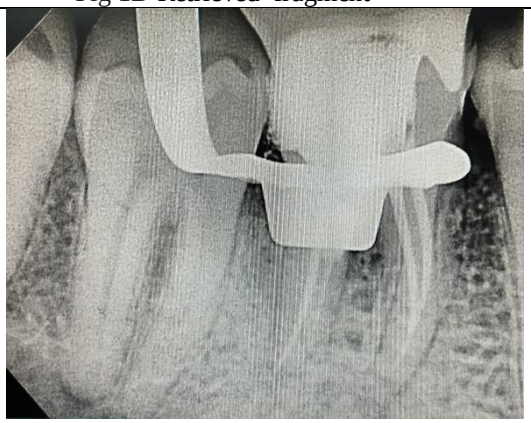

Fig 1F Obturation with 46

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B. Case II

A 30-year-old female patient came to the Department of Conservative Dentistry and Endodontics with a chief complaint of pain in the lower left back region of her jaw that had persisted for the past month. Radiographic examination showed dental caries in tooth 46. After a comprehensive history and clinical examination, it was determined that tooth 46 had dental caries with chronic irreversible pulpitis, and root canal treatment was recommended.

An access opening was performed under a rubber dam on tooth 46, and four canals were identified. The working length was established, but during the cleaning and shaping process, a #17.5% file was separated in the distolingual canal of tooth 46.

A radiograph was taken to confirm the level of separation of the instrument (Fig 2A). The instrument was found to be separated at the junction of coronal and middle third of the root canal. Masserann technique was used for retrieval of the instrument (Figure 2b); and after several attempts, the instrument was retrieved successfully (Figure2c, Figure 2d). Cleaning and shaping was completed in 46 with rotary instruments and intracanal medicament was placed.

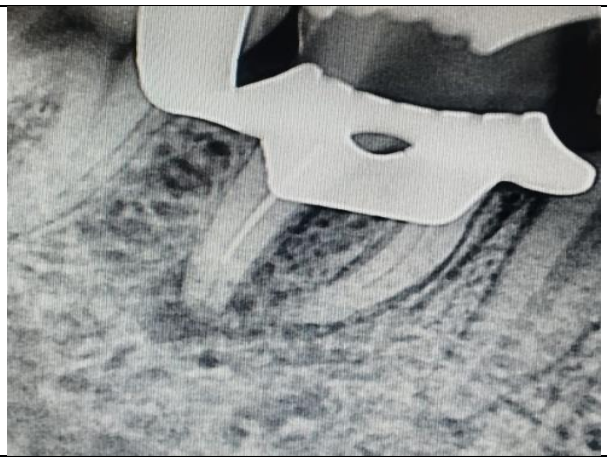

Fig 2(A): Separation of the Instrument

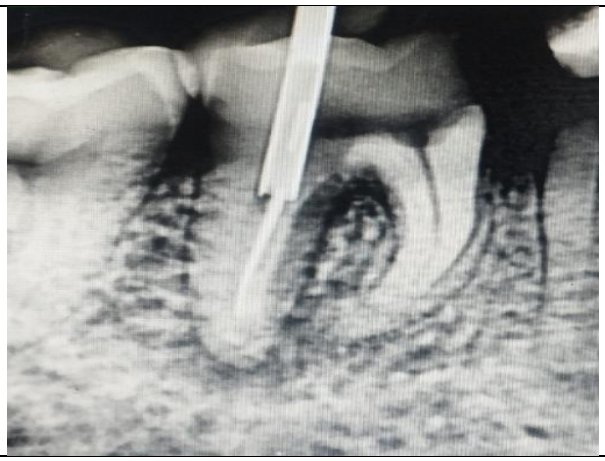

Fig 2(B): Retrieval of the Instrument

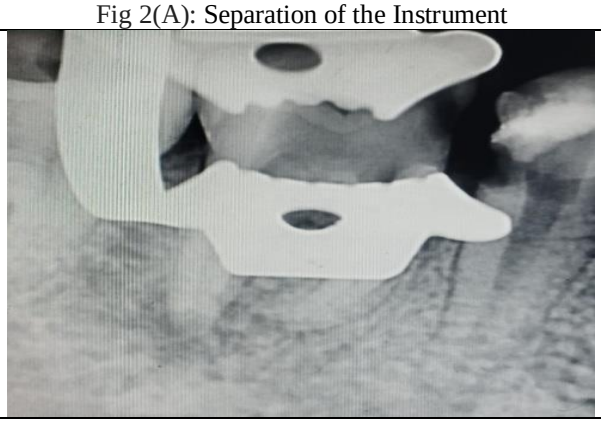

Fig 2(C): Retrieved Instrument

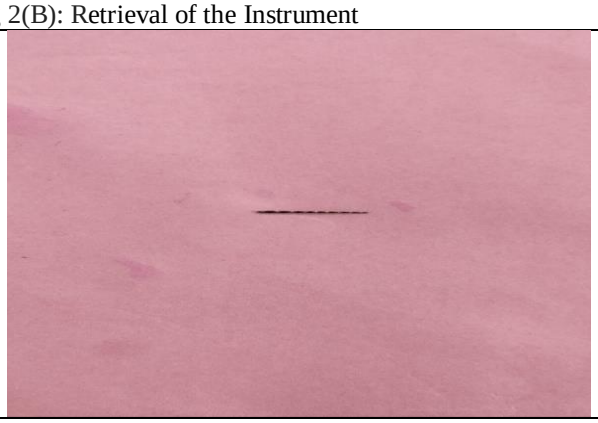

Fig 2(D): Retrieved Instrument

V. DISCUSSION

Intracanal separation of instruments often obstructs access to the apex, complicates thorough cleaning and shaping of the root canal, and can jeopardize the outcome of endodontic treatment, potentially diminishing the likelihood of successful retreatment. The prognosis in these situations depends on factors such as the condition of the root canal (whether vital or nonvital), the status of the tooth (symptomatic or asymptomatic, with or without periapical pathology), the extent of cleaning and shaping performed before the separation, and the location of the separation within the canal. Generally, the prognosis is less favorable compared to standard endodontic procedures.

Consequently, every effort should be made to bypass or retrieve the separated instrument. Successful orthograde retrieval depends on factors such as the canal's cross-sectional diameter, length, curvature, dentin thickness and root morphology, the instrument's composition and cutting action (clockwise or counterclockwise), and the length, location, and degree of binding or impaction of the fragment.

The Masserann kit, in use for over 30 years, has demonstrated success rates of 73% for anterior teeth and 44% for posterior teeth. However, it requires frequent radiographic monitoring and has limited effectiveness in cases involving thin or curved roots or instruments fractured apically. The use of large, rigid trephans may result in significant removal of root dentin, potentially weakening the tooth or increasing the risk of perforation.

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Despite these limitations, the Masserann kit is highly effective for removing metal obstructions from teeth with thick, straight roots. Its extractor's locking mechanism provides secure retention for gripping and dislodging tightly wedged fragments. Ensuring a straight-line access to the fragment allows for accurate centering of the trephan, safe cutting of the surrounding dentin, and effective retrieval of the fragment along the root's long axis, thus facilitating successful retreatment.

Although it is reported that this technique can be challenging for posterior teeth, our experience with the Masserann kit in such cases has been successful. All procedures were performed under a rubber dam. In instances of separation, priority should be given to safe retrieval or bypassing. While the Masserann technique is sensitive and time-consuming, its skillful application within clinical limits, combined with the operator's expertise, can lead to successful retrieval of separated files from mandibular molars. Additionally, using ultrasonics and a dental operating microscope can further enhance retrieval success in selected cases.

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