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ARE YOU READY TO OVERPOWER THE CHALLENGE OF INSTRUMENT SEPARATION IN ENDODONTICS: A REVIEW

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ABSTRACT

Every clinician who has performed root canal treatment has experienced a variety of emotions ranging from a perfect fill till the root apex to endodontic instrument breakage in the root canal. Non-surgical removal of these fractured or separated instruments is a real challenge for the clinician. This article deals with the advancement of newer techniques in magnification & accessibility such as dental loupes and surgical operating microscope & instrument removal kits (Masseran kit), ultrasonic instrumentation by which a clinician is able to make the right choices for separated instrument retrieval from the root canal.

INTRODUCTION

One of the most common mishaps that occur during routine endodontic treatment is the fracture of instrument inside the root canal. The separated instrument, particularly a broken file leads to metallic obstruction in the root canal and prevents thorough cleaning and shaping procedures. Continuous pain or discomfort occurs in the involved tooth if the broken instrument is not removed or bypassed. Reasons of this mishap include over & improper use of the instrument, microcracks inherent in the new instrument and calcified or curved canals. When instrument separation occurs, the clinician has the choice of leaving the instrument in the canal or attempting to remove it either surgically or nonsurgically.

Several factors need to be weighed when determining whether an attempt should be made to retrieve the separated instrument. Such factors include the position in the canal at which separation occurred, the amount of potential irritant remaining in the canal, and the amount of damage that would be caused to the remaining tooth structure if instrument removal were attempted, the diameter, length and position of the obstruction within a canal and the type of the metallic object. Crump and Natkin used statistical methods to show that separated instruments did not adversely affect the success rate of endodontic cases. Many clinicians associate "broken instruments" with separated files, but the term could also apply to a sectioned silver point, a segment of a lentulo, a Gates Glidden drill, a portion of a carrier-based obturator, nails, pencil leads, toothpicks, hat pins, needles or other metallic objects and any other dental material left inside a canal. These were listed in 1987 by Chenail and Teplitsky [1]. With the advent of rotary nickel-titanium (NiTi) files, there has been an unfortunate increase in the occurrence of broken instruments, and the factors contributing to breakage have been identified.

There are three possible outcomes that may be encountered when treating these cases of instrument seperation: (i) Retrieval, (ii) Bypass and sealing the fragment within the root canal space, (iii) True blockage. Today, separated instruments can usually be removed due to technological advancements in vision, ultrasonic instrumentation and microtube delivery methods.

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Specifically, the dental operating microscope allows clinicians to visualize most broken instruments, and fulfils the age-old adage, "If you can see it, you can probably do it." [2].

Factors Influencing Broken Instrument Removal: Instruments located in the straight portion of the canal can usually be removed. If the broken instrument segment is apical to the curvature of the canal and safe access cannot be accomplished, then removal is usually not possible and in the presence of signs or symptoms, surgery or an extraction will at times be required. The type of material comprising an obstruction is another important factor to be considered.

For example, stainless steel files tend to be easier to remove, as they do not further fracture during the removal process. Nickel-titanium broken instruments may break again, albeit deeper within the canal, due to heat buildup during ultrasonic efforts. Whether a separated file's cutting action was clockwise versus counter clockwise is important to visualize and know, as this factor will influence the correct ultrasonic removal technique. Another factor that is central to successful instrument removal is integrating the best presently developed and proven technologies. Traditionally, retrieving broken instruments posed formidable challenges. One time-honored technique has been the use of small files to either remove, or at least bypass, the broken instrument [3]. Over time retrieval techniques evolved, but were often ineffective because of limited vision and/or restricted space.

Frequently, efforts directed toward instrument retrieval, even when successful, weakened a root with overzealous canal enlargement, which in turn predisposed to a hopeless fracture and the loss of a tooth. Indeed, the prognosis of a tooth can be seriously compromised if the efforts to remove a broken instrument lead to iatrogenic events, such as a ledged canal or root perforation. When retrieval efforts are unsuccessful, cleaning, shaping, and obturation procedures are compromised, and the ultimate prognosis is in doubt. In such cases, prognosis following an endodontic therapy depends on the condition of the root canal (vital or nonvital), tooth (symptomatic or asymptomatic, with or without periapical pathology), level of cleaning and shaping at the time of separation, the level of separation in the canal; and is generally lower than that with normal endodontic treatment. Hence every attempt should be made to bypass or retrieve the separated instrument.

The orthograde retrieval depends on cross-sectional diameter, length, curvature of the canal; dentin thickness and morphology of the root; composition, cutting action (clockwise or counter clockwise) of the instrument; length, location, and amount of binding or impaction of the fragment in the canal [4]. Today, most broken instruments can be safely and efficiently removed with the use of advanced technologies and proper training. Leaving a fractured instrument inside the root canal coupled with incomplete obturation or ineffective coronal seal may lead micro-organisms to penetrate inside the canal and develops periapical lesion. Thus establishment of straight-line access to the target object often requires removal of considerable amounts of radicular dentine, which can lead to failure. Although some studies have reported relatively good rates of success in removing fractured instruments, a recent survey showed that 61.8% of dentists had experienced complications during or after the removal of fractured files. The most common complication reported was the excessive removal of tooth structure. This process can reduce root strength by 30–40% and may predispose the tooth to vertical root fracture. This can lead to the extraction of single rooted teeth and amputation or hemisection of multirooted teeth [5].

DISCUSSION

One of the most troublesome incidents is the fracture of endodontic instruments within root canal. Many objects have been reported to break and subsequently become lodged in root canals. The removal of foreign objects sometimes is difficult and the success rate has been reported as 55% to 79%. Several methods are described to remove broken instruments or objects within root canals. The evaluation of fractured instrument removal systems and techniques such as the Masserann Kit, Endo Extractor, wire loop technique, the Canal Finder System, and ultrasonic devices have all shown limitations [6]. The limitations of these devices include excessive removal of root canal dentin, ledging, perforation, limited application in narrow and curved roots, and extrusion of the fractured portion through the apex.

A number of treatment protocols for removing obstructions have been described in the literature. Earlier authors have suggested that the object, regardless of the primary endodontic diagnosis, should be left in the canal, and that the canal coronal to the object should be treated according to standard endodontic procedures [7]. Others have suggested that the object should be bypassed and incorporated into the root filling material. Surgical techniques for removal of either the object itself or the entire portion of the root encompassing the object have been recommended.

In addition, several authors have introduced special instruments and techniques for intradental retrieval of the obstructing object. However, the removal procedure might result in loss of considerable tooth structure and clinical complications such as root perforation. Thus it is important to assess the impact on prognosis of a retained fractured instrument so that it can be compared with the risk of damage during attempted removal [8]. Various techniques to remove these instruments from root canal have been explained in dental literature [9,10].

a) Use of Stieglitz pliers to remove the silver points.
b) Grossman has suggested that chloroform or xylol can be used to soften the gutta-percha which is then easily removed with a file or a barbed broach.
c) Riog Green demonstrated the use of a simple device consisting of a disposable 25-gauze dental needle, a segment of thin steel wire and a small mosquito hemostat to remove silver cones from the root canals.
d) Fors and Berg described a technique that required removal of internal root structure before the instrument is removed.
e) Williams and Vjirndal described the Masserann technique to remove the fractured post.
f) Ultrasonic scaler has been used to remove solid objects from the root canal.
g) Meidinger and Kahes successfully used the Cavi-Endo ultrasonic instruments to remove a broken bur tip and amalgam particles from the intracanal spaces.
h) Taintor et al. described various methods for the removal of silver cones.
i) Micro tube removal systems like Lasso and Anchor, Tube and Glue, Tap and tread, Endo extractor removal system.

The operative microscope and Instrument Removal System (iRS) have successfully overcome the drawbacks of earlier techniques to some extent. The use of Instrument Removal System considerably causes less damage to radicular dentin and it is comfortable for the operator.

Techniques for Broken Instrument Removal

Prior to commencing retrieval efforts, special attention is directed toward preoperative radiographs and working films to better appreciate the thickness of the dentinal walls and if present the depth of an external concavity. Coronal access is the first step in the removal of broken instruments. High-speed, friction-grip, surgical-length burs are selected to create straight-line access to all canal orifices. Special attention should be directed toward flaring the axial wall that approximates the canal holding the broken instrument in efforts to subsequently improve microsonic techniques below the orifice [11]. With safety in mind, radicular access is the second step required in the successful removal of a broken instrument. If radicular access is limited, hand files are used serially small to large, coronal to the obstruction, to create sufficient space to safely introduce Gates Glidden (GG) drills.

GGs are rotated at speeds ranging between 800 to 900 rpm and, importantly, are used like "brushes" to create additional space and maximize visibility coronal to the obstruction. Increasingly larger GGs are uniformly stepped out of the canal to create a smooth-flowing funnel that is largest at the orifice and narrowest at the obstruction. GG drills should be limited to the straightaway portions of the canal, with no effort made to carry them around the curve in the event the instrument lies apical to the curvature [12]. A GG-1 (0.50 mm) or GG-2 (0.70 mm) can usually be carried to the depth of the separated instrument. The GGs are used cautiously in approximation to the obstruction with attention to brush-cutting out of the canal and away from furction danger. Relocating the coronal one third of a canal away from the furcation reduces the potential for root thinning or a strip perforation, and improves straight-line radicular access. The GG-3 (0.90 mm) is carried short of the level where the GG-2 was used and in furcated teeth, the GG-4 (1.10 mm) is confined to a depth of no more than one bud length below the orifice [13].

Importantly, radicular access should be performed so that the canal is pre-enlarged and ideally shaped no bigger than it would otherwise be prepared if there was no broken instrument obstructing the canal. When the canal has been optimally shaped, then microsonic techniques may be employed to remove a broken file segment. At times, when an ultrasonic instrument is introduced into a pre-enlarged canal, its activated tip does not have enough space lateral to the broken file segment to initiate trephining procedures [14]. As such, if greater access is required lateral to the most coronal aspect of the obstruction, the bud of a GG can be "modified" and then used to create a circumferential "staging platform"

The staging platform is made by selecting a GG drill whose maximum cross-sectional diameter is slightly larger than the visualized instrument. The bud of the GG drill is altered by cutting it perpendicular to its long axis at its maximum cross-sectional diameter [15]. The modified GG drill is gently carried into the pre-enlarged canal, rotated at a reduced speed of 300 rpm, and directed apically until it lightly contacts the most coronal aspect of the obstruction. This clinical step creates a small staging platform that facilitates the introduction of an ultrasonic instrument. When properly performed, straight-line coronal and radicular access, in conjunction with magnification and lighting, should enable the clinician to fully visualize the coronal-most aspect of a broken instrument. To facilitate excellent vision to the intra-radicular obstruction, the canal should be vigorously flushed and thoroughly dried prior to beginning ultrasonic procedures. When the canal has been optimally shaped, then microsonic techniques may be employed to remove a broken file segment. At times, when an ultrasonic instrument is introduced into a pre-enlarged canal, its activated tip does not have enough space lateral to the broken file segment to initiate trephining procedures. As such, if greater access is required lateral to the most coronal aspect of the obstruction, the bud of a GG can be "modified" and then used to create a circumferential "staging platform." [16].

The Masserann Kit

It is an instrument (Fig 1.) that was designed to remove metallic objects from the root canals. It is limited in its application because it uses rigid and relatively large trepan burs and extractors. It has been used for over 30

years as a device for removing broken instruments and a success rate of 73% and 44% has been reported regarding its use in anterior and posterior teeth respectively. However, it needs frequent radiographic monitoring. It has limited application in teeth with thin roots, curved roots or in retrieving instruments which fractured apically, as the use of relatively large and rigid trephans leads to removal of considerable amount of root dentin and weakening of the teeth or risk of perforation. [17] This kit is very useful in removing metal obstructions from anterior teeth having thick, straight roots. Moreover, the locking mechanism of the extractor provides considerable retention in gripping and dislodging an obstruction which is tightly wedged in the canal. Obtaining a straight-line access to the fragment facilitated centering of the trephan over the fragment is essential. This ensured circumferential freeing of the coronal end of the fragment with safe cutting of the peripheral dentin around the fragment. This in turn promoted tight gripping of the fragment and its retrieval along the long axis of the root, thus allowing regular retreatment [18].

Piezoelectric Ultrasonics

The Satelec P5 (Dentsply Tulsa Dental) is the piezoelectric ultrasonic unit of choice for performing endodontic treatment and re-treatment procedures. This unit affords precise working accuracy and has a broad power range and its unique "feedback" system measures tip resistance, regulates tip movement, and reduces the potential for tip breakage [19].

Pro Ultra Endo 3, 4, 5 Tips

The Pro Ultra Endo tips (Dentsply Tulsa Dental) afford a clinical breakthrough in nonsurgical ultrasonic instrumentation, as their contra-angled and parallel walls improve vision when working below the orifice. Additionally, the Endo-3, 4, and 5 are stainless steel instruments coated with zirconium nitride to improve durability and cutting efficiency (Fig 2.). Importantly, zirconium nitride resists corrosion regardless of the irrigant employed, does not flake off during use, and provides safe efficiency when performing delicate and precise intracanal procedures, as compared with more aggressive diamond coatings. The Pro Ultra instruments are used on the lower power settings, and have been designed to intentionally work dry [20].

Pro Ultra Endo 6, 7, 8 Tips

The Endo-6, 7, and 8 ultrasonic instruments are made of titanium to provide clinicians with thinner diameters and longer lengths than the Endo-3, 4, and 5 (Fig 3.). These instruments are utilized on the lower power settings, work dry, and are employed to perform procedures in deeper spaces where access is more restrictive [21].

Instrument Removal System

Presently, an innovative mechanical device known as the Instrument Removal System (iRS) has been developed for the retrieval of broken instruments in more restrictive spaces. The iRS is a new two-component system designed to mechanically engage broken instruments. Each microtube has a small plastic handle to enhance vision during placement, a side window to improve mechanics, and a 45° beveled end to "scoop up" the coronal end of a broken instrument. Each screw wedge has a knurled metal handle, a left-handed screw mechanism, and a solid cylinder that becomes tapered toward its distal end to facilitate engaging an obstruction [22].

Post Removal System (PRS): The PRS kit contains several component parts that may be utilized to mechanically form threads and engage any obstruction whose diameter is 0.6 mm or greater **(**Fig 4.).Specifically, the No. 1 and No. 2 taps will often grasp intracanal obstructions that extend into the pulp chamber, such as a silver point or carrier-based obturator. The PRS contains certain microtubular taps that allow the clinician to form threads and mechanically engage the most coronal aspect of any obstruction whose diameter is 0.6 mm or greater. These microtubular taps contain a reverse thread and engage an obstruction by turning in a counter clockwise motion.

The outside diameter of the smallest microtubular tap generally limits its use to the coronal one third of larger canals; however, these microtubes can tap, form threads, and engage a variety of radicular obstructions that extend coronally into the pulp chamber. The instrument with the black handle is 19 gauge (1 mm), and is designed to work in the coronal one third of larger canals, whereas the instrument with the red handle is 21 gauge (0.80 mm), allowing it to be placed deeper into more narrow canals. Each complete instrument is composed of a color-coordinated microtube and screw wedge. A black- or red-handled microtube is then selected that can passively slide through the pre-enlarged canal and drop over the exposed broken instrument [23]. In a curved canal, it is axiomatic that the head of a broken NiTi file will always lie against the outer wall. In these instances, the microtube is inserted into the canal with the long part of its beveled end oriented to the outer wall of the canal to "scoop up" the head of the broken instrument and guide it into the microtube. Once the microtube has been positioned, the same color-coded screw wedge is inserted and slid internally through the microtube's length until it contacts the obstruction. The obstruction is engaged by gently turning the screw wedge handle counter clockwise. A few degrees of rotation will serve to tighten, wedge, and often displace the head of the obstruction through the microtube window. If a screw wedge with a specifically marked color is unable to achieve a strong hold on the obstruction, then the other gauge and color-coded screw wedge should be selected to

encourage engagement and removal. When engaged, the obstruction is removed by rotating the microtube and screw wedge assembly out of the canal. Caution should be used to not over-thread an obstruction, such as a silver point, so it does not bottom-out and shear off inside the lumen of the tap. Once the obstruction is securely engaged by the microtubular tap, the extracting plier is utilized with a protective bumper to cushion the removal force. The iRS is indicated when ultrasonic efforts prove to be unsuccessful, and may be used to remove broken instruments that are lodged in the straightaway portions of the root or partially around the canal curvature [24].

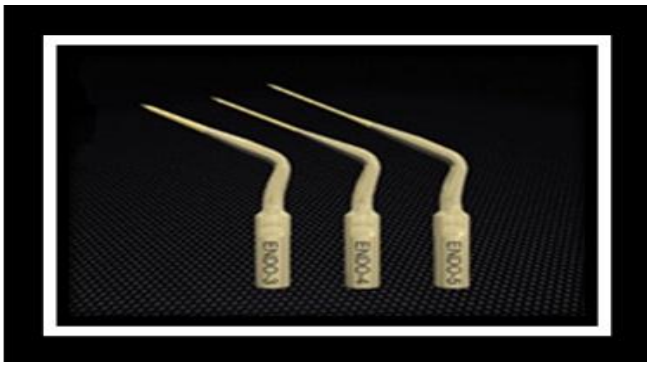
Magnification and Lighting

Magnification glasses, headlamps, fiber-optic transilluminating devices, and dental operating microscopes contribute to better vision. Specifically, the microscope provides options in magnification and coaxial light to promote superior vision. The microscope is a practice-building instrument that promotes professional growth, improves technical results, and distinguishes a practice in its community [25].

Figure 1. Masserann Extractor Along With Removed Fragments

Courtesy: Ruddle CJ. Broken instrument removal. The endodontic challenge. Dent Today 2002.

Figure 2. Pro Ultra Endo 3, 4, 5 Tips

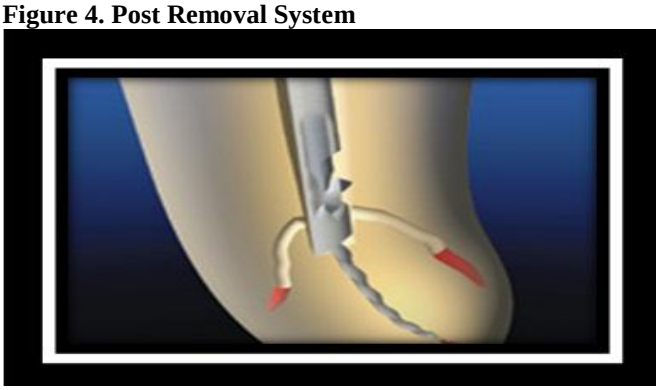


Courtesy: Ruddle CJ. Broken instrument removal. The endodontic challenge. Dent Today 2002.

Figure 3. The Pro Ultra Endo 6, 7, 8

Courtesy: Ruddle CJ. Broken instrument removal. The endodontic challenge. Dent Today 2002.

Figure 4. Post Removal System



Courtesy: Ruddle CJ. Broken instrument removal. The endodontic challenge. Dent Today 2002.

CONCLUSION

Prevention is the best antidote for a separated file in the canal. Adhering to proven concepts, combining the best strategies and making use of safe techniques during root canal preparation procedures will virtually eliminate the separated instrument procedural accident. Separation of instrument can be prevented if the instruments used for negotiating and cleaning and shaping the root canal are disposed and not reused. Discarding all instruments after the completion of each endodontic case will reduce breakage, lost clinical time, and upsets caused by procedural accidents. However, on occasion, an instrument might break and in spite of the best existing technologies and techniques, the retrieval may not be successful. In these instances, and in the presence of clinical symptoms and/or radiographic pathology, surgery or extraction may be the best treatment option.

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