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Review Article

Instrument Retrieval in Endodontics

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ABSTRACT

Root canal preparation is an important step in endodontic treatment and thorough debridement of the root canal system is essential for successful clinical outcome. Debridement should remove all the pulp tissue, bacteria and their by-products and provide adequate canal shape to fill the canal. Procedural errors such as ledging, zipping, canal perforation, apex transportation and separation of endodontic instruments can occur during root canal instrumentation. This prevents the achievement of efficient cleaning and shaping, which in turn can result in under-filling of the root canal.

The purposes of this narrative review of separated instruments was to review the literature regarding treatment options, contributing factors and suggest a decision-making process for its management.

Introduction

Separation of endodontic instruments is a problematic incident that prevents the achievement of efficient cleaning and shaping, which in turn can result in under-filling of the root canal in the practice of endodontics [1]. Fractured root canal instruments may include endodontic files, GatesGlidden burs, lateral or finger spreaders, and paste fillers and they can be made from nickel-titanium (NiTi), stainless steel or carbon steel. Fracture often results from incorrect use or overuse of an endodontic instrument[2], and seems to occur most commonly in the apical third of a root canal.The relatively recent advent of rotary NiTi root canal instruments has led to a perceived high risk of instrument fracture[3]. Furthermore, fracture of rotary NiTi instruments may occur without warning even with brand new instruments[4].Whereas fracture of stainless-steel files is preceded by instrument distortion serving as a warning of impending fracture. In any case, distortion of rotary NiTi instruments is often not visible without magnification.

The difficulty in removing fractured instrument fragments and a perceived adverse prognostic effect of this procedural complication is a main reason for resistance to adoption of rotary nickel-titanium technology[3]. Consequently, a great deal of research has been undertaken to understand the reasons for instrument fracture and how it may be prevented rather than treated. The purpose of this review is to summarize current understanding of the prevalence, causes, management of instrument fracture and its impact on prognosis, and to make recommendations concerning clinical decisionmaking associated with fractured rotary NiTi instruments.

Methods: An online search was conducted in journals listed in PubMed to retrieve clinical and experimental studies, case reports, and review articles by using keywords. After studying a series of related articles and publications we have reviewed and compared the different conservative treatment options for the management of intracanal fractured instruments

Prevalence and incidence of fractured instruments

During root canal therapy NiTi rotary files are preferred over stainless-steel files due to their shape memory, super elasticity, biocompatibility and corrosion resistance. The disadvantage of NiTi alloy is the low ultimate tensile and yield strength as compared to stainless steel, making it more

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susceptible to fracture[5]. A prevalence of retained fractured instruments between 0.7 and 7.4% in teeth undergoing root canal treatment (RCT) was revealed.It is most frequently reported in molars with similar instrument fracture rates for the maxilla and the mandible.The probability of file fracture in the apical area was estimated to be 33 times greater compared to the coronal third of the canal and almost six times greater when compared to the middle third of the root canal. However, the variability of fracture prevalence is wide for both materials, which has been attributed to the number of uses of the instrument and/or the operators skill/ experience level[6,7].

The overall reported incidence rate of fractured hand instruments range between 0.25 and 6%. The common perception is that NiTi rotary instruments have a higher failure incidence than SS hand instruments[8]. A very low fracture incidence was found with instruments with a reciprocation motion.

Factors Predisposing to Fracture

Rotary NiTi instrument fracture occurs because of incorrect or excessive usewhich stresses the importance of correct training in the use of rotary NiTi technology[9]. However, many factors have been linked to the propensity for fracture of rotary NiTi instruments and these can be grouped under a number of subheadings, as follows.

1.Operator skills/Experience

Operator experience is a consistently reported factor in relation to the incidence of clinical instrument fracture. When other factors (instrument speed and sequence, canal morphology) remained constant, the ability of the operator was the key factor in instrument failure[10]. The importance of the operator has been corroborated in other studies.However, no significant difference in fracture rate was also reported between experienced and inexperienced operators, a finding that was attributed to the allocation of complex cases to the more proficient operator.

2.Significance of instrumentation technique

A crown-down instrumentation technique (enlarging the coronal aspect of the canal before apical preparation) and creation of a manual glide path (preparing the canals manually with a SS file to working length before rotary NiTi instrumentation) has been proposed to reduce the frequency of instrument fracture[11]. These techniques aid in reducing instrument ‘taper lock’ or ‘instrument jamming’ which is associated with torsional fracture.

3.Dynamics of instrument use

A.Torque

Torque is a less straight forward parameter than rotational speed. It is a measure of the turning force applied to the instrument in order for the instrument to overcome friction and continue rotating. The contact area is mainly affected by the size, taper, and cross-sectional shape of both the instrument and the root canal; a wider contact area increases friction, so higher torque is necessary in order for a larger instrument to rotate inside a narrow root canal[12].

B. Rotational speed

The effect of rotational speed on fracture remains to be elucidated, with some studies reporting rotational speed to have no influence on fracture incidence[1,24].while others reported the opposite.However, manufacturers generally recommend a specific number of rotations per minute (rpm) for the safe use of rotary NiTi instruments, which is usually in the region of 250-600 rpm[13].

4. Canal geometry and tooth type

The probability of separating a file in the apical regions was thirty-three times greater than in the coronal-third and six times greater than the middle-third of the root. The observed increase in file fracture in the apical third of root canals was corroborated in other studies.

Additionally, the probability of fracturing an instrument in the mesiobuccal canal of a maxillary molar was three times greater than the distobuccal canal; similarly the probability of fracturing a file in the mesiobuccal canal of a mandibular molar (known for their greater curvature) was greater than the mesiolingual canal[7].

5.Effect of cleaning and sterilization

It has been postulated that the corrosive effect of the root canal irrigant sodium hypochlorite (NaOCl) may have a negative impact on the mechanical properties of NiTi instruments.Some studies have shown that sterilisation does not adversely affect endodontic instruments. Although others reported slight or significant adverse effects of sterilisation, it was confirmed that these adverse effects are not of clinical importance[14].

6.Instrument design

A.Cross-sectional dimensions and design

It has been demonstrated that enhancing the diameter and cross-section of a file provides increased resistance to torsional failurebut conversely reduces resistance to flexural fatigue failure[2].Crosssectional design may also be an important factor with regards to fracture incidence. Triangular ProTaper files were compared to U-fluted ProFile instruments and it was demonstrated that stress distribution was lower and more evenly distributed in the ProTaper instruments[15].

B.Instrument size

A higher incidence of fracture and distortion in smaller NiTi instruments has been recorded in a number of in vitro studies.Certain investigatorshave concluded that smaller instruments are more susceptible to torsional failure than larger instruments and have recommended that small files (eg 0.04 taper ProFile size 20) should be considered as a single use instrument, such is the likelihood of distortion[16].

Recommendations for the prevention of file fracture

Several of the factors which contribute to file fracture particularly of NiTi files can be minimised by the implementation of prevention guidelines[17]. Preventative measures not only reduce the probability of fracture, but also obviate the need for difficult management decisions and awkward patient conversations. The following recommendations have been suggested for the use of NiTi file systems:

• Ensure adequate training and proficiency in the NiTi system of choice before clinical use by practicing on extracted teeth or resin blocks.

• Create a manual glide path (K-file, size 10–15° or NiTipathfiles™ (Dentsply Maillefer, Ballaigues) to ensure unimpeded access to the root canal, before use of greater taper NiTi files.

• Employ a crown-down instrumentation technique to ensure straight-line access to the root canal.

• Use an electric speed and torque-controlled motor at the manufacturer's recommended setting.TheNiTi files should be used in constant motion using gentle pressure to avoid placing excessive torsional forces on the instrument[2]

• Avoid triggering or disable the autoreverse mode or disable the autoreverse feature on the motor, as it increases the risk of torsional fatigue[8].If not obligated to adopt a singleuse file policy ,consider adopting a personal policy to prevent overuse of files. Files used in particular challenging root morphology should be considered for early replacement or discard.

• Use of rotary files in abruptly curved or dilacerated canals should be avoided.

Management of fractured instruments

Management of separated instruments includes orthograde or surgical approaches. Orthograde approaches are as follow: attempts to remove the fragment, attempts to bypass the fragment, or cleaning/shaping and filling of the root canal to the level of the fragment.

Techniques for removal:

1. Chemical Solvents

The use of EDTA has been suggested as a method of softening root canal wall dentin around separated instruments, facilitating the placement of files for the removal of the fragment.Other chemicals such as iodine trichloride, nitric acid, hydrochloric acid, sulfuric acid, crystals of iodine, iron chloride solution, nitrohydrochloric acid, and potassium iodide solutions have historically been used to achieve intentional corrosion of metal objects[18].However, for obvious reasons, such as irritating the periapical tissue, they are no longer in use.

2. Mini Forceps

In the presence of sufficient space within the root canal system, an instrument separated in a more coronal portion of the root canal can be grasped and removed by using forceps[19] such as Steiglitz forceps (Union Broach, York, PA), Peet silver point forceps (Silvermans, New York, NY), or Endo Forceps (Roydent, Johnson City, TN).

3. Broach and Cotton

If the separated fragment is a barbed broach and not tightly wedged in the root canal, another small barbed broach with a small piece of cotton roll twisted around it can be inserted inside the root canal to engage the fragment; then the whole assembly is withdrawn[19].

4. Hypodermic Surgical Needles

The beveled tip of a hypodermic needle can be shortened to cut a groove around the coronal part of the fragment by rotating the needle under light apical pressure. The needle size should allow its lumen to entirely encase the coronal tip of the fragment (Fig. 1), which guides the needle tip while cutting so as to remove the minimum amount of dentin[20].Counterclockwise rotation may enhance removal of instruments with right-hand threads and

vice versa.

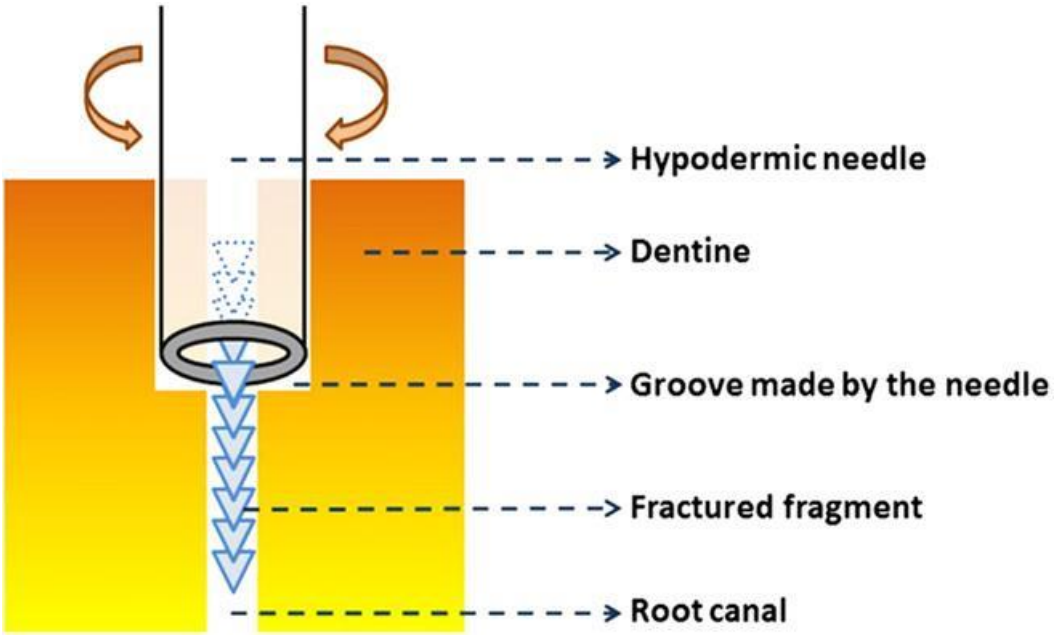

Figure 1. The shortened tip of a hypodermic needle is rotated in a counterclockwise or clockwise direction (under light apical pressure) to cut a groove around the coronal part of the fractured fragment. As the needle advances apically, its lumen encases the coronal tip of the fragment

Fig.2a ProUltra ENDO Tips (Dentsply Tulsa Dental, Tulsa, OK)

5. Braiding of Endodontic Files

A Hedstreom or K-type file(s) can be inserted into the root canal to engage with the fragment and then withdrawn. This method can be effective when the fragment is positioned deeply in the canal and not visible and the clinician is relying on tactile sense, or the fragment is loose but cannot be retrieved by using other means[21,22]. The largest possible size of files should be used with caution because of the possibility of separation of the braided files.

6. Masserann Instruments

The Masserann kit (Micro-Mega, Besanc¸on, France) consists of 14 hollow cutting-end trephine burs (sizes 11–24) ranging in diameter from 1.1–2.4 mm and 2 extractors (tubes into which a plunger can be advanced). The trephines (burs) are used in a counterclockwise fashion to prepare a groove (trough) around the coronal portion of the fragment. When inserted into the groove and tightening the

Fig.2 b Ultrasonic unit

screw, the free part of the fragment is locked between the plunger and the internal embossment. The relatively large diameters of extractors (1.2 and 1.5 mm) require removal of a considerable amount of dentin, which may weaken the root and lead to

perforation or postoperative root fracture[23].

7. Canal Finder System

The original Canal Finder System (FaSociete Endo Technique, Marseille, France) consisted of a handpiece and specially designed files. The system produces a vertical movement with maximum amplitude of 1–2 mm that decreases when the speed increases . It effectively assists in bypassing a fragment, but caution should be exercised not to perforate the root or apically extrude the fragment, especially in curved root canals. The flutes of the file can mechanically engage with the separated fragment, and with the vertical vibration, the fragment can be loosened or even retrieved[24].

In a clinical study that used the Canal Finder System as the primary retrieval technique, a 68%

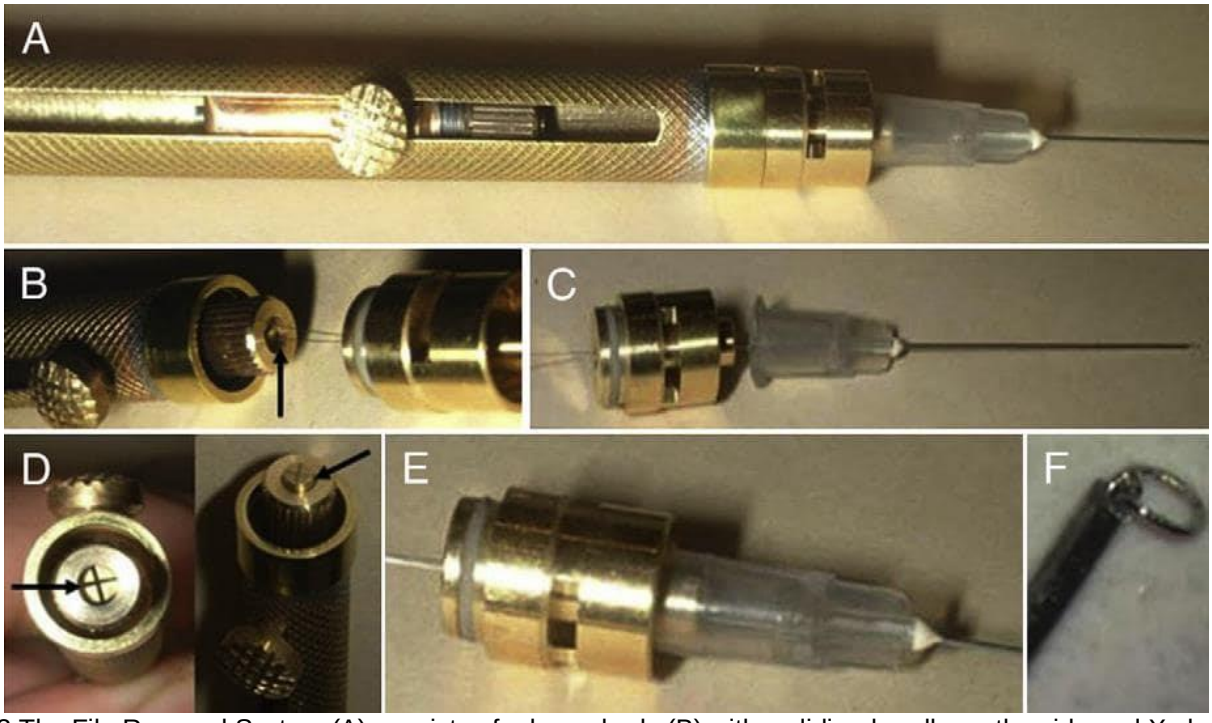

Fig.3 The File Removal System (A) consists of a brass body (B) with a sliding handle on the side and X-shaped hole on the top (black arrows) (D). Thelatterembraces the double NiTi wire passing through the attachment (C and E) (a head connected to a disposable tube) (C); thus the loop is formed and ready to engagethe fragment (F). (Courtesy of Dr Yoshitsugu Terauchi.)

overall success rate was reported.

8.Ultrasonic

Ultrasonic instruments have a contra-angled design with alloy tips of different lengthsand sizes (Fig.2a) to enable use in different parts of the root canal. A staging platform is prepared around the most coronal aspect of the fragment by using modified Gates Glidden burs (no. 2–4) or ultrasonic tips. The ultrasonic tip is activated at lower power settings (Fig.2b), so it trephines dentin in a counterclockwise motion around a fragment with right-hand threads and vice versa. If little care is taken and excessive pressure on the ultrasonic tip is applied, the vibration may push the fragment apically or the ultrasonic tip may fracture, leading to a more complicated scenario [25,26].

9.File Removal System

This system has been developed by Terauchi Y et al (2007)[27] and it is claimed that the amount of dentin removed is minimal. It involves 3 sequential steps that use specially designed instruments (Fig. 3).

Summary

The decision on management should consider the following: the stage of root canal instrumentation at which the instrument separated, the expertise of the clinician, armamentaria available, possible associated complications, the strategic importance of the tooth involved, and the presence/or absence of periapical pathosis. Clinical experience and understanding of these influencing factors as well as the ability to make a balanced decision are essential

First management option should be removal of fragment when the following is true:

- The fragment is accessible (located in the coronal third, middle coronal part of the root canal, or before the canal curvature).
- There is a low risk of further complications.
- The tooth is strategically important.
- The instrument separated at an early stage of root canal cleaning and shaping.
- The clinician is well trained or has sufficient experience.

A second approach of bypassing the fragment should be considered if removal attempt(s) fail
Leaving the fragment in situ, filling the root canal to the fragment level, and reviewing the case can be considered in the following circumstances:

- As a last conservative approach when attempts at removal and bypassing of the fragment are unsuccessful.
- As a first approach if the clinician is not confident or competent at other conservative options.
- As a first approach if the instrument separated at a late stage during root canal cleaning and shaping in inaccessible part of the canal.

Surgical approaches can be considered in the following situations:

- As a last resort if other conservative approaches fail, post-treatment disease developed, and the tooth is strategically important.
- As a first approach when periapical pathosis is present at the time of instrument separation, especially if the separation occurred at an early stage of instrumentation.

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