CASE REPORT

Precursors and Consequences of Endodontic Instrument Separation: A Case Series

Omprakash Dulhani, Amoolya Teja N
Army Dental Corps, Delhi Cantonment, New Delhi, India

Email for correspondence: dromprakashdulhani@gmail.com

ABSTRACT

Every dental clinician who has treated many root canals has encountered the separation of tip of file, broach or a reamer. It is a matter of fact that as we undertake the task of preparation of curved/narrow/tortuous canal, there is an accepted heightened chance of endodontic instrument separation. Clinician skill is main contributory factor in separation as well as management of separation cases. Bypassing the separated instrument fragment is a reasonable technique for management of instrument separation, it offers a favorable prognosis, of the root canal treatment with basic minimum armamentaria, without unnecessary loss of dentin thereby long-term rehabilitation of tooth has better chances compared to the intricacies of retrieval.

Key words: Bypassing, separation, instrument, fatigue

INTRODUCTION

The primary requisites of root canal treatment (cleaning and shaping, followed by a good quality obturation) get compromised once an instrument gets separated in the root canal system. The incidence of separation of NiTi rotary instruments is similar to SS hand instruments, in the range of 0.4–5%. It is worth noticing that 0.9% of previously unused NiTi instrument gets separated during their first use, probably due to misuse/manufacturing defect.[1] Instrument mishap results from incorrect use or overuse of an endodontic instrument. Separation of rotary NiTi instruments may occur without warning, even with brand new instruments, whereas separation of SS files is preceded by instrument distortion serving as a warning of impending fracture.[2-4]

Grossman substantiated Strindberg's speculation and reported that prognosis is compromised only in cases of retained instruments with concomitant periapical pathology.[5] Instrument fragment may indirectly compromise the prognosis by hindering the access to apical portion of canal, leading to compromised cleaning, shaping and obturation. Management of separated endodontic instruments includes retrieval of the fragment or to bypass the fragment. Ideal way to manage instrument separation is to retrieve the separated instrument without sacrificing significant dentin structure and maintaining the strength of the tooth. Furthermore, it must be noted that the retrieval of separated instrument is one of the most intricate procedure to be performed in endodontics, requiring operative skills, specialty armamentarium, and patience. The dentinal structure loss during retrieval procedure can lead to ledge formation, this ledge acts as the area of stress concentration, and subsequently, it may acts as the precursor of perforation or vertical fracture. The long-term objective of management of separated instruments is not only to retrieve/bypass the separated fragment, but also to preserve the integrity and strength of the tooth. In view of the iatrogenic errors, which can occur during retrieval procedure and compromise the overall prognosis, bypassing the fragment can be the suitable treatment option.

Quick Response Code

Article Info:

doi: 10.5866/2023.13.10028

Received: 19-11-2022
Revised: 13-12-2022
Accepted: 16-01-2023
Available Online: 02-04-2023, (www. nacd. in)

Factors Responsible for Endodontic Instrument Separation[2-4]

Fatigue signs, before instrument separation are usually seen in SS instruments but not in NiTi

instruments, probably due to shape memory. NiTi alloy has more flexibility and better resistance to torsional fracture, compared to SS instruments. However, the low yield and tensile strength of NiTi, predispose to separation at lower loads. Separation of SS instruments is generally due to overuse and rotary NiTi instruments separate as a result of cyclic flexural fatigue and/Or torsional fatigue.

Cyclic flexural fatigue – Occurs when a curved canal is being instrumented and the file rotates along its own axis, repeated tension, and compression cycles that the instrument undergoes inside a canal curvature, leads to cyclic fatigue and ultimately to separation.

Torsional fatigue – Occurs when the tip of rotating instrument gets entrapped in the canal walls, but the shank continues to rotate, as a result the elastic limit of the alloy is exceeded, leading to instrument separation. The rate of file fractures increases as the radius of the root canal curvature decreases.[3]

Operator Skill and Experience

Keeping the other factors at par, the training and skills of the clinician are the key factor, causing a variation in the prevalence of instrument separation rates across studies.

Instrument factors

A. Separated Fragments: Intracanal separated H-files are difficult to retrieve, in comparison to K-files, attributing to larger helix angle and positive rake angle of the flute design for H-files. NiTi file fragments are separated in shorter lengths, and thread into root canal walls, making the retrieval difficult compared to SS rotary files. Due to their elastic memory NiTi files straighten out when they separate in curved canal.
B. Instrument Design: Smaller files are used for initial negotiation of canal to full working length, followed by initial instrumentation of canal, these files exhibit the greatest torsional stress and may thus be considered as single use instruments, such is the extent of distortion. With the increase in the cross-section and diameter of files, the files become more stiff, along with greater strength, to instrument the canals. Smaller instruments succumb to torsional fatigue, while larger instruments to cyclic flexural fatigue. Large clinical cohort studies have reported that, the greatest number of instrument failures occur while using larger cross-section files, establishing that large files have greater internal stress accumulation.[1,5]
C. Manufacturing Process: During the manufacturing and processing of NiTi files, environmental contamination of NiTi alloy occurs, formation of the oxides leads to the weakness of alloy at grain boundaries and subsequently the precipitation of cracks. Furthermore, when the alloy is machined for production of endodontic files, the surface microstructure of alloy is irregular with milling grooves, cracks, pits, and metal rollover. These irregularities of surface microstructure are the sites of stress concentration and cracks are initiated at these places. Cracks can be axial or transverse to the surface of the files. Defects on the surface microstructure, decides the ultimate strength of the endodontic files and is a deciding parameter of the fatigue resistance of the files.
D. Dynamics of Instrument Use: Torque controlled electric motors are used with light apical pressure, similar to a feather touch, in pecking motion and not pushing too hard. If the motor does not exceed the elastic limit of file and performs below the elastic limit of file, chances of the instrument separation are minimum, due to torsional failure. Repeated activation of auto reverse function in the motor, carries a risk of torsional fatigue and failure.
E. Canal configuration: File separation can occur either as a result of cyclic flexural fatigue or as a result of torsional fatigue. Torsional fatigue occurs when narrow canals are being instrumented or the canal diameter decreases suddenly. It has to be noted that, as the angle of curvature increases and the radius of curvature decreases, there is reduced number of cycles to instrument separation.
F. Preparation Technique: During cleaning and shaping of root canal system, some time we come across taper lock/instrument jamming and the familiar clicking sound, thereby generating higher torsional stress, as a result there can be torsional fatigue and subsequently instrument separation. Its recommended to follow crown down technique, and use orifice shapers (Initial rotary files)/orifice enlargers (Gates Glidden drills) to shape the coronal part of the canal, before cleaning and shaping the remaining portion of the canal, thereby preventing taper lock. Varying instrumentation sequences and

using combination of different tapers seemed to be safer regarding torsional and cyclic fatigue failure, but necessitates using a greater number of instruments.

G. Number of Uses: Till date, no study has conclusively established correlation between number of uses and frequency of file separation, particularly in respect of NiTi instruments where distortion of files is often not evident visibly before separation. It must be hereby stated that manufacturers recommend single use policy and have introduced features into files which distort on autoclaving, thereby preventing reuse.

H. Cleaning and Sterilization Procedures: Sodium hypochlorite neither affects the mechanical properties of NiTi Files, nor their cutting efficiency; however, measurable amount of corrosion occurs at a concentration of 5–5.25% of sodium hypochlorite.[5] It must here be taken into consideration that after multiple cycles of heat sterilization, NiTi files show decreased cutting efficiency, along with increase in depth of surface irregularities and crack initiation/propagation.[1] These evidences are clearer in terms of recent files which are manufactured by twisting rather than machining, with decreased cyclic fatigue resistance subsequent to multiple heat sterilization cycles. The sterilization cycle positively reverses the stress induced martensite state back to the parent austenite phase, provided the temperature required for this positive transformation is achieved in a clinical setting.

CASE REPORT

Case Report 1

A 32-years old woman presented with pain in the lower right back teeth region for the past 5 days. Pain was spontaneous and persistent. On clinical examination, tooth number 46 was shown to have advanced caries with suspected pulp involvement. The involved tooth was tender on percussion. Pre-operative radiograph was shown to have advanced caries with widened periodontal ligament space irt distal root. The patient was provisionally diagnosed to have apical periodontitis irt 46, by correlating the clinical and radiographic findings, and root canal treatment was planned. Anesthesia was achieved with inferior alveolar nerve block, and access opening was made, working length determined radiographically. Canals were prepared with ProTaper rotary files, during the completion of cleaning and shaping, F1 file was separated in mesiobuccal canal [Figure 1].

File separation occurred during the final stages of cleaning and shaping of a tooth with vital pulp; hence, bypass was planned and after few initial attempts separated instrument was bypassed with 06 K-file [Figure 2].

Subsequently, the mesiobuccal canal was prepared till F1 ProTaper hand file, along with other three canals. Canals were dried, closed dressing given and recall visit was scheduled after 3 days. On the next visit, patient being asymptomatic, obturation was done with cold lateral condensation method [Figure 3] and the patient is under observation for the last 5 years. The recall visits have been uneventful.

Figure 1: F1 ProTaper rotary file separated in the mesiobuccal canal of tooth 46

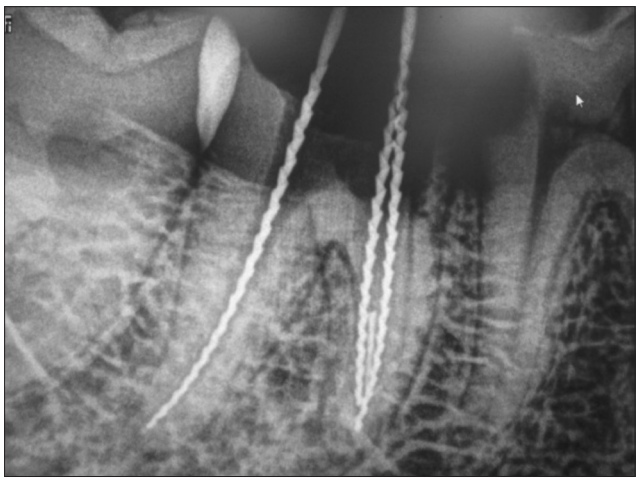

Figure 2: Separated instrument bypassed with size 06 K-File

Figure 3: Post-operative radiograph showing complete obturation that was done with cold lateral condensation method

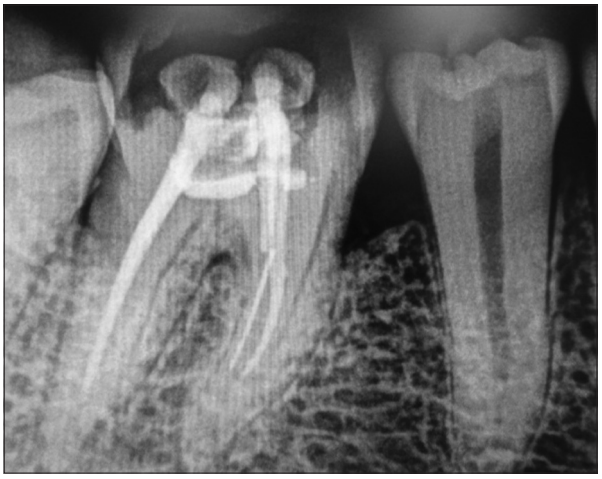

Figure 4: Tooth 46 with a separated endodontic instrument in the middle-apical region of mesial root

Case Report 2

A 41-years old woman presented with pain in lower right back teeth region for the past 15 days. Pain was spontaneous, severe, radiating to temple, and relieves by OTC analgesics. Patient gives a history of filling in the same tooth region 6 months back. Clinically, tooth no 46 had a huge restoration with tenderness on percussion. Radiographically, tooth reveals a failed root canal treatment along with a separated endodontic instrument in the middle-apical region of mesial root [Figure 4].

Subsequently, inferior alveolar nerve block was administered and a reentry in the chamber was made with access modified, and a straight line access was gained to the canals. Root fillings were removed from mesial and distal canals; moreover, additional fourth canal was located, in distal root by tracing the dentinal map. Separated endodontic instrument in the mesiobuccal canal was negotiated with 06 K-file, after few initial attempts [Figure 5].

Figure 5: Separated endodontic instrument in the mesiobuccal canal was negotiated with 06 K-file

Working length was recorded using apex locator. Cleaning and shaping were completed using crown down technique, along with copious irrigation using 5.25% of sodium hypochlorite and N-saline. All the four canals instrumented till apical preparation of 30. Calcium hydroxide inter appointment dressing was given, the patient was recalled after 2 weeks. At the next visit, patient was asymptomatic, calcium hydroxide dressing was removed using N-saline irrigation along with K-files. Canals were dried and obturation was completed with cold lateral condensation [Figure 6] and the patient is under observation for the last 5 years. The recall visits are uneventful.

Case Report 3

A 65-year-old man reported for having pain in upper left front teeth region, for 5–6 days. Pain was persistent. Patient also reported undergoing root canal treatment at some clinic. On clinical examination 23, it was tender on percussion. Radiographic examination shows a separated endodontic instrument in the apical third of the canal, measuring 2–3 mm. There is mild periapical haziness involving the same tooth, but no well-defined periapical lesion. On the same visit, local anesthesia was administered, access modified and straight line access was established [Figure 7].

Figure 6: Post-operative radiograph of 46 showing obturation that was done with cold lateral condensation method

Figure 7: Separated endodontic instrument in the apical third of the tooth 23, measuring 2–3 mm

Bypassing was planned and started with 06 K-file, after multiple attempts, bypass was achieved with 06 K-file, going successfully past the separated instrument [Figure 8].

Working length was recorded, cleaning and shaping, completed with Crown-down technique. Copious irrigation was done with 5.25% of sodium hypochlorite and N-Saline. Canals were shaped till apical preparation of 30. Inter appointment calcium hydroxide dressing was given for a week. At subsequent visit, obturation was done with cold lateral condensation and the patient is under observation for the past 1 year. The recall visits are uneventful [Figure 9].

Figure 8: Bypass was achieved with 06 K-file, going successfully past the separated instrument

Figure 9: Post-operative radiograph of 23 showing obturation that was done with cold lateral condensation method

DISCUSSION

Treatment protocols available post-endodontic mishap are entomb/bypass/orthograde retrieval/ surgical retrieval. Orthograde retrieval requires sacrificing dentine to gain access to the broken fragment, similarly in surgical retrieval, significant amount of tooth structure needs to be sacrificed, these loss of dentine structure may lead to poor long-term rehabilitative prognosis of the tooth, due to root perforation, root stripping, loss of tooth strength, and poor crown root ratio. The final decision whether to retrieve or to bypass the separated instrument is determined by making a judicious decision, by striking a balance between

amount of dentine which needs to be sacrificed and strength of root subsequently.[2] Final treatment is planned as per the dynamic treatment algorithm.

Specialty equipments for retrieval like Masseran Kit and Endo Extractor sacrifice significant amount of dentin structure, as such devices require the caliber burs to prepare the canal, before devices adaptation within the root canal, along with forming a straight line access to the fragment. Modalities for retrieval are intricate, difficult, and destructive procedures.[6] Straight-line access is mandatory for successful removal of instruments, but conservation of tooth structure is paramount to the tooth's resistance to fracture.[5] Clinically, the separated endodontic instruments, which can be visualized under the dental operating microscope without removal of any dentin or root canal straightening, are considered to be located before canal curvature. Radiological findings to precisely locate separated endodontic instrument in relation to canal curvature is not very promising, due to the 2D nature of radiographic image. At times, radiographs reveal the separated instrument to be located in the straight portion of canal, but clinically, they cannot be visualized without sacrificing significant amount of dentin structure, commonly seen in mesial canals of mandibular molars.[7] At present, there are no laid down criteria for safe retrieval. Latest technique used for retrieval utilizes ultrasonics, endodontic operating microscope, and microtube delivery methods. File removal generally results in ledge formation and therefore a possible stress concentration point.

The conservative approach of bypassing the separated fragment is based on tactile sensation and not the visibility of the fragment. An attempt to bypass the separated instrument should always be considered initially, as bypassing is usually successful. Prognosis after bypassing is more favorable, if the separation of instrument occurs at a point where initial debridement of canal has significantly been completed and vice versa.[5] Incorporation of separated fragment in the obturating material, significantly improves the case prognosis.[8]

The ideal management for instrument separation is prevention. Adhering to proven concepts, integrating best strategies and utilizing safe techniques during the root canal preparation procedures will virtually eliminate the broken instrument procedural accident. Prevention may also be greatly facilitated by thinking of negotiating and shaping instruments as disposable items. However, on occasion an instrument will break and in spite of the best existing technologies and techniques the broken file segment may not be able to be bypassed or retrieved.[9]

Prognosis, subsequent to separation depends on few important things, firstly, the state of contamination of root canal system at the time of separation, whether adequate cleaning and shaping was completed, at the time of instrument separation, also whether the cleaning and shaping can be completed in the presence of separated instrument. Second, whether the instrument can be retrieved, if required. The presence of a periapical lesion serve as the main prognostic factor for the successful treatment of such cases. In case of instrument separation, it is usually recommended to bypass the separated instrument and incorporate the separated fragment in the final obturating material. It must be noted here that The Classic Washington study concluded that the final treatment outcome was unaffected by a retained separated instrument.[2,3,5]

The probability of instrument separation in the mesiobuccal canal of maxillary molar is thrice, compared to distobuccal canal. Similarly, in mandibular molar, due to the greater curvature again, probability of separation of instrument is more in mesiobuccal canal compared to mesiolingual. Even after following best practices, sporadic incidences of instrument separation will always occur. Incorporating the fragment in the obturating material significantly improves the case prognosis. Here, a good quality of obturation is mandatory so that the obturating material or sealer flows and seals the spaces between the flutes of separated file and canal wall. Grossman[10] quoted an overall success rate of 90.3% for a total of 66 fragments left *in situ*.

Dentolegal Implications

Increased awareness of the environment have resulted in greater clinician awareness of instrument fracture consequences. Dental insurance providers in the western countries have reported claims for separated and retained instrument in the root canal. The claims have arisen as the patients have not been warned of any such possibility and much worse, have not been informed of the mishap. The clinicians have a legal obligation to initially forewarn the patient of any such possibility, inform

the patient, if such incidence ever happens and document it in the patients records, radiographs to be taken at different angles if required, substantiating good patient communication. If the separated file is retained, case should be kept on a routine follow-up, should any periapical pathology develops.[1,5]

CONCLUSION

After going through the cases discussed above, we can form an opinion about the treatment outcomes which can be achieved post bypass. Bypassing technique avoids unnecessary dentin removal, thereby the long term prognosis of bypassing technique is laudable, unlike retrieval. There are many modalities available for instrument retrieval, which work on the basis of different techniques, but one thing which is common among all these modalities is dentinal structure loss. It must be stated that retrieval procedures are always carried out under dental operating microscope. Furthermore retrieval procedures predispose the tooth to various iatrogenic errors such as ledging, perforation, stripping, extrusion of fractured portion through the apex, and vertical fracture of tooth. Conservation of the tooth structure is of paramount of paramount importance, for the long term success of the treatment. It is hereby conclusively evident that, once a file is bypassed, subsequent cleaning and shaping is best completed with hand files, so that the clinician can have a better tactile sensation. In addition, when a rotary file contacts a metallic fragment while rotating, it becomes more fatigued. Bypassing a separated fragment achieves all the primary requisites of a root canal treatment: Adequate cleaning and shaping, followed by a good quality obturation. If at all we are planning invasive retrieval procedures, it should be adequately justified. In case, bypass and retrieval attempts prove unsuccessful, and the case continues to be symptomatic, alternative treatment options such as apical surgery, intentional replantation and extraction should be considered.

REFERENCES

1. McGuigan MB, Louca C, Duncan HF. Endodontic instrument fracture: Causes and prevention. Br Dent J 2013;214:341-8.
2. Rambabu T. Management of fractured endodontic instruments in root canal: A review. J Sci Dent 2014;4:40-8.
3. Madarati AA. Retrieval of multiple separated endodontic instruments using ultrasonic vibration: Case report. J Taibah Univ Med Sci 2016;11:268-73.
4. Adl A, Shahravan A, Farshad M, Honar S. Success rate and time for bypassing the fractured segments of four NiTi rotary instruments. Iran Endod J 2017;12:349-53.
5. Parashos P, Messer HH. Rotary NiTi instrument fracture and its consequences. J Endod 2006;32:1031-43.
6. Monteiro JC, Kuga MC, Dantas AA, Jordão-Basso KC, Keine KC, Ruchaya PJ. A method for retrieving endodontic or atypical nonendodontic separated instruments from the root canal: A report of two cases. J Contemp Dent Pract 2014;15:770-4.
7. Shiyakov KK, Vasileva RI. Success for removing or bypassing instruments fractured beyond the root canal curve-45 clinical cases. J IMAB 2014;20:567-71.
8. John P, Kumar MR, Jayasree S. Bypassing separated instruments in the root canal-two case reports. IOSR J Dent Med Sci 2016;15:8-13.
9. Kunhappan S, Kunhappan N, Patil S, Agrawal P. Retrieval of separated instrument with instrument removal system. J Int Clin Dent Res Organ 2012;4:21-4.
10. Grossman LI. Fate of endodontically treated teeth with fractured root canal instruments. J Br Endod Soc 1968;2:35-7.