

Review Article

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Endodontic instruments fracture in root canal: Integrative review

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Abstract

Introduction: Endodontic instruments fracture is related to several factors from internal dental anatomy and type, to operator inability and inexperience.

Objective: To review case reports related to fracture of endodontic instruments inside the root canal.

Methodology: A literature review was carried out using papers available in the PubMed and Lilacs databases. Only case reports were included, with no restriction on language and publication year.

Results: It was analyzed eight papers with 11 instrument fracture cases, with the highest prevalence (45.5%) of rotary instruments fracture, occurring mainly in middle-cervical and middle-apical root canals thirds. In 90.9% of cases, techniques used for removal showed successful results and in only one case (9.1%), the technique was unsuccessful and the instrument was kept inside the root canal.

Final considerations: Endodontic instruments fracture is a complication can directly affect prognosis and endodontic treatment success. Several techniques and devices can be used to remove fractured fragments inside root canals, however, there is no specific protocol for their removal.

Keywords: accidents; endodontics; fracture; dental instruments; prognosis.

Introduction

Instruments fracture during root canal treatment is a complication during endodontic treatment [1], which can occur due instrument torsion or its cyclic fatigue and/or operator inability. In rotary instruments, torsional fracture occurs when tip or any other instrument part locks into the canal while the rest continues to rotate until it fractures. Flexural fatigue, on the other hand, manifests itself when repeated compression and tension movements occur in a root canal at its flexion maximum point [2].

Stainless steel hand files have been widely exclusively used to canal preparation for a long time, however, these instruments can cause steps, deviations and canal perforations due their high rigidity and low elasticity. To minimize complications and overcome anatomical challenges of root canals, rotary Nickel-Titanium (NiTi) instruments were introduced in the market. Rotary NiTi files have high flexibility and elasticity, greater mechanical strength and less tendency to rectify the canals, when compared to stainless steel files [3]. Despite advantages of NiTi instruments, especially in curved canals, is relatively high, com-

promising treatment success. The prevalence of stainless steel instruments fracture during the canal exploration was 1.39% and using NiTi rotary instruments was 2.77% [4].

Faced a fracture instrument, the chances of successful removal must be evaluated for potential complications. Clinical conduct and treatment prognosis will depend on fragment type and size, fracture site and its accessibility, internal anatomy and pulp condition and also canal preparation at the time of instrument fracture, which reflects microbial control. Three approaches can be used to solve intracanal instrument fracture: remove or bypass the instrument, or prepare and fill the root canal over the fractured fragment [5,6].

Operating microscope is a valuable resource, as it allows a direct visualization of root canal and fractured instrument [7], thus presenting better results in instrument removal [8].

The aim of this study was to carry out an integrative review of case reports covering endodontic instrument fractures inside the root canal.

Methodology

This is an integrative literature review of case reports, referring to factors related to endodontic instrument fracture inside root canal. Only observational case report studies were included, with no restriction on language and publication year.

Search was carried out in November 2020, in electronic databases PUBMED (<http://www.pubmed.gov>) and LILACS (www.bireme.br), using the following descriptors: [(“endodontics”) AND (“fractured” instrument) AND (“Case Report”)]. After reading papers titles/abstracts, those which met eligibility criteria were saved. After reading the full text, the references that confirmed the eligibility criteria fulfillment were included in this review.

Data contained information about study country, imaging examination, affected tooth, fractured instrument location and type, removal technique, use of magnification, follow-up and case outcome were collected.

Results

Results are shown in Table 1.

Cases reported in Brazil, India, Australia and Mexico were observed in eight papers, involving 11 teeth affected by instrument fractures, which eight (72.7%) were molars and three (27.3%) were anterior teeth. Periapical radiography was performed in 100% of the cases, and only one study associated cone beam computed tomography with this exam.

Regarding fractured fragments location, four (36.4%) instruments fractured in the coronal/middle third; four (36.4%) in the middle/apical third and three (27.2%) instruments in the apical third of the root canals.

Of 11 fractured instruments, five (45.5%) were rotary files (one Profile 25.04 File, one Race Rotary File, one HeroShaper Rotary File and two S1 Protaper Files); two (18.2%) were stainless steel hand files (Hedstroem File #25 and Kerr File #25); one (9.1%) was a manual NiTi file (#35) and one (9.1%) was related to metallic drill fragments. In two (18.2%) cases, the type of

fractured instrument was not identified.

To remove the fragments, the Masserann technique was used in four (36.4%) cases, ultrasonic tips were used in three (27.3%) cases (operating microscope was used in only two cases - 18.18%). Alternative methods were used in the other cases (27.3%), such as softening gutta percha cone with chloroform, a modified extractor and a modified anesthetic needle with metallic steel wire. The techniques used showed good results in 10 (90.9%) cases with the fragments being removed. The technique was unsuccessful in only one case (9.1%) and the fragment remained inside the canal. Clinical and radiographic findings revealed absence of signs and symptoms in followed up cases.

Discussion

Technological innovations in NiTi files have enabled a better root canal system biomechanical preparation [9], as they allowed an increase in taper, thus causing root canal widening with greater efficiency in removing debris and increased flow of irrigating solution. However, NiTi files associated with a rotating system increase their canal adhesion and cause difficulties in fragment removing in case of fracture [10].

During endodontic treatment, stainless steel instruments often fracture due excessive amounts of torque and NiTi instruments fracture due combined action of tension, twist and cyclic loading. However, stainless steel files are easier to remove, as they do not fragment during the process [3]. When compared to continuous rotation, reciprocating rotary systems provide greater resistance to fracture, as they increase cyclic fatigue of the NiTi instrument [11]. In rotary NiTi instruments, torsional failure, which may be caused by using too much apical force during instrumentation, occurred more frequently than flexural fatigue, which may result from use in curved canals [2].

Endodontic Instrument fractures may be related to several factors, such as internal anatomy and incorrect access to root canal; instrument confection material and manufacturing process and inadequate use. According to Parashos et al. [5], variables related to the operator and canal anatomy have more influence on fractures than the instrument itself. A root canal with a high degree of curvature, added to an incorrect technique increase the possibility of instrument fracture. In addition, insufficient access without adequate dentin removal from coronal cavity walls makes it difficult to properly view and locate the canals, resulting in inadequate instrument orientation, which negatively affects cyclic fatigue and strength, generating stress concentration and fracture predisposition [12].

Clinical management and treatment prognosis of an instrument fractured will depend on pulp condition (vital or nonvital), signs and symptoms, internal anatomy (curvature degree), and level of canal cleaning and shaping; presence of periapical lesion; type, size, visualization and accessibility to the fragment, in addition to chemical-mechanical debridement before fracture, reflecting microbial control [13,14]. Fractured instrument position, whether in apical, middle or cervical thirds of the root can also interfere in the prognosis [15].

Table 1: Case reports of instruments fractured inside the canal included in the review.

AUTHOR (YEAR), COUNTRY	TEETH	IMAGINOLOGICAL EXAM	INSTRUMENT LOCATION	TYPE OF INSTRUMENT	REMOVAL TECHNIQUE	USE OF MAGNIFICATION	FOLLOW UP	OUTCOME
Ward (2003), Australia	16	Periapical Radiography	Curvature of Apical Third (MB conduct)	2.5 mm fracture of Profile 25.04 file	Ultrasound technique variation describe by <i>Ruddle</i>	Microscope (8x)	12 months Assintomatic tooth, with no periapical radiolucence	Successful technique, allowing preparation, disinfection and filling of conducts
Thirumalai et al. (2008), India	Case 1: 16 Case 2: 36 Case 3: 22	Periapical Radiography	Case 1: Coronal and Middle Thirds (DB conduct) Case 2: Coronal and Middle Thirds (DL conduct) Case 3: Middle and Apical Thirds	Case 1: Fracture of 5mm Hedstroem #25 file Case 2: Fracture of hand file stainless steel #K25 Case 3: Fracture of hand file NITI #35	<i>Masserann</i> Technique	NO	NO	Successful technique. A straight-line access to the fragment facilitated centering the trephan. Locking mechanism of the extractor provides retention in gripping and dislodging a fragment which is tightly wedged in the canal.
Rahimi; Parashos (2009), Austráalia	46	Periapical Radiography	Curvature of Apical Third (DB conduct)	3 mm fracture of Race rotary instrument	chloroform- dipped gutta percha cone	NO	NO	Conservative and safe technique for removing loose fractured instruments in hard-to reach areas
Choksi et al (2013), India	12	Periapical Radiography	Coronal and Middle thirds	Not informed	<i>Masserann</i> Technique	NO	NO	Endodontic treatment ended with no complications
Brito Jr et al. (2014), Brasil	37	Periapical Radiography Cone Beam Computed Tomography (Follow up)	Middle and Apical thirds (MB conduct)	10 mm fracture of S1 ProTaper Rotary instrument	Gates Glidden drills, Endo z bur and bypassing the instrument without success. Instrument left in the canal	NO	3 years. Clinical and radiographic findings with absence of periapical radiolucency	Successful Treatment. The presence of fractured instrument did not impact the prognosis during the follow up period
Chinna et al. (2015), Índia	36	Periapical Radiograph	Coronal and Middle Thirds (DB conduct)	10mm Fracture of HeroShaper instrument	Ultrasonic Tip ET25	NO	6 months. Radiographic findings with no alterations.	Conservative and safe Technique for removing fractured instruments
Cruz et al. (2015), México	36	Periapical Radiograph	Apical third (Distal conduct), crossing the foramen	Radiopaque area suggesting fractured instrument (#15 or #20 file)	Modified Gates Glidden drills, ultrasonic tips #4 (<i>Pro-Ultra, Dentsply</i>), and <i>IRS</i> , that was removed with the instrument	Microscope (6x)	2 years. Asymptomatic Patient. Disappearance of small radiolucency in distal conduct	Operative microscope + ultrasound+ <i>IRS</i> system by staging platform technique allowed the removal of instrument beyond the foramen
Brito Jr et al. (2015), Brasil	Case 1: 21 Case 2: 37	Periapical Radiograph	Case 1: Middle and Apical thirds Case 2: Middle and Apical thirds (MB conduct)	Case 1: Bur metallic fragments Case 2: F1 ProTaper Rotary instrument	Case 1: Fragments removal with costumized extractor Case 2: Modified injection needle and steel wire	NO	NO	Cases 1 e 2: Successful removal

According to each case specificity, instrument can be removed or kept inside the canal, or can be performed bypass [6]. Bypass allows root canal preparation with instrument incorporation to the filling material [12]. Chances of successful removal must be evaluated carefully considering potential complications. Tooth prognosis can be seriously compromised due excessive dentin wear to recover the instrument, predisposing root fractures and irreversible tooth loss [12,13].

Instrument fractures do not always lead to an unfavourable prognosis. Instrument removal from apical third of curved canals should not be routinely attempted [16]. Fractured fragment may not cause treatment failure when pulp is vital without periapical involvement. When the instrument is located in a difficult access place, where its removal can cause severe root structures damage, bypass technique is indicated [17]. After three years of follow-up using this technique, Brito Jr. et al. [17] observed an absence of signs and symptoms. On the other hand, if the instrument is not removed or it has passed the canal foramen in an infected and necrotic pulp, the prognosis will be less favorable [9,18].

Technologies integration such as ultrasound magnification (optical microscope and magnifying glass) and computed tomography are valuable resources during the removal planning in instrument fracture cases. They allow better instrument visualization and selective root canal shaping. That association presents better results in instruments removal when compared to manual methods [8]. Cone beam computed tomography allows more accurate dental morphology assessment and endodontic complications diagnosis, highlighting fractured instruments location [19]. Chinnna et al. [20] demonstrated the ultrasound is a conservative and predictable technique for removing fractured instruments. However Brito Jr et al. [17] were not successful with ultrasonic tips to remove instruments in root apical third. Despite the success rate, using ultrasonic removal also poses risks, with some accidents such as fragment transposition to another location, perforation and fracture of the root. The more apical the instrument location, the greater perforation risk [21].

Several alternative techniques have been applied for different clinical situations. Among them, Masserann kit, adhesives (cyanoacrylate), Canal-Finder system, Instrument Removal System (IRS) and use of surgical hypodermic needle [12]. Masserann kit has been used for over 50 years, with highest success rate for anterior teeth, which have thick and straight roots. It has an end-cutting trepan burs of increasing size which are rotated anticlockwise to create space around fragment coronal end by cutting the surrounding root canal dentin. Also it contains a hollow tube that is subsequently positioned around the fragment [22,23]. However, it has limited application in thin and curved roots teeth or instrument fracture in the apical region, as the use of relatively large and rigid trephans leads to considerable root dentin removal, generating tooth weakening or perforation risk [24].

Brito Jr et al. [12] developed a modified injection needle technique to reduce dentin wear. It was a conservative and low-cost method for removing intracanal instruments. Other alternative method was proposed by Cruz et al. [25], who used a dental operating microscope, ultrasound and the IRS system combined, which allowed endodontic instrument removal located beyond the foramen and enabled a conventional disinfection protocol. Ward [26] used a staging platform and ultrasonic tips with direct visualisation using an operating microscope, to remove a fractured rotary NiTi instrument from the apical third of a curved

root canal. The definitive management should be based on a thorough knowledge of success rates of each treatment option balanced against potential removal risks or file retention [6].

Final considerations

Factors related to endodontic instruments fracture are: internal dental anatomy, mechanical fragility of instruments due constant use and operator inability. Fragment location, type and size; instrumentation phase and periapical condition directly influence protocol choice and treatment prognosis. Several techniques and therapeutic modalities are available for fractured instruments recovery from root canal, however, without having satisfactory results with a single protocol. Associated use of microscope and ultrasonic systems can be a promising option. Further studies should be carried out to establish more conservative and safer protocols for the fractured instruments removal.

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