Complications Associated with Fractured File Removal Using an Ultrasonic Technique

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Abstract

A technique utilizing modified Gates Glidden burs and ultrasonics has recently been advocated to remove fractured instruments from root canals. Varying extents of tooth structure are removed during this procedure, potentially leading to complications. This study evaluated the in vitro and in vivo complications associated with fractured file removal. Fractured instrument fragments were removed from three different levels (coronal, middle, or apical third) of mesiolingual canals of extracted human mandibular molars. The success rate, frequency of perforations, and root strength were recorded for each group. Perforations and unsuccessful file removal occurred only with fragments lodged in the apical third. Fracture resistance declined significantly with more apically located file fragments. A review of 60 clinical cases showed similar rates of successful file removal and rate of perforations. Removal of a fractured file fragment from the apical third of curved canals should not be routinely attempted.

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Rotary nickel-titanium (NiTi) endodontic instruments are now commonly used to prepare root canals. Several studies have reported the ability of rotary NiTi to produce well-centered, smooth, minimally transported canals while minimizing procedural errors (1, 2). One reported disadvantage with their use is file breakage, which often occurs without prior warning to the operator (3, 4). If the broken file impedes adequate cleaning of the canal beyond the obstruction, the prognosis may be affected.

Numerous methods have been proposed to remove obstructions from within the root canal, with varying degrees of success (5–8). Ruddle (9) recently reported a technique utilizing modified Gates Glidden burs and ultrasonics, in association with the operating microscope. This method has been quantified in vitro and in vivo as a highly successful technique in removing broken instruments (10, 11). The technique involves varying degrees of dentin removal both in gaining access to the obstruction and in removing it.

Excessive enlargement and formation of irregularities in canal shape can predispose teeth to vertical root fracture (VRF) (12, 13). Also, file fracture often occurs in narrow, curved canals such as mesial roots of mandibular molars, where the amount of dentin between the canal wall and the outer root surface is often minimal and at risk of perforation even during standard canal preparation (14, 15).

How to deal with a fractured instrument depends on numerous factors. Even if file removal is successful, complications in removing it may decrease the long-term prognosis and result in clinical failure. The effect on root strength of fractured file removal is yet to be investigated. This study aims to report on the complications encountered in vitro and in vivo as a result of fractured file removal using the recently proposed technique.

Materials and Methods

Experimental Study

Sixty extracted human mandibular molars with fully formed apices and no history of previous root canal treatment were used. All teeth were initially stored in 0.1% thymol following extraction and were continuously hydrated throughout the experimental procedure. The mesial roots were examined for pre-existing cracks at 25× magnification. All teeth were radiographed preoperatively and then accessed and any remaining pulp tissue was removed. Patency was established in the mesiolingual canals with a size 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland). Mesiolingual canals were chosen as they have been used previously in a study investigating fractured file removal (10).

A method of breaking instrument tips of a standardized length at various levels within canals has been reported previously (10). During an initial pilot study it proved difficult to fracture #25/.04 taper ProFile rotary files (Dentsply Maillefer) at predictable levels within the canal. Thus a larger size Profile file (#35/.04 taper) was used to achieve reliable fracture within the canal at the various levels required. Teeth were randomly divided into a control group (15 teeth, with no attempt to fracture an instrument within the canal) and an experimental group (45 teeth, with approximately a 3 mm section of instrument fractured in the mesiolingual canal). Varying the angle of insertion, speed of rotation, and amount of apical pressure applied allowed control of the level of fracture. All teeth in the experimental group were then radiographed and categorized into one of three groups according to the position of the fragment, corresponding approximately to coronal, middle, and apical thirds of the root (11).

The procedure for removing fractured instruments mirrored the technique comprehensively described by Ward et al. (10), which is a slight variation on the technique originally described by Ruddle (9). Briefly, following straight-line access, Gates Glidden burs were used to enlarge the canal to a funnel-shape coronal to the instrument fragment, to allow visualization of the broken instrument with the operating microscope. The Gates Glidden burs were then modified by sectioning them at their maximum cross-sectional diameter with a diamond bur, creating an end-cutting drill. These were then taken down to the level of the obstruction to create the so-called "staging platform." Typically, a size 3 Gates Glidden was required to provide sufficient space around the instrument to allow the introduction of ultrasonics. Fine ultrasonic tips (CPR, Obtura-Spartan Corp., Fenton, MO) were then used to trephine around the obstruction to unlock it and free it from the canal. If the broken instrument could not be seen following platform formation, then no further attempt was made to remove the file and an unsuccessful attempt at file removal was recorded. The use of the operating microscope was mandatory for the whole procedure and all roots were carefully inspected afterwards for root perforations.

Once the file segment was removed, each canal was renegotiated with a #10 K-file to the apical foramen. Canal preparation was then completed using ProTaper/Profile instruments (Dentsply Maillefer) to an apical size of 35/.04. Control teeth were prepared in the same manner, also to #35/.04. All prepared canals were obturated using gutta-percha and AH26 sealer (Caulk/Dentsply, Milford, DE). A matched taper master cone was placed to obturate the canal below the level of the staging platform and seared off at that level with a System B heat source (Analytic Technology, Redmond, WA). The remaining portion of the canal was back-filled with warm thermoplasticized gutta-percha using Obtura II (Obtura-Spartan Corp., Fenton, MO) to a level 1 mm below the canal orifice. Teeth were then stored at 37°C and 100% humidity for 7 days to allow setting of the sealer.

Root strength was determined by insertion of a narrow, tapered probe into the obturated canals. The probe was mounted on an Instron testing machine (model 5544 series; Instron Corp., Canton, MA) which provided the load to the root via the gutta-percha until fracture occurred. Immediately before loading, each tooth was mounted vertically in a 20 mm internal diameter plastic ring by surrounding it in elastomeric laboratory putty so as to stabilize the root during loading (Coltène AG, Alstätten, Switzerland). The probe was centered over the canal orifice and advanced through the gutta-percha at a rate of 3 mm/min until fracture of the root occurred. The load at fracture was recorded in Newtons (N).

Clinical Study

Clinical cases involving attempted fragment removal over a 3 yr period undertaken at the Endodontic Unit of the Royal Dental Hospital of Melbourne and in a private specialist endodontic practice were reviewed. For cases to be included in the study a broken file (hand or rotary) needed to be lodged in the canal below the orifice and the technique for file removal followed the same procedure as described above. Cases were reviewed with respect to success of file removal and evidence of damage (i.e. perforations) as indicated either in the clinical notes or on the postobturation radiographs.

Statistical Analysis

A one-way ANOVA was conducted to compare the load to fracture among the experimental groups and the control group. Data were subjected to logarithmic transformation for statistical analysis. A test of normality was conducted to confirm a normal distribution. Post hoc comparisons between the different levels at which the files were removed and the control were conducted using the Tukey test. All statistical analyses were performed at the 0.05 level of significance.

Results

Experimental Study

Of the 45 teeth in the experimental group containing fractured instruments, 14 were classed as being in the coronal third, 16 in the middle third, and 15 in the apical third. Removal was successful in all cases where the file fragment was located in the coronal or middle third. Only 11 of the 15 files located in the apical third were successfully removed (Table 1). Stripping perforations occurred in three cases, all where the fragment was located beyond the curve (Table 1).

The mean load required to induce root fracture decreased with greater depth of file removal within the canal (Fig. 1). File removal had a significant effect on root strength compared with control ($p = 0.002$, one-way ANOVA). Post hoc comparisons between groups showed that file removal from the middle and apical thirds significantly weakened the root compared with control ($p = 0.03$, $p = 0.003$, Tukey post hoc test). File removal from the coronal third showed no significant difference from the control group ($p > 0.05$).

Clinical Study

A total of 60 cases were reviewed, representing all patients managed in the two clinics over 3 years. Removal was successful in all cases with the file fragment lodged in the coronal third (11 cases) or the middle third (22 cases), with no perforations occurring. Only nine of the 27 cases involving the apical third were successful, with seven perforations resulting (Table 1). Two clinical examples of file removal and its outcome are shown in Fig. 2.

TABLE 1. Success of instrument removal and perforation occurrence

Location of fractured instrument	Removal successful	Removal unsuccessful	Perforations
Experimental Group			
Coronal Third	14	0	0
Middle Third	16	0	0
Apical Third	11	4	3
Clinical Group			
Coronal Third	11	0	0
Middle Third	22	0	0
Apical Third	9	18	7

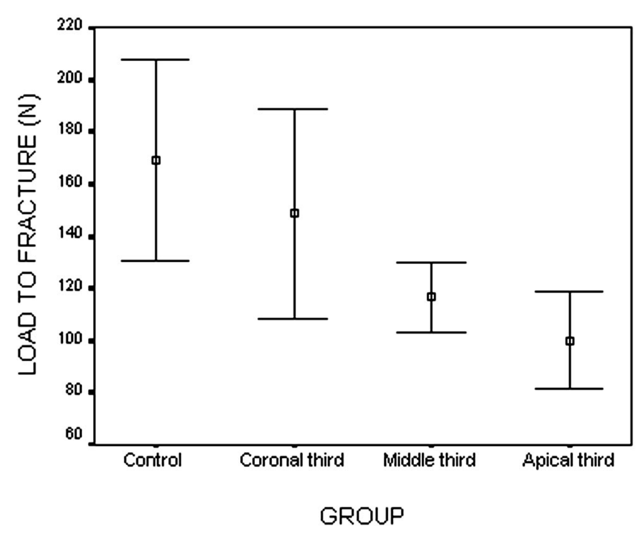

Figure 1. Effect of location of the instrument fragment on experimental fracture strength. Mean load to fracture and 95% confidence interval for the mean are shown for each group.

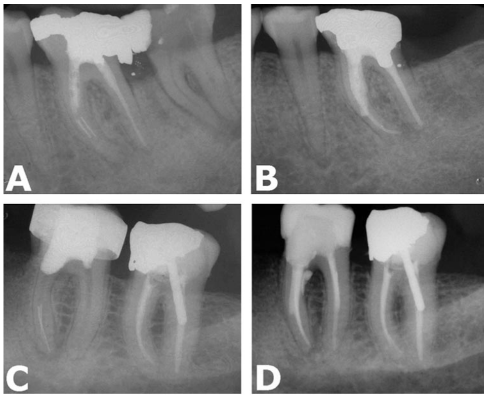

Figure 2. (*A*) Preoperative radiograph of mandibular left first molar showing two fractured instruments located in the middle third of the mesial root but more significantly, beyond the main canal curvature. (*B*) A 12-month review. File removal was successful and the tooth restored with an overlay amalgam. The extent of canal enlargement can be seen and is typical when files located beyond the main canal curvature are attempted to be removed. Periapical healing of the mesial root has occurred. The second molar was extracted because of vertical root fracture. (*C*) Preoperative radiograph of mandibular first molar showing two fractured instruments located in the apical third of the mesial root. (*D*) Completed treatment with successful file removal and moderate canal enlargement. No perforation was noted at the time of file removal however a post obturation radiograph revealed root canal sealer extruded through a stripping perforation.

Discussion

Many factors are involved when deciding how to deal with fractured instruments lodged within the root canal. If removal is attempted, the chances of success should be balanced against potential complications. Previous methods were often grossly destructive and unsuccessful (5, 16), but recently a more routinely safe and successful technique has been demonstrated (10, 11). This study confirms that this technique is highly successful in removing files lodged in the coronal and middle thirds of curved canals, but considerably less successful with files in the apical third.

As with prior techniques, attempting file removal results in loss of root dentin. Mandibular molars were chosen for the experimental study as they have a high frequency of fractured instruments (16) and have thin, narrow, curved canals that are at risk of iatrogenic damage even during standard canal preparation (15). Three perforations occurred during file removal in the experimental study, in every case when the file was lodged entirely beyond the main canal curvature. Greater dentin removal is generally required for this group, to obtain straight-line access and to disengage the file from the canal wall. The distal dentin thickness in the mesial root of mandibular molars averages just over 1 mm in an uninstrumented canal (15, 17), and therefore, is at greatest risk of perforation. Close inspection of preoperative radiographs and knowledge of root anatomy is imperative before attempting the removal procedure in any tooth, to ascertain the relative amount of surrounding dentin and the risk of perforation. Even then, a two-dimensional view of the root may provide an inaccurate estimate of dentin thickness (18).

Vertical root fracture is essentially untreatable, and usually results in tooth loss. Causes of VRF have included stresses generated during lateral condensation (19), post placement (20, 21), and excessive canal enlargement (12). More recently, asymmetrical canal shape and the formation of irregularities have been proposed as crucial factors in the generation of VRF (13). File removal typically results in ledge formation, and therefore, a possible stress concentration point. This study has shown that the removal procedure significantly reduced root strength when the file was located in the middle or apical third of the root. Root strength was decreased by 30% and 40%, respectively, compared with control. The level at which this becomes clinically significant is unknown but is an important variable for clinicians to be aware of. A large range in root strength was found, not unexpectedly, in the control group because of the natural anatomical variation within the teeth. This range, however, was markedly reduced with file removal from deeper within the root canal, demonstrating that the operative procedure becomes decisive in determining root strength (Fig. 1).

The clinical cases mirrored the experimental results in terms of success of removal and frequency of complications. Files lodged in the coronal and middle thirds of the root can consistently be removed without major complications. The limited success of file removal, increased risk of perforation, and reduced root strength, suggest that file removal beyond the curve should not be routinely attempted.

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