Success Rates for Removing or Bypassing Fractured Instruments: A Prospective Clinical Study

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Abstract

Introduction: The objective of this study was to evaluate the success rates of standardized techniques for removing or bypassing fractured instruments from root canals and determine whether visualization of the fractured instrument with the aid of an operating microscope has any impact on the success rates. Methods: In this prospective study, attempts were made to visualize 112 fractured instruments under a dental operating microscope after creating a straight-line access to the fragment. By using ultrasonic tips alone or associated with bypassing, the Ruddle technique was attempted to remove the 68 visible instruments. Bypassing was performed for the 44 nonvisible fragments. The χ² test was performed to assess whether any significant difference occurred between the success rates observed for the visible and nonvisible fractured instrument groups. Results: The overall success rate (removal and bypassing) was 70.5% (n = 79). In the visible fragment group, the success rate was 85.3% (n = 58), and in the nonvisible fragment group it was 47.7% (n = 21). Success rates were significantly higher when the fragment was visible (P = .0009). Conclusions: The standardized techniques used in this study for removing or bypassing fractured instruments were effective, and approximately 2 times greater success rate was obtained when the fragment was visible inside the root canal compared with when it was nonvisible. (J Endod 2012;38:442–444)

Key Words

Bypassing, fractured instrument, instrument removal, operating microscope, ultrasonics

During endodontic therapy, dental instruments might fracture within the root canal. Furthermore, while examining the patient’s radiographs for retreatment planning, the endodontist might unexpectedly encounter 1 or more retained endodontic instrument fragments. In clinical studies, the incidence of this complication has been reported to range from 0.39%–5% (1, 2).

In a systematic review, Panitvisai et al (3) assessed the prognosis of teeth after instrument fracture during endodontic therapy and found no statistically significant difference in healing rates between teeth with and without retained instrument fragments. However, the odds of treatment failure are higher when fragments prevent a thorough cleaning and shaping of the entire canal system and when periodontal lesions are present preoperatively (3–6). When infection is present, removal or bypassing of the fractured instrument is essential to ensure more predictable outcomes.

Technological advancements such as the dental operating microscope (DOM) and ultrasonics have enabled enhanced visualization of the operative field and easier manipulation of the root canal, respectively (7, 8). These technologies have made it possible for the clinician to obtain access to fractured instruments and can secure high success rates in the removal of instrument fragments, as reported by Cují et al (9).

Ruddle (10) has proposed a technique for the removal of metallic instrument fragments from the root canal by using a combination of Gates-Glidden burs, microscopic magnification, and ultrasonic tips. This approach has since been adapted by Ward et al (11) and tested in clinical practice. Both studies have reported that all fractured instruments visible by using a DOM and located before or at the curvature could be removed uneventfully. When removal cannot be achieved, bypassing the fractured instrument enables cleaning, shaping, and obturation of the entire canal, even when the retained fragment is located in the middle or apical third of curved canals (12, 13).

According to Fardi et al (14), the most frequent studies in the 100 top-cited articles published in journals dedicated to endodontics were basic science articles. This finding is consistent with the published literature on fractured instrument removal and bypassing, which largely comprises case reports and basic science articles in which a variety of techniques and approaches were used (15–21). Few clinical trials have been conducted, and those available report success rates ranging from 33.3%–95% (9, 13).

The present prospective clinical study thus sought to assess the success rates of techniques for removing or bypassing fractured instruments and determine whether visualization of the fractured instrument with the aid of an operating microscope has any impact on the success rates.

Materials and Methods

The study protocol was approved by the Research Ethics Committee, São Leopoldo Mandic Dental Research Center. All of the 112 patients included in the study provided written informed consent to take part in the study.

All procedures were standardized and previously calibrated according to a descriptive protocol and were performed by the 4 authors of this study in their private practice offices. All authors are experienced endodontists and apply the proposed techniques routinely. The study sample comprised all cases of fractured instruments occurring with patients treated in the authors’ dental offices between January and October.
2010. Of the 112 teeth, 58 had fragments of instruments fractured by the authors during initial treatment, and 54 were cases referred by other professionals. Teeth with a preoperative diagnosis of root or furcation perforation were excluded from the sample.

Straight-line access to the fragment was created by using size #15–40 hand K-files (Dentsply/Maillefer, Ballaigues, Switzerland), followed by #3 and #2 Gates-Glidden burs (Dentsply/Maillefer) and irrigation with 2.5% sodium hypochlorite. Direct visualization was then attempted in all cases by using a DOM (DF Vasconcelos S/A, São Paulo, Brazil).

The Ruddle technique (22) was used whenever the fractured instrument was visible under the DOM. Ultrasound was applied to create a groove around the fractured instrument by using diamond-coated zirconium ultrasonic tips (CPR 1-CPR 5; Obtura Spartan, Earth City, MO), which were selected according to the anatomy of the root canal. Dislodgement of the fragment was then attempted with titanium cutting tips (CPR 6-CPR 8; Obtura Spartan), which were placed in close contact with the fragment and worked in a circular, counterclockwise motion. All procedures were performed dry to ensure constant visualization, with the ultrasonic unit at a low power setting (20%–30%).

When the fragment could not be removed with the technique described above or when it was not visible under the DOM, bypassing was attempted. The bypassing procedure consisted of wedging a size 8 or 10 K-file (Dentsply/Maillefer) between the fragment and the canal walls to create space between them. The file was then advanced and withdrawn repeatedly in an attempt to widen the canal space and loosen the retained fragment from the root canal. When removal was impossible, an attempt was made to reach the working length with the hand files, prepare the entire root canal system, and incorporate the fragment into the obturation.

Success was defined as the complete removal or complete bypass of the fragment without creating a perforation. The procedure was considered unsuccessful when one of the following events occurred: the fragment was not completely removed or not completely bypassed; a root perforation occurred (as detected by radiography, under the DOM, or with an apex locator); or the fragment was pushed beyond the apical foramen into the periradicular tissues. To ascertain whether successful visualization of the fractured instrument under a DOM had any effect on the success rates, the visible and nonvisible instrument groups were compared by means of the $\chi^2$ test ($\chi^2 = 11.08$, 1 degree of freedom).

**Results**

Sixty-eight of the 112 separated instruments were visible and 44 were nonvisible under the DOM. The overall success rate for removal or bypassing was 70.5% (n = 79) (Table 1). For visible fragments, the success rate was 85.3% (n = 58) versus 47.7% (n = 21) for nonvisible fragments (Table 1). The $\chi^2$ test confirmed that success rates were significantly higher when the instrument fragments were visible with the aid of the DOM ($P = .0009$).

**Discussion**

In our study, the DOM allowed visualization of 68 of the 112 fragments. Because the visual reach of the operating microscope is limited to the straight portions of the root canal system and because intracanal visualization from a clinical standpoint is only possible in teeth whose anatomic inclination favors the use of this technology, we did not stratify teeth by tooth morphology, radiographic position of the instrument fragment, or canal anatomy but rather by the ability or inability to visualize the fractured instrument with the aid of the DOM.

We concur with Ward et al (11), Ruddle (22), Suter et al (24), and Cujé et al (9) that the DOM plays a key role in fractured instrument removal, because it enables enhanced visualization and improved control of intracanal procedures. Our statistical analysis showed that the possibility of visualizing the fractured instrument under a DOM had a direct influence on the success rates of the tested approaches.

Ruddle (22) stresses that ultrasonic tips should only be used for fractured instrument removal when the separated fragment is visible

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**TABLE 1.** Success and Failure Rates for Removing or Bypassing Fractured Instruments Visible and Nonvisible under a DOM

<table>
<thead>
<tr>
<th></th>
<th>Removed</th>
<th>Bypassed</th>
<th>Total</th>
<th>Left in situ</th>
<th>Perforation</th>
<th>Total</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
</tr>
<tr>
<td>Visible</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incisor/canine</td>
<td>37 54.4</td>
<td>21 30.9</td>
<td>58 85.3*</td>
<td>9 13.2</td>
<td>1 1.5</td>
<td>10 14.7</td>
<td>68 100.0</td>
</tr>
<tr>
<td>Maxillary</td>
<td>9 13.2</td>
<td>1 1.5</td>
<td>10 14.7</td>
<td>1 1.5</td>
<td>1 1.5</td>
<td>2 2.9</td>
<td>14 20.5</td>
</tr>
<tr>
<td>Mandibular</td>
<td>9 13.2</td>
<td>1 1.5</td>
<td>9 13.2</td>
<td>1 1.5</td>
<td>1 1.5</td>
<td>2 2.9</td>
<td>14 20.5</td>
</tr>
<tr>
<td>Premolar</td>
<td>4 5.9</td>
<td>1 1.5</td>
<td>5 7.4</td>
<td>1 1.5</td>
<td>1 1.5</td>
<td>2 2.9</td>
<td>14 20.5</td>
</tr>
<tr>
<td>Maxillary</td>
<td>2 3.0</td>
<td>1 1.5</td>
<td>3 4.4</td>
<td>1 1.5</td>
<td>1 1.5</td>
<td>2 2.9</td>
<td>14 20.5</td>
</tr>
<tr>
<td>Mandibular</td>
<td>2 2.9</td>
<td>1 1.5</td>
<td>2 2.9</td>
<td>1 1.5</td>
<td>1 1.5</td>
<td>2 2.9</td>
<td>14 20.5</td>
</tr>
<tr>
<td>Molar</td>
<td>24 35.3</td>
<td>19 27.9</td>
<td>43 63.2</td>
<td>2 3.0</td>
<td>1 1.5</td>
<td>3 4.4</td>
<td>42 63.2</td>
</tr>
<tr>
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<td>13 19.1</td>
<td>8 11.7</td>
<td>21 30.9</td>
<td>2 3.0</td>
<td>1 1.5</td>
<td>3 4.4</td>
<td>38 55.3</td>
</tr>
<tr>
<td>Mandibular</td>
<td>11 16.1</td>
<td>11 16.1</td>
<td>22 32.3</td>
<td>2 3.0</td>
<td>1 1.5</td>
<td>3 4.4</td>
<td>38 55.3</td>
</tr>
<tr>
<td>Nonvisible</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incisor/canine</td>
<td>21 47.7</td>
<td>21 47.7*</td>
<td>42 75.4</td>
<td>4 9.1</td>
<td>4 9.1</td>
<td>8 12.5</td>
<td>50 77.5</td>
</tr>
<tr>
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<td>1 2.3</td>
<td>1 2.3</td>
<td>2 4.5</td>
<td>1 2.3</td>
<td>1 2.3</td>
<td>2 4.5</td>
<td>12 17.9</td>
</tr>
<tr>
<td>Mandibular</td>
<td>2 4.5</td>
<td>2 4.5</td>
<td>2 4.5</td>
<td>1 2.3</td>
<td>1 2.3</td>
<td>2 4.5</td>
<td>12 17.9</td>
</tr>
<tr>
<td>Premolar</td>
<td>18 40.9</td>
<td>18 40.9</td>
<td>36 55.3</td>
<td>18 40.9</td>
<td>1 2.3</td>
<td>19 31.3</td>
<td>37 55.3</td>
</tr>
<tr>
<td>Maxillary</td>
<td>8 13.6</td>
<td>6 13.6</td>
<td>14 20.5</td>
<td>8 13.6</td>
<td>6 13.6</td>
<td>14 20.5</td>
<td>33 49.2</td>
</tr>
<tr>
<td>Mandibular</td>
<td>12 27.2</td>
<td>12 27.2</td>
<td>24 37.5</td>
<td>12 27.2</td>
<td>12 27.2</td>
<td>24 37.5</td>
<td>52 76.8</td>
</tr>
<tr>
<td>Total (visible + nonvisible)</td>
<td>37 33.0</td>
<td>42 37.5</td>
<td>79 70.5</td>
<td>31 27.7</td>
<td>2 1.8</td>
<td>33 29.5</td>
<td>112 100.0</td>
</tr>
</tbody>
</table>

*Success rate for visible fragments was significantly higher than that for nonvisible fragments ($P = .0009$).
under the DOM (a principle followed in the present study) to minimize the possibility of excessive root damage. Unecessarily vigorous use of ultrasound as well as use of ultrasonic tips in more apical regions of the root canal could lead to adverse outcomes such as root perforation (24) or weakening (25, 26). In the present study, perforation occurred in only one root instrumented with ultrasound (1.5%, 1 of 68). The perforation occurred in the apical portion of the canal and was detected with the aid of an apex locator.

When ultrasound-aided removal was not possible or when the fractured instrument could not be visualized with the aid of a DOM, we chose to bypass it. The purpose of this procedure is to bypass the fractured instrument with hand files and disengage it from the canal by means of manual instrumentation, thus enabling retrieval of the fragment (16, 22, 27). When retrieval is impossible, some authors recommend that the fragment be fully bypassed for a more thorough cleansing of the canal and then sealed into the obturation (12, 28, 29).

The presence of an instrument fragment alone within the root canal is not enough to determine the treatment outcome, but canal infection associated with a retained instrument fragment might lead to a poor prognosis (3). Hence, the ability to clean the entire working length of the root canal provided by the bypassing procedure might help ensure a favorable prognosis. In this study, bypassing maneuvers were attempted for 74 fractured instruments (30 visible, 44 nonvisible), and even though none were removed by this procedure, complete bypassing was achieved with 42 fragments (56.7%, 21 visible and 21 nonvisible fragments).

In our study, the bypassing maneuver was performed with stainless steel hand files. These instruments are rigid and could cause accidents such as ledges, perforations, and transportations, particularly in curved canals (30), which is why these instruments must be used with great caution. We found bypassing to be a technically challenging procedure, depending solely on the tactile sensitivity and sheer perseverance of the endodontist. Nevertheless, in our study, no canal transportation was detected radiographically, and only 1 root perforation (1.3%, 1 of 75) was detected with the aid of an apex locator in the apical third of the root.

Only a few clinical trials have been conducted to evaluate removal or bypassing of fractured instruments, with success rates ranging from 33.3%–95% (9, 13). In our study, the overall success rate was 70.5% (79 of 112 fragments). Ward et al (11) and Souter and Mesher (23) achieved success rates of 67% (16 of 24 fragments) and 70% (42 of 60 fractured instruments), respectively, both with the aid of a DOM. These rates were similar to those obtained in our sample, although the criteria for success were different, inasmuch as complete bypassing was also considered a successful outcome in the present study.

Although Suter et al (24) reported a success rate of 87% (84 of 97 fragments) by using a variety of retrieval techniques and the DOM, when these authors used ultrasonic tips, extensive cutting of dentin tissue was required to visualize the instrument fragments not initially visible under the DOM or located apically to the curvature. Root damage was greater than desired in some cases and led to a perforation in 7.2% of cases (7 roots). In our study, the overall incidence of perforation was lower (1.8%, 2 of 112).

Another interesting finding was that most of the teeth with fractured instruments in our sample were molars, 51.8% of which were mandibular molars (Table 1). This finding agrees with that of Shen et al (31) and of Cuj et al (9), who also conducted clinical trials on fragment removal and found that separated instruments were found more frequently in mandibular molars.

In conclusion, the standardized techniques used in this study for removing or bypassing fractured instruments were effective, and an approximately 2 times greater success rate was obtained when the fragment was visible inside the root canal, compared with when it was nonvisible under an operating microscope.

Acknowledgments
The authors deny any conflicts of interest related to this study.

References