50.06 (Dentsply Maillefer, Ballaigues, Switzerland) was taken to working length in the mesial canals and a Profile 35.06 in the distal canal. Patency was kept in all three canals throughout the entire treatment, with a ISO size 10 K-file. After the canals were shaped, they were rinsed with citric acid 10 per cent, which was ultrasonically activated, three times for 20 seconds, with an Irrisafe tip. During the third activation, the tip fractured and got stuck in the isthmus between the mesial canals. Cotton pellets were placed in the mesio-lingual and distal canal to avoid that the instrument would fall into these canals during its retrieval (Fig. 5). Retrieval was done with another Irrisafe tip (Fig. 6). A final rinse was performed with NaOCl 5 per cent, which was warmed by giving a few bursts with the System B (Elements Obturation Unit, Sybronendo, Orange, USA). Finally, cone pumping was performed with a tapered guttapercha. Cone pumping is known in the literature as manual dynamic irrigation and it has been showed that manual dynamic irrigation is more effective than regular irrigation. A confirmation radiograph was then taken with gutta-percha master cones (Dentsply Maillefer, Ballaigues, Switzerland) in place (Fig. 7). The canals were dried with paper points (Roeko, Langenau, Germany).

Obturation was performed with a hybrid technique in which cold lateral condensation is used to fill the apical 4mm. After that the System B needle is taken into the canal, four mm short of working length. Backfill was performed with the Elements Extruder in small increments of two mm each time, to reduce shrinkage. Topseal (Dentsply Maillefer, Ballaigues, Switzerland) was used as a sealer. During the backfill, I could see the isthmus being obturated with guttapercha (Fig. 8), which is a desirable result. If tissue would have been left in the isthmus, it could have led to failure. After obturation, the excess of sealer in the pulp chamber was removed with alcohol 96 per cent (Fig. 9). A temporary restoration was then placed with Fuji IX Fast A2 (GC Europe, Leuven, Belgium).

Final radiographs (Figs. 10 & 11) were taken and the patient was sent home with instructions about post-op discomfort and a prescription for ibuprofen 400mg.

**Conclusion**
In the past there have been several revolutions in the field of endodontics. These comprise the isolation procedure with the rubber dam, cleaning with NaOCl, shaping with rotary instruments and others which we cannot think away anymore. In the present we are still holding on to these revolutions, but we are using evolutions of the originals to make treatment easier, better controlled and to gain a favourable outcome. I presented this case to give an overview of the current evolutions which are used in modern day endodontics.

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### Table 1: Working lengths and apical diameters of the canals

<table>
<thead>
<tr>
<th>Canal</th>
<th>Working length</th>
<th>MAF</th>
<th>Reference Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>21.5mm</td>
<td>55</td>
<td>MB cusp</td>
</tr>
<tr>
<td>MB</td>
<td>21.5mm</td>
<td>50</td>
<td>MB cusp</td>
</tr>
<tr>
<td>ML</td>
<td>22.5mm</td>
<td>30</td>
<td>ML cusp</td>
</tr>
</tbody>
</table>

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**Fig. 10 Final radiograph**

**Fig. 11 Final position**

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Illustrating principles of diagnosis and treatment
A case report by Dr Kendel Garretson

Endodontic anatomy varies greatly and single canal teeth provide an opportunity to illustrate principles of diagnosis and treatment. In this case (Figure 1), a patient presented with a “toothache”. Medical history was non-contributory. Diagnostic testing revealed a necrotic maxillary central incisor with symptomatic periapical periodontitis. Even in cases with obvious pathology, thorough endodontic diagnosis is completed to determine the proper pulpal and periodontal status of teeth in the affected area, including examination of the affected sextant and the opposing arch.

Based on these findings, a decision was made to treat the tooth in two visits. Emphasising debridement in a crown down fashion, the canal system was entered and flared coronally. A variety of instruments can be used for this purpose, including Gates–Glidden drills as used in this case, followed by tapered rotary nickel titanium instruments. No attempt is yet made to instrument to full length until coronal flaring and preliminary disinfection can be completed. The goal is to minimise the risk of pushing debris through the apical foramen. A preliminary canal length is established, followed by a definitive working length as treatment progresses.

Apical preparation
The apical preparation was sized and finalised with non-tapered rotary instruments (LSX, Discus Dental). Again, a variety of instruments can be used for this purpose. The apical preparation was sized and finalised with non-tapered rotary instruments (LSX, Discus Dental). Irrigation was accomplished with sodium hypochlorite, as well as aqueous EDTA. Irrigants were activated with sonic agitation and copious irrigation exchange was encouraged with small k-files used in an exploratory fashion.

After drying, a non-setting calcium hydroxide paste was delivered to length in the canal and a secure interim restoration was placed. Calcium hydroxide aids in tissue digestion, disinfection, and neutralisation of LPS. Other agents may also be used, both as irrigants or dressings, to help optimise microbial control.

The patient returned in two weeks to complete treatment. Symptoms resolved within a day or two of the initial visit. Use of aqueous EDTA, with sonic activation and instrumentation, assisted removal of the dressing. The apical preparation was verified prior to obturation. Since the tooth was prepared with LSX, a corresponding Simplifil (Discus Dental) gutta percha obturator was used. This allows for excellent apical control and compaction of gutta percha, and this was followed by a backfill from a heated gutta percha delivery injection device. Composite resin was then used to complete access closure. Several lateral canals are noted in cases with minimal microbial control.

Predictable healing
A second case is included, previously treated, with similar presentation and preparation philosophy, along with a 16-month control image (Figures 5, 6). By adhering to biologically based treatment philosophies which flow from a thorough diagnosis, our patients can expect predictable healing and disease prevention.

References

About the author
Dr D Kendel Garretson is a 1989 graduate of the University of Texas Health Science Center at San Antonio, Dental School. Since 2001 he has limited his practice to endodontics and lectured on a regular basis in AEGD residencies on a variety of endodontic topics. He is a member of the ADA and an associate member of the AAE, and maintains a private practice in San Antonio, Texas. Questions and comments welcomed at onlyendo@gmail.com.
Periapical microsurgery for removal of a fractured endodontic instrument

Leandro AP Pereira details a case presentation using a piezoelectric device for removal of a fractured endodontic instrument

During endodontic treatment, procedural errors may occur, such as the breakage of endodontic files. These accidents may compromise the treatment and prognosis of the clinical case. Frequently, it is necessary to perform additional procedures to resolve the problem.

With the development of cleaning and shaping endodontic systems, there is decreasing frequency of procedural problems in dental practice. However, concern persists that rotary NiTi instruments are more susceptible to breakage. This has been the second most common reason for dentists not using rotary instruments.

A recent study has shown that the incidence of broken instruments accounts for 11.7 per cent of all endodontic malpractice cases. The incidence of NiTi file fractures has been shown to range from 0.4 to five per cent and their use is considered safe. Fractures can occur through torsional failure or as a result of flexural fatigue.

Minimising breakages

To minimise these incidents, care must be taken as follows: evaluate the tooth anatomy carefully before treatment; ensure a straight-line access; create a "glide path" with small hand files; use the crown-down technique; use a torque-controlled motor; keep files moving in and out of the canal and control the number of times files are used discarding files after a specified number and types of canals.

Failure to remove the fractured endodontic instrument results in deficient cleaning, shaping and filling of the root canal system. Under these conditions, in addition to the endodontic diagnosis, the time during treatment when the instrument fracture occurs is of great importance in the prognosis of the case.

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When instrument fracture in a contaminated canal occurs at the beginning of treatment, the prognosis is worse, because there is still a large quantity of bacteria, and the presence of the instrument may prevent adequate microbiological control. The presence of the instrument may also contribute to inadequate endodontic filling. The prognosis is better when the fracture occurs near the end of the canal-cleaning and shaping process, as it is a more advanced stage of endodontic microbiological control.

In situations of instrument fractures associated with pulp vitality, the prognosis does not change significantly.

Removing broken instruments

When taking the decision to remove the instrument, factors such as pulp diagnosis, location, root curvature and length, size and type of fractured instrument, remaining dentinal thickness, and risks of iatrogenies during the attempted removal must be taken into consideration.

A technique commonly used for removing fractured instruments is to achieve a bypass with a manual file, so that the fragment can be drawn to the pulp chamber and be removed. Another removal technique is by means of ultrasonic vibration of the fractured fragment, associated with the use of an operating microscope. The application of ultrasonic energy causes the fractured instrument to vibrate, causing it to detach from the canal wall, and it can then be drawn to the pulp chamber and finally removed.

The application of these methods in atresic canals may result in excessive wear of the root walls, therefore their use associated with the operating microscope is safer, due to the possibility of improving visualisation through the magnification and illumination provided by the microscope.

In cases of unsuccessful removal of the instrument and control of infection, with persistence of signs and symptoms of endodontic disease, surgical removal of the fragment may be indicated.

A clinical example

This article demonstrates the resolution of a clinical case in which there was fracture of a K3 rotary instrument in the apical third, extending out of the root apex.

The patient, a healthy 44-year-old woman, pulse 68bpm, BP 115X 65 mmHg, SpO2 98 per cent, temperature 36.5°C, came to the dental office complaining of constant, low intensity, spontaneous pain, in the vestibular apical region of tooth 24, and presented intra-oral edema, pain on chewing and vertical percussion. She reported having undergone endodontic treatment in tooth 24 more than six years previously. In the periapical radiographic exam it was possible to visualise deficient endodontic treatment and the presence of apical bone rarefaction (Figures 1, 2). The diagnosis of acute periapical abscess was made.

The proposed treatment was endodontic re-treatment, because in the previously performed treatment there was inadequate canal cleaning and shaping, leading to filling with empty spaces and maintaining the intracanal endodontic infection. Periapical surgery was contra-indicated due to the presence of deficient endodontic treatment.

Endodontic re-treatment began with access to the pulp chamber, with removal of the occlusal resin restoration, using ultrasonic diamond inserts...