Endodontics
Feature Article

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Abstract
The apical third of a root canal system is the most difficult section to clean and shape because of its ramifications and tortuosities. This article discusses the clinical anatomy of the root and lists the "10 commandments" of cleaning and shaping to achieve predictably successful endodontics.

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Cleaning and shaping the apical **third** of a root canal system

Cleaning and shaping the root canal system is essential to clinical success in endodontic treatment. The apical third is the most difficult to clean and shape because of the ever-increasing complexity of the anatomy; that is, the ramifications (Fig. 1 and 2) and the tortuosities (Fig. 3 and 4). The objective of this paper is to demonstrate clinical debridement of the apical third of the root canal system.

The clinical apical anatorny
It is important to understand some of the terms of the apical anatomy and their clinical treatment perspectives (Fig. 5).

Apical terminus
The end of the main canal, where the root canal filling ends. Different schools of thought finish the filling materials differentIy (Fig. 6).

Rootapex
The vertex of the root. The main canal and the accessory canals may or may not exit at this point. Clinically, this is the radiographic apex. Curvature of the root should be considered radiographically (Fig. 7).

Cementodental junction (Co})
This is where the cementum and the dentine meet. It is not uncommon for these two substances to meet in various ways, namely, butt,

Fig. 1. Mandibular first premolar filled with gutta-percha and sealer, disclosing the loop, accessory canals, and fins of the root canal system. Multiple foramina are sealed.

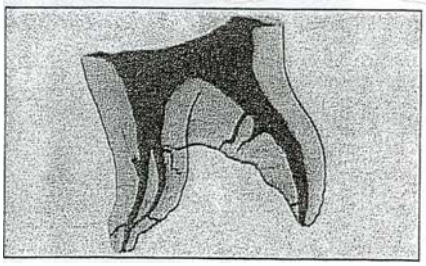

Fig. 2. Moral's China ink test reveals the complex root canal system of a human molar. Multiple foramina are present (Photo courtesy of Professor Nicola Perrini.)

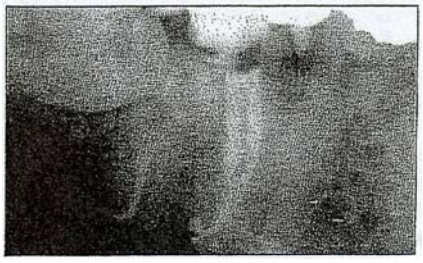

Fig. ,3. It is not uncommon for a mandibular molar to show sharp acute angled turns of the canals at the very end of the root. The exits of the root canal system are not at the radiographic apices.

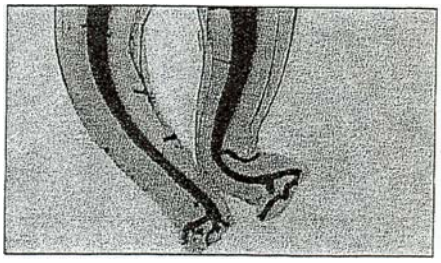

Fig. 4. Moral's China ink test reveals !he distal turn of the distal canal of a mandibular molar. More ramification and tortuosities are evident at the apical thirds of the roots.

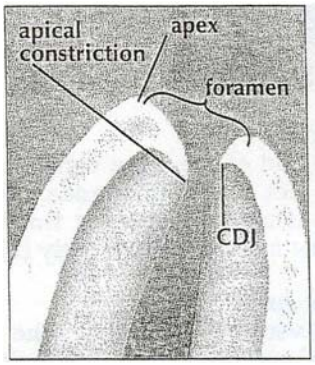

Fig. 5. Graphic depiction of the apical terminus and anatomic features of a root.

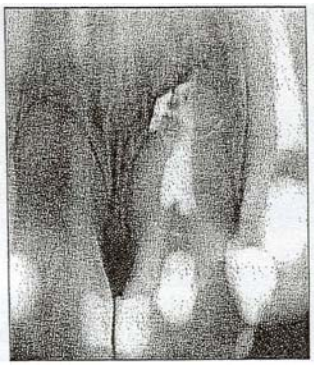

Fig. 6. Maxillary central incisor shows six or more genuine portals of exit of the root canal system.

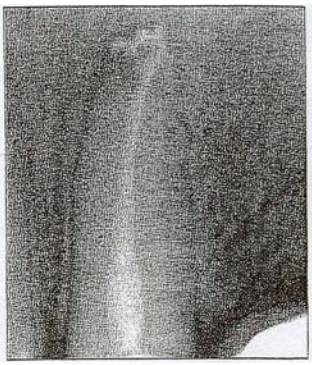

Fig. 7. Maxillary canine shows multiple portals of exit. One is located at the vertex of the radiographic apex but others are not

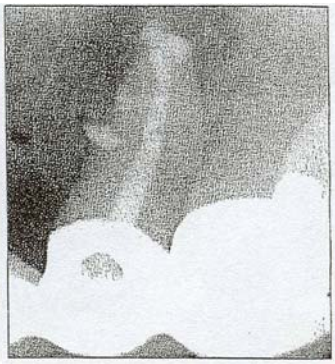

Fig. 8. Maxillary lateral incisor indicates the funnel shape of the main canal foramen. The two accessory canals contribute to the oval configuration of the endodontic lesion. (Courtesy of Dr. Henry Yu.)

Fig. 9. Apical constriction may be at the junction of the apical root canal branches.

Fig. 10. Maxillary molar with four canals plus accessory canals and the funnel-shaped apical foramina. Apical constrictions are present (Courtesy of Dr. Eric Kwan.)

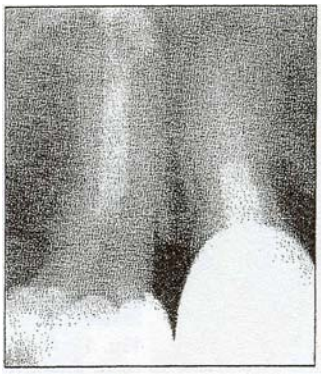

Fig. 11. Maxillary second premolar shows the bulbous root apex., This excess dentine had been generated by extra pulp. Apical constriction is not present

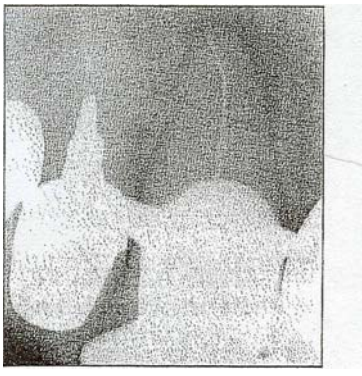

Fig. 12. A No. 15 file touches the PDl at the radiographic terminus of a maxillary central incisor.

overlap, or even outside the root canal on the root surface. CDJ is of no significance in clinical treatment Usually, an oral histologist would consider the soft tissue coronal to the CDJ as the pulp; beyond it is the periodontal ligament.

Foramen
The opening of the canal. The main foramen is believed to be funnel-shaped. On average, the smaller diameter is half the size of the larger diameter at the root surface (Fig. 8 and 9).

Apical constriction
The narrowest area of the apical region of the root. Most operators will clean and shape the canal to fill it to this constriction. It ls commonly believed that this constriction is located 0.5-1.5 mm from the radiographic apex (Fig. 10 and 11).

Radiographic terminus
This is a c1inical term coined by Dr. Schilder. It is defined as the ",end of the canal" shown on the radiograph. Here the sma11 file touches the periodontal ligament (PDL) space an the radiographic terminus (Fig. 12 and 13). Because of the facial and palatal lingual curvature of the root, the file may extrude beyond the root surface. However, conscious

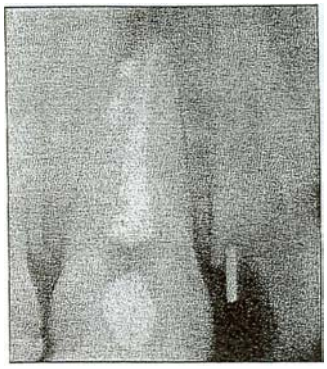

Fig. 13. Warm gutta-percha in conjunction with sealer is filled to the radiographic terminus and the accessory canals at the root surface. The hydraulic pressure from the serial waves of vertical compactions filled the accessory canal, moving not only apically but also coronally.

Fig. 14. Maxillary first molar demonstrating "five fingers of death" in the distal root apex and several accessory canals from the middle of mesial root. This type of hermetic seal prevents the apical microleakage of any potential noxious organic substances.

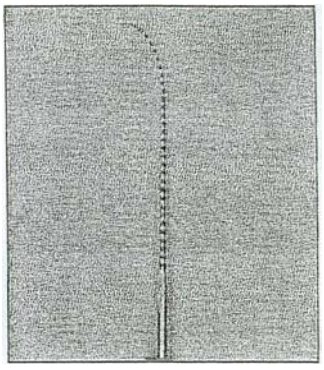

Fig. 15. A precurved No. 10 file provides probing action and increases tactile feeling for the operator.

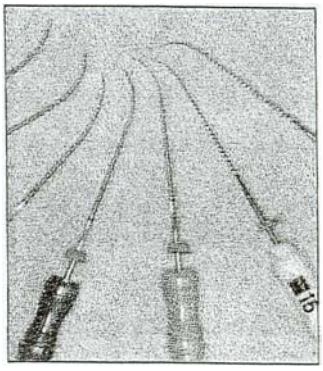

Fig. 16. Smaller instruments are precurved closer to the tip; larger instruments are precurved farther from the tipo

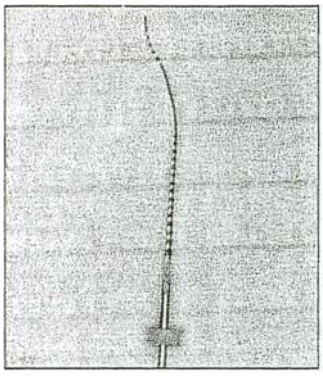

Fig. 17. A small stainless steel file takes the "impression" of the original three-dimensional multiple-plane "ftow" of the root canal system.

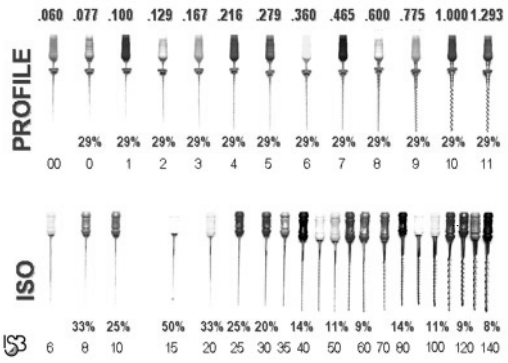

Fig. 18. ProFile Series 29-the "new" instruments.

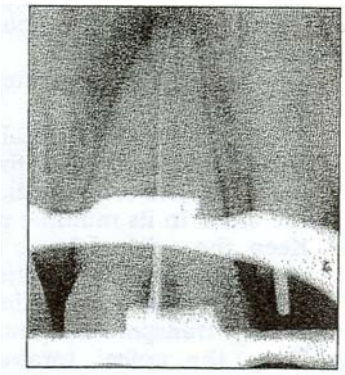

Fig. 19. The No. 10 instrument slips, slides, then finally reaches the PDL at the radiographic terminus of the maxillary central incisor.

manipulation of this fine instrument will not cause irreversible damage to the PDL.

Porta/s of exit

The multiple openings of the root canal system on the root surface. Through these foramina, noxious materials egress to the periodontium, resulting in lesions of endodontic origin (Fig. 14). It is interesting to note that the clinical reality of these apices is far more complex than the customary graphic depiction.

Cleaning and shaping

Cleaning and shaping is the most important phase of the root canal treatment. *Cleaning* involves the removal of all organic substrates of the root canal system. These are the substances that can promote and support bacterial growth, such as pulpal remnants; body fluids, and food debris. *Shaping* means developing the canal into a continuously tapering cone. The purpose of this is so that any licensed dentist can fill the root canal system effortlessly and effectively.

Simply put, shaping facilitates cleaning. It is easier and more effective to clean a well-prepared and enlarged canal. Most often, the root canal system is never completely cleaned, debrided, and sanitized. It is not surprising that without proper shaping, it is difficult to fill the root canal system adequately. Endodontic treatment can be predictable, successful, and relatively easy to perform if every individual step is done correctly. Hasty mechanical and chemical manipulation of the root canal system can lead to outright failure.

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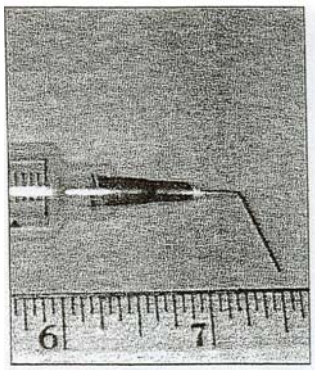

Fig. 20. A 10 mL irrigating syringe with a cutoff 22 gauge needle. The bend of the needle allows easy access to the tooth.

Fig. 21. The root canal system is filled completely to the surfaces of the two apically fused roots. Ramifications are expected and predictably sealed.

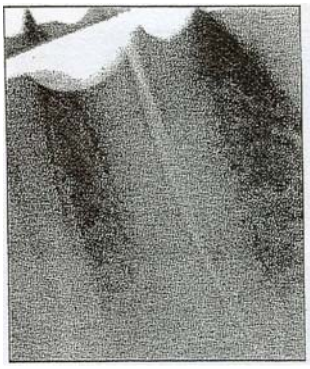

Fig. 22. After cleaning ahd shaping this premolar, a precurved No. 10 fiJe probes for the accessory canal. A No. 20 file is placed in the main canal.

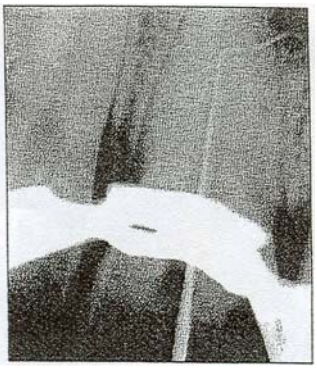

Fig. 23. This accessory canal is cleaned with a No. 20 file.

Mechanical obiectives of deaning and shaping

Achieving the following mechanical objectives ensures the root canal system is subsequently sealed and obturated hermetically, even at the apical third:

Develop a continuing tapering cone shape canal

Prepare a narrower apical cross sectional diameter within the canal

Maintain the original "flow" of the canal in its multiple planes

Keep the original locus of the apical foramen in relationship with the root surface and the bone

Do not transport the foramen

Keep the apical foramen as small as is practical

"Ten commandments" of deaning and shaping

Probing

The first instrument used is a probing instrument; it also can be a "kiss of death" instrument. Usually, a No. 10 file is used {Fig. 15). The instrument is held gently and freely at the end of the handle with the thumb and finger. This "lengthens" the file and magnifies the tactile sensation. In the coronal canal, the calcified particles are suspended by the collegen fibers. The sharp tip of the instrument will dissect and incise the fibers and glide through the calcified, fibrous barrier. Too often, an indiscriminate, forceful thrust on the instrument will bulldoze and plough through the "dentinal mud "ahead" This results in blockage, or what mistakenly is classified as "Icalcification."

In the apical canal, which frequentIy ramifies and turns abruptly (Fig. 14), the pulpal tissue is firmer and more fibrous. Here, high tactile sensation is employed with care, confidence, and patience.

Carving back

A curved instrument has two areas of contact in the dentinal wall of the canal: the tip and the elbow. At the elbow, the few activated flutes positively rake out the debris. A rotational and translational withdrawing action of a precurved instrument effortlessly scrubs the canal wall at random. It also brings the dentinal mud out of the canal when it is flooded with sodium hypochlorite. This carving back action reduces the problems associated with transporting the foramen both internally and externally, such as blockage, false path, perforation, and rip

Precurving

The magnitude of the curvature must be greater than that of the canal. For the smaller instruments, such as No. lO, 15, and 20, the elbow of the curve is small and right at the tip, producing an excellent probing antenna. For the larger instruments, such as No. 30, 35, 40, the elbow is larger and farther from fue tip, producing a strong, effective rake, cutting dentine in a larger circurnference, and swiftly carting out the dentinal mud (Fig. 16).

Bouncing

The fine instrument is never intended to attack resistance and barrier. Whenever the pointed tip encounters aberrations, the instrument retreats and bounces back. The instrument is re-precurved differently and appropriately. Stainless steel provides the rigidity but is flexible enough to do the bouncing of the small instrurnents (Fíg. 17). "*Let* the canal take the instrument" is the monumental concept in cleaningand shaping the apical third of the root canal system.

Serial sequence

By filing and reaming in sequence, the canal is enlarged evenly and smoothly without steps and ledges. However, because standardized instruments increase in size by fixed, absolute increments (0.05 mm in diameter, 1.0 mm from the tip end), increases in size are not constant. For example, there is a 50% increase in size from No. 10 to No. 15, a 33% increase in size from No. 15 to No. 20, and a 25% increase in size from No. 20 to No. 25. This standard is not rational and is a fatal flaw in negotiating the fine canal and its branches.

The "new" instruments now available (ProFile Series 29, Dentsply Tulsa Dental, Tulsa, OK; 800/662-1202) increase from one size to another by a constant 29% (Fig. 18). This means that more instruments are available in the useful smaller range. With these "new" instruments, the canal is cleaned and shaped rapidly at the apical area and, most importantly, there is no large increase in size.

Recapitulation

This term refers to the repeated reintroduction and reapplication of instruments previously used throughout the cleaning and shaping process in order to create well designed, smooth, unclogged, evenly tapered, and unstepped root canal preparations. After a few recapitulations, the files and reamers effortlessly advance deeper and closer to the radiographic terminus. The canal is enlarged yet its original flow still is maintained. The difference between the angle of access in the coronal access cavity and the angle of incidence at the apical foramen is reduced dramatically. The pluggers can reach the deeper area of the root canal for effective compaction of warm gutta-percha.

Enve/ope of motion

The instrument slips and slides in contact with the dentinal wall, then rapidly withdraws in a clockwise rotation movement. The file, such as size No. 10, 15, or 20, is used to go beyond the curve in the apical regíon of the canal. The reamer, such as size No. 2O, 25, 30, and so on, is used in the straight canal and the straight portion of a curved canal. The up-and-down stroke, push-pull motion of the precurved file is very delicate and has an amplitude of 0.5-2.0 mm to establish the apical patency (Fig. 19). The precurved reamer is used in a rotary motion around the entire circumference of the canal wall and throughout the entire length.

Irrigation

Copious irrigation using 2.5% sodium hypochlorite ensures the canal system is well-bleached, allowing less chance of tooth discoloration. This irrigant digests necrotic organic debris readily. It has low surface tension and therefore acts as a lubricant and a suspension medium for dispersing clogged dentinal mud. In addition, it is a potent antimicrobial agent. It kills bacteria, viruses, and fungi yet is very mild to viable human tissue such as PDL and bone.

Sodium hypochlorite is not injected but rather is ejected gentIy using a syringe with a 22 gauge needle (Fig. 20). Tam and Yu have indicated that, using serial filing and reaming, sodium hypochlorite by itself can clean the dentinal wall not only at the coronal and middle thirds but also at the apical third. At least 30 mL is used per canal; every time an instrument is removed, the irrigant is turned over and the canal is flooded with sodium hypochlorite. The instrument displaces the irrigant into the fine accessory canals.

Peeking

The No. 10 patency file peeks gentIy through the root surface and "shakes hands" with the PDL. This is not an overinstrumentation. The conscientious placing of the file to the radiographic terrninus, just touching the PDL, may sometimes but not always be beyond the root surface. The apical foramen may not be positioned at the geometric vertex of the root. Clinically, the canal is not readily blocked or stopped internally with dentinal mud The root canal filling ideally ends at the root surface and touches the PDL at the radiographic terminus (Fig. 21).

Hunting for accessory cana/s

After the canal is cleaned, shaped, and recapitulated, the accessory canals should be found before the gutta-percha cone fit. It is easier to search for accessory canals if the main canal is scrubbed and smooth. A No. 10 precurved file (Fig. 15) probes for the location of the accessory canals. The curve must be small, approximately 90 degrees. With some experience and patience, it is possible to place a small instrument into the accessory canal (Fig. 22). A relatively large accessory canal can be cleaned to No. 20 size (Fig. 23).

Summary

By following these ten commandments, the apical third of the root canal system can c1eaned and shaped and rendered free of organic substrates and debris. From here, three-dimensional vertical compaction of warm gutta-percha in conjunction with sealer is easy and accessory canals are filled routinely. The authors have found clinically that approximately 70% of teeth are filled with accessory canals. Predictably successful endodontics is expected.

Author information

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~ r. Yu will present his lectures, "predictably successful endodontics I & 11," at the New York *V* 2001 Annual Meeting.