The goal of quality endodontic therapy has remained the same since its inception. Appropriate removal of pulpal tissues with proper cleaning and shaping followed by an obturation system and coronal seal will satisfy both mechanical and biological objectives. As clinicians we need to appreciate each of these aspects and know that our therapy’s success is dictated by the weakest element of our treatment. One area that has the potential for improvement is our ability to accurately instrument root canal systems in a manner that maintains the original path of curvature in both significant and multiple curvature systems. Failing to realize canal curvature before treatment can lead to preparation errors (i.e., apical zips, perforations, canal blockages, or instrument separation), which can leave the canal unprepared and lead to continued pathology compromising the outcome of treatment.

The question now becomes, “How do we treat these excessively curved cases appropriately?” The purpose of this paper is to provide dentists with the available tools and knowledge to treatment plan success for tooth retention through endodontic therapy on curved root canal systems. Cases will be provided to demonstrate a sample treatment sequence.

Step 1 – Strategize your approach to success

The most logical approach to begin treating these intricate root systems is to start with a clear vision of what you are trying to accomplish. Understanding the anatomy prior to the onset of treatment allows the clinician to anticipate potential challenges and work to prevent procedural errors. Several tools can be beneficial in this regard, one of these being the American Association of Endodontists (AAE) case difficulty assessment form. In a checklist format, a dentist can use this form to select whether the patient falls into a minimal, moderate, or high difficulty ranging from radiographic analysis, canal calcification, and medical history to tooth access. This document is readily available online and there to assist with treatment planning. A key point within this form is “Canal and Root Morphology.” Justifiably, the degree of curvature or multiple curvatures increases the difficulty of the case from minimal to high levels of difficulty.

The degree of curvature and number of curves within the tooth can produce challenges for appropriate shaping of the canal system. Prior to initiation of treatment, the clinician should consider both the angle and radius of curvature, as this has been suggested as a more accurate resemblance of true canal anatomy. The smaller the angle of curvature and the smaller the radius of curvature, the greater the complexity of the case (Figure 1).

However, the disadvantage of conventional periapical radiographs is that they only provide information in two dimensions. Another critical tool is the radiographic evaluation of the tooth. Conventional periapical radiographs are important with endodontic treatment. These images can provide information regarding the curvature of a canal or root. While conventional and panoramic radiographs allow the operator to visualize the root structures in two dimensions, the advent of three-dimensional radiography allows for accurate assessment of the root canal space in multiple planes. Three-dimensional imaging can allow the clinician to view proximal views with a high degree of accuracy. This is beneficial because many teeth have curvatures that are only present in a proximal view. One example of a cone beam CT machine is the Kodak 9000 3D. It has been shown to accurately depict the relationship of the internal canal anatomy compared radiographically and histologically.
Step 2 – Have the tools necessary to make this success a reality

In the treatment of curved canals, several key products are instrumental in achieving true success. These include small stainless steel hand files, nickel-titanium hand files, and rotary nickel-titanium files. First, the stainless steel hand files are used to assist with creating a glide path. Passive movement with a light touch is necessary to debride pulpal tissues and negotiate apical anatomy. However, larger stainless steel instruments can alter the internal structure of the canal (i.e., increased canal transportation) when compared to nickel-titanium instruments. Nickel-titanium hand files can be used to increase the diameter of the glide path while maintaining the canal anatomy. Nickel–titanium rotary files are flexible, but multiple curves or significant curves can still put incredible strain on these instruments. Recently, a new product, Typhoon Controlled Memory (Clinician’s Choice), has been developed that uses thermal treated NiTi alloy that enhances the mechanical properties of nickel-titanium. These files have been shown to be more resistant to cyclic fatigue than standard nickel-titanium files. These three tools: small stainless steel hand files, moderate-sized nickel-titanium hand files, and rotary Controlled Memory or CM files, are essential for treating the moderately to severely curved canal systems predictably.

Step 3 – Use the tools appropriately

Each instrument has a specific function and should be used in the correct manner. Endodontic files are designed to create additional space within the root canal to decrease contact with subsequent files. Endodontic files should have minimal contact along the root canal. Slow, consistent enlargement of the canal can decrease the forces applied to each file used during instrumentation, minimizing chances for instrument failure. Hand files should be used in a watch-winding, or preferably, the balanced force technique. Rotary instruments should never be forced apically to avoid unnecessary strains and possible failure/fracture of instruments.

Two types of failure occur with root canal instruments: torsional loading and cyclic fatigue. Torsional loading occurs if a file binds within the canal and continues to rotate to the point of separation (torsional failure). Cyclic fatigue is the result of continued forces being placed on an instrument as it operates around curves. This results in repeated strain on the file resulting in eventual work hardening and fracture. In root canals with significant curves, cyclic fatigue is always a concern during treatment. The literature has demonstrated two key points. One, using CM files increases the resistance to fracture versus non-treated NiTi rotary files. Two, operating CM instruments in the presence of fluid increased resistance to fracture versus use in a dry environment by over 200%. Clinicians should always operate endodontic rotary instruments with canals flooded. This increases contact time between the internal root surface and the disinfectant as well as decreases potential for instrument separation.

Now that the steps to treat curved canal systems have been discussed, I would like to present a few cases that show the utilization of these steps and techniques.

Case 1

A 17-year-old male with non-contributory medical history presented for evaluation of Quadrant 1. Vitality tests confirmed a diagnosis of irreversible pulptis with acute apical periodontitis for tooth 1.6. Cone beam CT images (Kodak) confirm pronounced curve in MB canals and S curvature in DB canal. Dental caries were removed, and aseptic treatment was maintained with a resin-modified glass ionomer cement (Fugi II, GC Corporation). Vital tissue in 5 (MB1/2/3, DB, and P) canals was confirmed upon pulp chamber access. Initial coronal debridement with a rotary Sx file (Dentsply Tulsa Dental Specialties) in conjunction with stainless steel hand files to remove pulpal tissues. A glide path was created using a combination of stainless steel hand files and NiTi hand files (Flex Files, Dentsply Tulsa Dental Specialties). After achieving repeatable patency measurements with the Elements Apex Locator (Sybron Endo) and 15 NTK®, a 20/04 Typhoon (Clinician’s Choice) rotary file was introduced into each canal. Passive movement into each canal allowed for appropriate cleaning and shaping of the canal system. If the file appeared to stop moving apically while in the canal, the instrument was withdrawn, irrigation and recapitulation with a 15 NTK® hand file. In an apical enlargement approach, initial instrumentation with a 20 and 25 NTK® was used. Subsequent 25/04 through 35/04 instruments were used in all buccal canals and a 45/04 for the palatal canal. After disinfection was completed, obturation with master gutta-percha cones, Kerr EWT sealer (Sybron Endo) and Calamus® gutta percha (Dentsply Tulsa Dental Specialties) was completed. The floor of the chamber was sealed with a resin-modified glass ionomer cement (Fugi IX, GC Corporation) and temporized with Cavit™ (3M).

Case 2

A 39-year-old female with non-contributory medical history presented for evaluation of Quadrant 4. Vitality tests confirmed a diagnosis of necrotic pulp with...
symptomatic periradicular periodontitis for tooth No. 4.6. Cone beam CT images indicate significant mesial and distal canal curvatures. Access through the porcelain-fused-to-metal crown was completed with a combination of coarse #2 diamond and #557 carbide burs (NeoBurr®, Microcopy). Necrotic tissue in two distal canals and vital tissue in three mesial canals were confirmed upon pulp chamber access. Similar instrumentation completed as in Case 1 with the MB/ML canals shaped to a 35/04, the middle mesial to a 25/04 and the distal canals to a 40/04.

Conclusion

Although manufacturers often tout a preassembled system for root canal debridement, it is imperative for the clinician to assess each tooth or canals on a case by case situation and realize which instruments or techniques give the best chance of success. It is often far too easy to adhere to the “cookie cutter” pamphlet included in the packet of files rather than take the time to strategize the correct sequence to treat a tooth. Each tooth, and furthermore each canal of a tooth, is unique and requires diligent attention to detail for success to be possible. For example, the palatal canal of Case 1 was relatively straightforward. A standard cleaning and shaping protocol could be applied to produce a good result. However, when we approach the buccal canals, our strategy needs to be much more detailed and calculated to ensure appropriate treatment. Our role is to think biologically rather than operate as a technician. Do not misinterpret what is being presented. We are all capable of providing excellent endodontic therapy.

Appropriate courses can help you advance your craft. Utilize your local endodontic specialist’s knowledge and discuss cases during local study club events. Follow the current literature on new products and resources. Our profession prides itself on an evidence-based approach to treat our patients in the highest standards possible. Apply these resources and focus on the end result. EP

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REFERENCES