

Ahead of the Curve: The Latest Advances and Future Direction of Endodontics for Specialists and Generalists Alike

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The demise of endodontic treatment as a credible procedure in dentistry has been greatly exaggerated, to paraphrase Mark Twain. This is ironic in light of the fact that nearly every endodontic instrument and technique has been radically improved over the last 15 years. The concurrent rise of implant dentistry has occurred for many similar reasons, not the least being the greatly enhanced esthetic and functional success rates seen over the same time period. However, to categorically say that placing an implant is better than saving a tooth with endodontic therapy is either naïve or self-serving by those who only do implant surgery. As an endodontist who also does implant surgery, the question becomes very simple—what is in the patient's best interest?

To answer this question requires an understanding of the current advances and limitations of endodontic therapy so this article will present a viewpoint informed by what is technologically possible and biologically adequate in order to help our patients make the best decisions for themselves as to whether a tooth should be saved or replaced. In the end, I always ask myself what I would want done for myself or a loved one and the answer is then pretty straightforward. The greatest difficulties, in that regard, come in treatment planning for teeth that have failing endodontic treatment begging the question, "why did this fail?" Without the answer to that question, there is no way to conscientiously decide whether to save or sacrifice that tooth.

Diagnosis & Cone Beam CT Imaging

Perhaps the greatest improvement in the specialty, relative to treatment planning endodontic failures, is the advent of CBCT imaging to endodontic practices. The traditional projection (plain film) radiograph is a two-dimensional shadow of a three dimensional object. Three-dimensional (3-D) imaging overcomes this major limitation by allowing us to visualize the third dimension while at the same time eliminating superimpositions. Cone beam computed tomography (CBCT), also called Digital Volume Tomography (DVT), is a new technique that produces three-dimensional digital imaging at reduced cost and less radiation for the patient than traditional CT scans¹.

It also delivers faster and easier image acquisition. The first endodontist in the world (that I know of) to have his own CBCT machine is Dr. Yoshi Tarauchi in Tokyo, Japan. Four years ago he installed a CBCT machine in his office and thereafter preoperatively scanned every patient he consulted and/or treated. Yoshi is an exceptionally gifted endodontist (he can get any broken file out of any root) and while I understood the advantages of volumetric imaging for certain cases, I thought that he was a bit excessive in scanning every case. That was before I installed a J. Morita Accuitomo CBCT machine in my office.

My best analogy here is that of endodontists when they got their first microscope, thinking that it was only really needed for doing endodontic surgery. Shortly into the experience most of us realized that to do any case without the perfect light and multiple levels of magnification provided by an operating microscope was foolish and needlessly difficult. I am finding more and more cases every week that are better diagnosed, treatment planned, and treated with 3D imaging on board.

Being able to see bone lesions in all dimensions is a huge advantage! (Figs. 1A-D) Spiral fractures—often difficult to probe—become obvious with CBCT. Seeing the position of roots and adjacent structures like sinus spaces and nerve bundles in three dimensions is a beautiful setup for surgical retreatment. However, with the very tight resolution

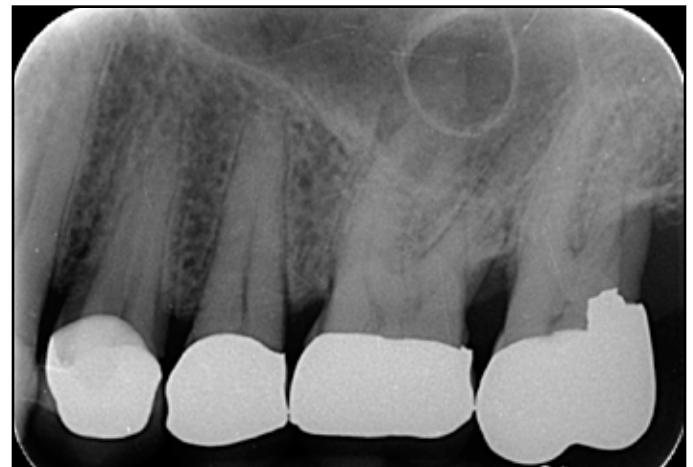


Figure 1A. Periapical film of maxillary molar showing a circumscribed lesion apparently dissociated from this tooth. (G. Horn)

provided by J. Morita's CBCT machine, complex root canal anatomy is easily seen, so fourth canals in upper molars are immediately ruled in or out, and if present, are far more easily located. Lateral canals, amazingly enough, can often be seen preoperatively in vital cases, giving the clinician greater motivation to effectively irrigate the root canal system after shaping (Figs. 2A & B). Beyond these uses, I was most blown away by how many periradicular lesions are unseen on standard 2D images that are dramatically obvious in CBCT images (Figs. 3A & B).²

The small field of view acquired by the Accuitomo exponentially (compared to other CBCT machines) reduces absorbed radiation to the patient down to 8-12 micro Severs—less than an analog panoramic image—so I can literally scan at will.³ When I installed my Morita unit I expected it to be most useful for my implant cases but found that it was more important for my endodontic cases.

Does having a CBCT machine define an endodontist as an excellent clinician? No, of course not. However, just as it was with operating microscopes in the '90's, those endodontic specialists who have them will be able to do things that those without cannot.

Concepts

The most important concept required for predictable endodontic therapy results (after correct diagnosis and treatment planning) is understanding that the more thoroughly we can treat this complex avascular system, the more often root canal therapy works. This has been understood by some clinicians (most exceptionally and brilliantly taught, in our time, by Dr. Herbert Schilder) since the late 1900's,⁴ but remarkably is not yet understood by all clinicians today.



Figures 1B-D. CBCT imagery showing the unusual periradicular lesion emanating from the terminus of the palatal canal and extending laterally in a buccal/palatal direction onto the sinus floor.



Figure 2A. CBCT pre-operative view of buccal root structure of upper second molar, showing the MB and DB canals merging and bifurcating in the apical third.

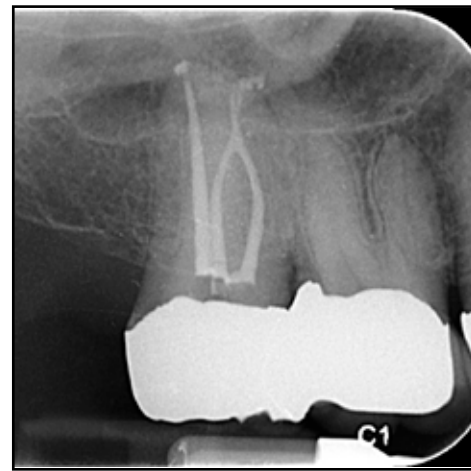


Figure 2B. Post-operative radiograph showing that anatomy shaped and filled. Having the volumetric imaging beforehand informed the requirements for successful treatment.

That's just crazy (Fig. 4). It's the most fundamental concept in the whole field of Endodontics. It's the elephant in the living room. It defies all logical consideration. However, as more progressive educators slowly take over our teaching programs, advancements in this regard are encouraging. Unfortunately there are still itinerant lecturers who corruptly give permission to general dentists to treat just parts of root canal systems.

This makes me emotionally distraught. I recommend that the next time someone in a lecture tells you that a cold gutta percha single cone filling technique (typically rationalized because there is a sealer spinner used) is sufficient; I recommend that you walk out of the auditorium. You can three-dimensionally condense warm gutta percha or a synthetic thermoplastic resin into every fin, web, isthmus, lateral or accessory canal in seconds (through remarkably conservative coronal shapes) if they have been properly cleaned and disinfected during the irrigation phase of treatment.

Conceptually many dentists, including some specialists, are still laboring under mistaken directives given to them in school, most critically the fear of treating root canals to and through their terminal

points.⁵ Why dentists fear taking a small file through the end of a root canal when implant surgeons cut through patient's jaws with massive drills is beyond me. This one concept cannot be overstated. Without carrying treatment to and through the ends of primary canals we have no chance of even approaching predictable results.^{6,7} However, if you practice in an area of the country where this is verboten, you just might think implants are more predictable than endodontic therapy. For those of us who treat the whole root canal system, endodontic therapy works at least as often as implant placement, takes less time to completion of the restorative effort, and costs the patient half as much.

The fact is that virtually every root canal can be negotiated and treated to length; if dentists use a lubricant during this initial procedure (not hypochlorite or aqueous EDTA) and use a small enough file in the first pass to length (an #08 in small canals and a #10 in larger canals).⁸ The only other barriers to patency are impediments such as apical irregularities or abrupt bends in the canal requiring the very tip of files to be likewise bent (Fig. 5). While these concepts of treatment are not new to dentistry, they are yet to be universally taught.

Figure 3A. Periapical radiograph of maxillary central incisor showing no definitive PA lesion (compared to generalized mottled lucencies).



Figure 3B. CBCT sagittal image showing very distinct and large PA lesion. beforehand informed the requirements for successful treatment.



Figure 4. CT reconstruction of mesial root of a mandibular molar showing a large isthmus and four apical portals of exit.

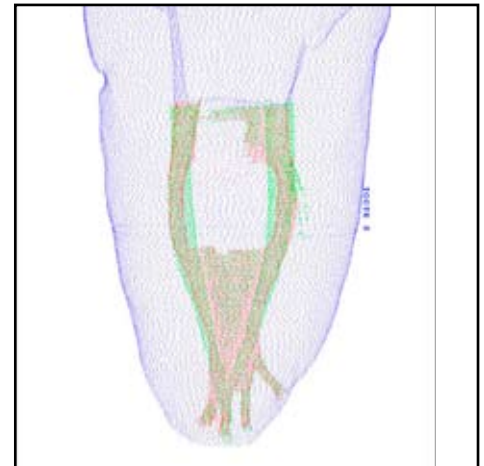


Figure 5. Mandibular molar with very simple mesial canal anatomy that required a single 20-.06 GTX File to shape and a very complex distal canal showing several abruptly curving canal impediments that required pre-bent negotiating and shaping files to prepare.



Conceptually, it is also important to remember that root canal systems, especially in molars, are complex enough that all surfaces of these spaces can never be cleaned with files without destroying the structural integrity of the tooth so irrigating effectively and three-dimensionally obturating them to the best of our abilities is critical for predictable success of treatment. Ironically, the astounding reduction of time (from 30 minutes down to 1 minute) provided by the advent of rotary instrumentation has resulted in an increase

in irrigation failures. Without a commitment to these concepts, the latest new endodontic technology is irrelevant.

Instruments and Devices

Before discussing the advancements in this section, I would like to point out that one of the greatest changes in endodontic devices (although not new) has been the apex locator. Despite their misnomer (apices have no direct relationship to the terminal points of canals), apex locators have changed endodontic therapy forever and for the better. Any dentist reading this who does not use an apex locator in the determination of every canal length they treat is spending more clinical time for a lesser result. With today's technology, it takes more time to acquire a well-angulated length determination film than it does to find length with an apex locator, shape, and conefit the canal. My preference is to accomplish these treatment objectives (without a test length film) and then confirm length with a conefit film after canal preparation has been completed.

Get an apex locator now, learn how to use it, lose the length determination film, and own the canal! I recommend the J. Morita Root ZX unit, the leader, by 90% in the US. The Root ZX is the most stable, most easily read and used apex locator in the world. A Japanese dentist, Dr. Sunada, first invented the device and it's no surprise that a Japanese company makes and sells the best unit on the market.

The most notable improvement in endodontic instruments has been the nickel titanium rotary shaping file revolution. We have seen many changes in instrument design as the number of competitors has increased. One of the biggest, which is still going on, was the push toward file designs that cut fast but didn't predictably prevent transportation or breakage. Unfortunately, the consequences resulting from ripping apical curvatures open are only seen in overfills, a coincidence usually mistaken for the true etiology of the ensuing failure—dangerous shaping files that ripped the apical architecture of the canal. While the functional characteristics of file geometry are very complex, where every design advantage presents a disadvantage as well, we know that radial lands on file blades prevent, or greatly reduce, straightening of curved canals compared to non-landed (so-called "cutting blades") flutes (Figs. 6-8).⁹

Figure 6. CT reconstruction of canals shaped with landed (right) and non-landed (left) rotary shaping files. Note the dramatic apical ripping with the very efficient yet unsafe files vs. the fidelity of the final shape to the original canal path created by the landed instrument (30-.06 GT File).

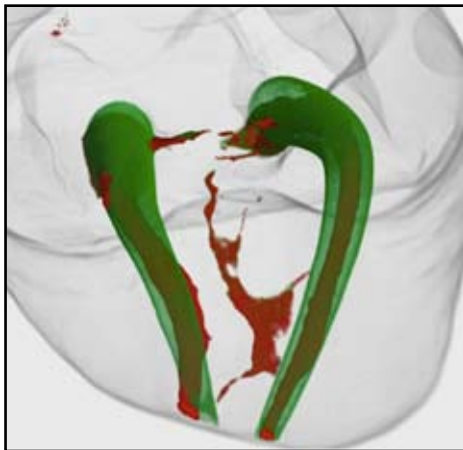


Figure 7. Premolar and molar with significantly curved canals, straightened (ripped) during shaping with non-landed, fast-cutting rotary shaping files. Both treatments failed within 6 months, requiring apical surgery as no conventional retreatment could resolve the severe apical damage.



Figure 8. Mandibular molar shaped with variable-land GTX rotary files. The mesial canals were cut to a 30-.06 shape and the distal to a 40-.08 shape. Note in the mesial root the remarkable fidelity of the final shapes to the original canal path despite multiple curves.



Less understood, but more important than the fact that we can shape canals with a handpiece-driven file, is the capability—made possible by the strength and flexibility of nickel titanium—to impart very specific shapes to our preparations with variably-tapered instruments.¹⁰ The improvement in speed and accuracy of variably-tapered shaping files over the serial step-back method is incalculable. A dental student of average skill now has the chance of creating a perfect shape in a root canal in his or her first attempt, while it previously took a naturally-skilled student 250-400 cases to achieve predictable results. Also misunderstood is the advantage of limiting the extent of coronal enlargement, a function that most rotary file sets cannot provide (Fig. 9 & 10).

The biggest recent change in the rotary instrument realm is the introduction of the new R-phase (rhombohedral) nickel titanium metallurgy for file fabrication. This innovation, created by two heat treatment processes interspersed with cold working the wire, provides improved flexibility and much greater resistance to cyclic fatigue—the most common cause of file separation. While this very

significant evolution has improved that aspect of file function, maintaining fidelity to the original canal path requires well-designed geometry to achieve its full potential. Geometry matters!

The next wave of innovation in the NiTi rotary revolution is cresting towards rotary negotiating instruments. This could be very cool but there are several serious challenges blocking this objective. One is the necessarily small diameters of these instruments, which makes them prone to torsional failure. The other challenge is how to prevent ledging when handpiece-driven files meet an impediment, requiring a safe tip (always) and a means to traverse that impediment. The initial entries to this new product category, with their small increases in tip diameters, will not solve these problems; however, solutions to these problems will hopefully be developed, causing hand file negotiation to be a thing of the past.

After shaping is completed, dentist's attention must be directed towards cleaning canal spaces. Many dentists doing root canal therapy do not understand the difficulty and importance of effective irrigation procedures. If you shape a root canal in less than a minute with two files (happens all the time with current technology), and fill it immediately, you will see cases that never heal. This case experience is usually connected to a vital inflamed case that is shaped and filled without sufficient irrigation time.

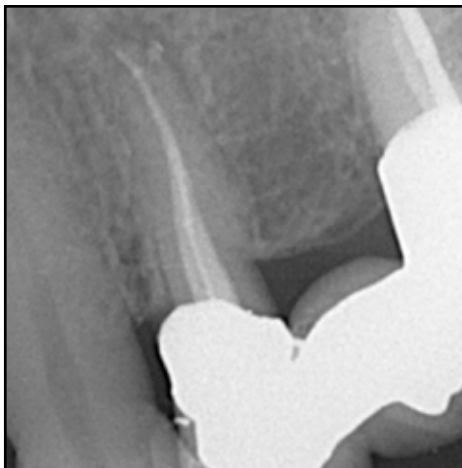
The treatment result looks perfect, no periradicular lesions, no improvement on effective antibiotics, but the tooth loses its sensitivity to percussion only after an NSAID has been taken. Virtually all of these cases presented originally with very inflamed vital pulps. Ergo, the etiology is vital inflamed pulp tissue left in lateral or accessory canals. Tissues in these peripheral canal regions are close enough to the rich periradicular blood supply to stay alive, yet they are pathologic enough to never heal. Retreatment with more adequate irrigation time will usually allow subsequent success.

Despite many attempts, dental company's efforts to improve on the efficacy of sodium hypochlorite and EDTA as cleaning solutions in root canal systems has been for naught. Unfortunately, efficacy with these solutions currently requires direct contact with all the walls in a shaped canal for a significant time period (20-40 minutes) in order to disinfect and dissolve organic tissue.

Figure 9. Maxillary molar with a vertical root fracture in the MB root due to coronal over-enlargement.



Figure 10. Maxillary premolar prepared with a single 20-.06 GTX File, resulting in a very conservative coronal shape yet showing three-dimensional treatment result (lateral canal cleaned and filled).



Many methods have been proposed to improve that efficacy, including heating of the solutions, sonic, and ultrasonic activation. The primary concern about ultrasonic activation has been that even at low power levels, ultrasonic activation of a small file in a shaped canal, if not done carefully, will often result in an apically ledged canal—a serious impediment to ideal obturation. Sonic activation has been shown to be safer, and very helpful in cleaning molar isthmuses in coronal regions, yet relatively ineffective in apical regions.¹¹ Negative pressure irrigation (suctioning through the irrigating cannula) is a recently developed irrigation technique. This system, which differs significantly from traditional positive irrigation, has demonstrated promising results. Although more time consuming, it has been shown to produce a better cleaning and disinfection.^{12,13}

Progress in resolving this clinical challenge has lagged the developments in shaping and obturation technologies because there is so much less awareness about the importance of cleaning procedures. However, this is currently where the greatest R&D opportunities lie for dental companies in the near future.

As to the current state-of-the-art in obturation, all available evidence (the number of clinicians using this method, the obturation results achieved, and the research done) indicates that Centered Condensation is it. Whether you fit a cone and drive through it with an electric heat plugger or push a pre-heated obturator through a canal space, the streaming effect of the thermosoftened filling material will fill any anatomic complexity that has been cleaned during irrigation.

Single cone technique is from the early 1900's, lateral condensation is from the late 1900's, Centered Condensation methods are today's state-of-the-art in obturation.¹⁴⁻¹⁶ No other filling method can fill as well, in as little time, through such small coronal diameters.

One last comment: there are several companies who trumpet laser sized gutta percha cones, and truth be told, they are more precisely sized. However it is not the accuracy of the cone that determines apical accuracy of obturation, it is the accuracy of the canal preparation. Without landed blades, files can only make a shape that is larger than the silhouette of the file. Apical accuracy of cone fitting required a predefined shaping outcome³.

Technique

Just a few notes about technique:

-Brilliant diagnosis and treatment planning is worth waaay more than good hands. Don't retreat loser teeth!

-Technology is an empty bag in the hands of a poorly intended, poorly trained dentist.

-The wrong negotiation technique will block you out in 1 out of 3 vital cases.

-If you negotiate to the terminus of root canals in the presence of NaOCl (no lubricant), you are going to have to say you prefer to treat vital cases short—"I meant to do that"—because you will get no other consistent result.

-If someone taught you that a #10 K-file (without a lubricant) is the appropriate size to approach the terminus in a small canal, you need to help them understand that they don't know their file from an orifice.

-If you have done root canal therapy in the last week without an apex locator you have failed the IQ test.

-If you don't know the Balanced Force Technique of K-file manipulation, you could do better in tight canals.

-If you think it takes 5-8 rotary shaping files to ideally shape a root canal, you are listening to the wrong salesperson.

-If you have used any type of Gates Glidden bur in the last year, you are going to the wrong lectures.

-If you think any irrigation technique, no matter how much improved, is going to get the job done in 3-5 minutes, you have never looked at CT reconstructions of endodontic anatomy.

-If you have been told by an Endodontist that carriers cannot be removed for retreatment, show them how to do it after you learn the 60 second method shown on my website, endobuchanan.com.

At the end of the day, technique is the Art of Endodontics. I would rather have a root canal treatment on my own tooth by a seasoned pro who is using the oldest, most mundane instruments but the best concepts and techniques, rather than a

newly-minted dentist with the latest equipment, no real experience, no grasp of the conceptual basis for endodontic success, poor technique, or (worst of all in this scenario) great confidence and self esteem.

Regardless of where you practice, you will find no different outcome if you ignore the anatomic realities of root canal systems, because root canals are all the same throughout the world (OK, they can be different in Asia). They are complex and they can be difficult to treat successfully. Hopefully, I have informed you about the very consistent success that can be expected when treating root canals to their full apical and lateral extents. The good news is that it has never been so straightforward or so efficient. In terms of the financial challenges occurring throughout the world today, elective procedures will be pursued less often and pain relief (endodontic therapy) will be seen to be more recession proof. Despite rumors to the contrary, this is, literally, the Golden Age of Endodontics.

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