Dental
Education
Laboratories

1515 State Street, Suite 16
Santa Barbara, CA 93101 USA

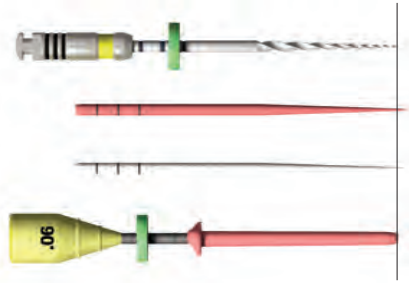
800.528.1590 / 805.899.4529
www.endobuchanan.com

The Art of Endodontics

A System-based Approach to Endodontic Therapy

designed by Dr. L. Stephen Buchanan

The GT*X* System is a fully developed, clinically tested set of instruments and materials that are designed to optimally work together.



Each GT*X* Rotary File or GT Hand File cuts an identical shape allowing a corresponding size of

GT*X* gutta percha points

GT*X* paper points

or GT*X* Obturator to ideally fit in these GT*X* cut preparations.

Chart 1	Access: How to cut perfect file paths through very conservative cavity preparations
Chart 2A	Hand File Negotiation: Avoiding apical blockage and ledging
Chart 2B	The Balanced Force Technique: Cutting on the backside
Chart 3	Negotiating Impediments: Sneaking around apical irregularities
Chart 4A	Rotary File Negotiation: Vortex Blue and Pathfile Instruments
Chart 4B	Rotary File Negotiation: Vortex Blue and Pathfile Instruments (visual charts)
Chart 5	Cutting Initial Shape in Small Canals: Rough-cutting with small tipped, non-landed razor files
Chart 6	GT*X* Rotary File Selection and Settings
Chart 7	Cutting Initial Shape in Medium and Large Canals: a 30-.08 GT*X* Rotary File to length
Chart 8	Apical Gauging: Assessing the terminal diameters of canals
Chart 9	Cutting Final Shape: GT*X* Rotary and GT Hand Files
Chart 10	Shaping Around Impediments: Pre-bending nickel titanium rotary files
Chart 11	Lubricants, Irrigants and Chelating Agents: Selection and Use
Chart 12	Carrier-based Obturation: GT*X* and GT Obturator technique
Chart 13	Continuous Wave Obturation Downpack: From 2D to 3D in 2.5 seconds
Chart 14	Continuous Wave Obturation Backfill: Avoiding the void

Access

How to cut perfect file paths through very conservative cavity preparations

Cutting Tool Selection

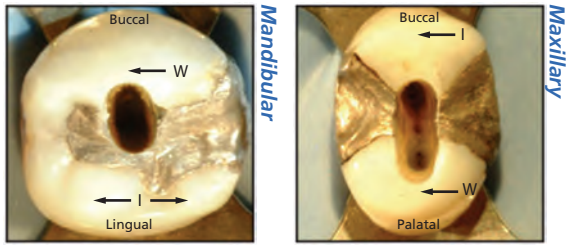
Removal of Decay	#6 surgical length carbide round bur at slow RPM
Cutting through Prostheses to Dentin	Porcelain - #2 round diamond bur with water spray Cast metal - round-ended cross cut carbide fissure bur with water spray
Cutting through Dentin to the Pulp Chamber	Anteriors, Bicuspids, Molars - tapered diamond bur - surgical or XL length
Cutting Perfect File Paths through Minimal Outline Form	LA Axxess high speed diamond bur (SybronEndo)
Access Refinement	BUC-1, 1A (Spartan)
Removal of Pulp Stones	BUC-2 or 2A (Spartan) ultrasonic tips

Anterior Access Design

Cut slot-like outline forms shy of the incisal edge and cut under the cingulum to remove the lingual dentin triangle.

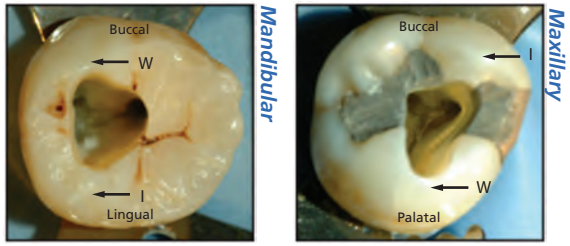
Premolar Access Design

Cut slot-like outline forms—off center toward the working cusp (B-L)-round outline form is inappropriate for premolars.



Molar Access Design

Preserve tooth structure by limiting extension of the distal wall (to the M-D midline). Create convenience form by cutting the mesial wall forward.



Calcified Canal Hunting

Searching for calcified pulp chambers without loupes or a microscope or an ultrasonic handpiece is a fool's errand. Conversely, the incredible visual access provided by magnification and ultrasonic cutting makes this a whole different game. The Buc-1 is the first U/S tip used, until the depth achieved requires the smaller Buc-1A tip. Using a round-tipped instrument is critical to the success of this procedure.

When the smoothly-cut dentin surface of the trough shows a dust-laden dot or line, a DG16 endo explorer is pressed firmly into it and removed—tugback indicates a canalform, no tugback means you need to keep looking.

When tugback upon removal of the DG16 is felt, bring a 21mm 15-.06 Vortex Blue Rotary File to the explorer divit and with light pressure spin the file and observe whether it enters the canal. If it does, carefully advance 3-5mm's and you are ready to finish the access cavity prep. Complete the file path cut with a single light use of an LAX diamond bur in a high speed handpiece at _ speed or full speed in a friction grip attachment on a slow speed handpiece.

If you can slide a #15 KF smoothly, from cavo surface into each canal, the access cavity is complete!

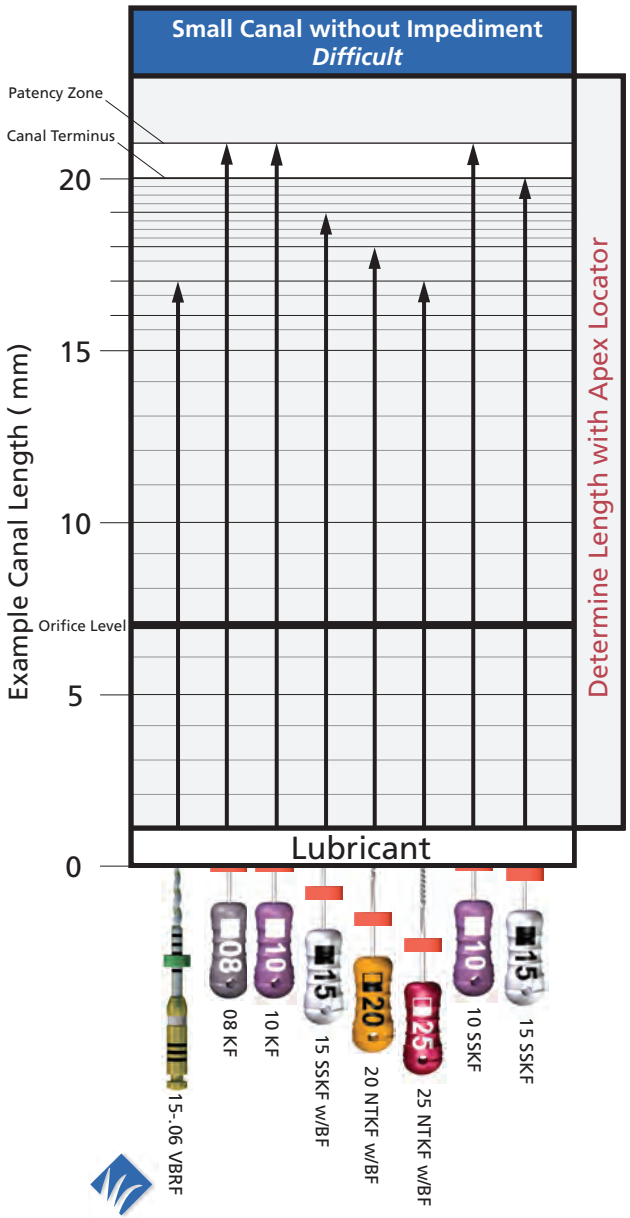
If the rotary file fails to advance into the canal, think hard about where to look next—deeper where you are or in a different direction? If uncertain, take a radiograph. Then with your new plan in mind, cut again with the U/S handpiece, look for dust dots or lines, repeat. When frustrated, take a break or re-appoint the patient. When faced with a canal not found, referral is indicated, if not for all calcified cases (trust me, endos only do them because they have to).

Tools for calcified canal hunting:
Buc-1, 1A (Spartan) ultrasonics tips, Magnification, a DG16 explorer, and a 15-.06 Vortex Blue Rotary File.

Dental Education Laboratories
L. Stephen Buchanan, DDS

Hand File Negotiation
Avoiding apical blockage and ledging

Procedural Flow →



- N*egotiation Objectives:*

  1. Sneak an #08 K-File to length and beyond.
  2. Determine length with an apex locator.
  3. Work progressively larger files to the root canal terminus until a #15 K-file (KF), or larger, fits to length with a stable, reproducible apex locator reading.

- **Always use lubricants** (such as ProLube) to fill the access cavity prior to and throughout negotiation until a #15 KF or larger gets to length. Lubricants stabilize apex locator readings and help prevent apical blockage with pulp tissue. Stop using sodium hypochlorite during negotiation procedures!

- **Beginning with a 15-.06 Vortex Blue Rotary File (VBRF)** used as an orifice opener in the coronal 1/3 makes everything afterwards easier.

- **Small, straight stainless steel (SS) KF's will usually move to length with no pre-bending,** despite significant canal curvature. If you encounter loose resistance to apical file placement, it indicates an "impediment" in the canal which requires file bending and mental visualization skills to traverse.

- **Never turn a SS negotiating file more than 90 degrees in a clockwise direction** or separation will occur. *Safe activation of negotiating files:* Push the instrument into the canal until it binds, wiggle it a bit and see whether it advances into the canal. If it does, it will tighten, requiring 3-4 push-pull strokes to loosen it, after which it is again pushed into the canal and wiggled, etc.

- **Start with a safe size of file:** Blockage will occur, even in the presence of lubricants, if the first file taken to length is too large. In small root canals #08 SSKF's are appropriate. Occasionally, small dilacerated canals will require an #06 SSKF to reach length. In medium and large canals, a #10 SSKF can safely be taken to length without concern of blockage.

- **Get patent** beyond all apical foramina by at least a full millimeter. If this hurts your patient, they aren't numb. If this gives you the willies, get therapy—this is critical to controlling the remainder of the procedure and the success of the case.

- **Use an apex locator** with all negotiation files as they approach estimated length. Using an apex locator usually supplants the need for a length determination x-ray as apex locators are at least 20% more accurate than radiographs. Beyond that, taking negotiating files into unknown territory without an apex locator reading is lunacy.

- **Never attack an impediment**, bend your file and dance around it. Engaging an impediment can turn it into an iatrogenic ledge—way worse than just an anatomic impediment—possibly an impassable situation.

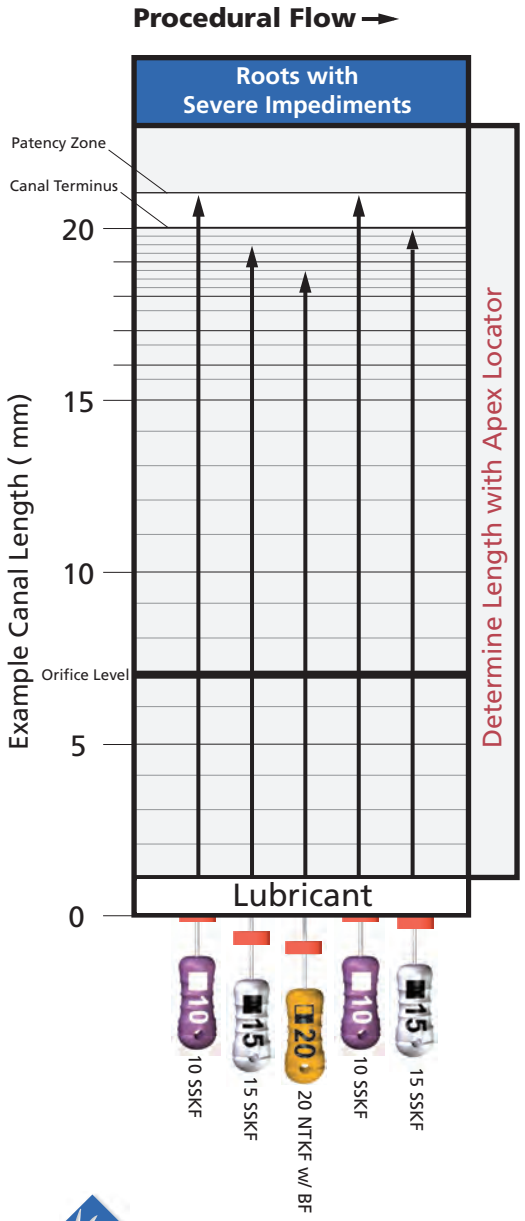
- **If the instrument does not advance apically, remove it.** Using 1-2 larger instruments at increasingly shallow depths is the most effective way to get the intended instrument to length. This is called serial *step-back negotiation.*

- If the #15 SSKF balks at cutting to length, using a #20 Nickel Titanium (NT) KF with the Balanced Force (BF) Technique (see Chart 2B) to cut just short of that length will usually allow the #15 SSKF, after patency is confirmed with a #10 SSKF, to passively drop to length.

- **Be patient, clever, and persistent.** Negotiation is one of the most difficult and artful aspects of root canal therapy. In tough molars, you may be lucky to get to length in all canals in the first two-hour appointment. Canals don't calcify apically, there are only impatient clinicians who give up before they get to length.

Dental Education Laboratories
L. Stephen Buchanan, DDS

The Balanced Force Technique
Cutting on the Backside



Invented by Dr. James Roane in the '80's, the Balanced Force (BF) Technique is the most effective way to cut dentin with a hand file. It is a bit obscure at first, but is so efficient, so valuable in tight shaping situations, that it is worth the effort to learn.

One of the best, most practical applications of BF is the situation where lubricant fills the access cavity, a #10 SSKF slides to and through the terminus, but the #15 SSKF hangs up 3mms short. Don't panic and get aggressive with the #15 SSKF. Use the "#20 NTKF with BF" trick to get the #15 SSKF to length.

The "#20 NTKF with BF" trick explained: When the #15 SSKF resists cutting to length it is most often binding in the coronal 7/8ths of the canal. Rather than excessively working files smaller than the hung up #15 SSKF, use a #20 NTKF just short of it. This will remove all the dentin that was previously binding the sides of the #15 SSKF and allowing the #15 SSKF to literally "drop" to length passively.

1. Bring a #20 NTKF into the canal, pushing it to its binding point. This is always done with lubricant in the canal, and using a counter clockwise (CCW) rotation.

2. With ***NO*** apical pressure, the file is rotated less than 90 degrees in a clockwise (CW) direction. The file should feed into the canal and tighten up. Avoid inserting the file more than a quarter turn. Bad things could happen.

3. Apply firm apical pressure to the file and simultaneously rotate the file in a counter clockwise (CCW) direction—at least 360 degrees. You will feel the file tighten as it is wound up in the reverse direction, until (between 180 and 270 degrees) the file gives, clicking twice, and then rotates smoothly as the dentin lands between the flute-cut grooves have been cut off in this CCW move. Be certain to hold apical pressure on the file during this CCW motion, or the file will back out of the canal without cutting.

4. The file is not removed unless the desired length has been achieved, it is instead threaded CW back into the canal another 1/2 to 1 mm (tightening), followed by Step #3 above.

5. Repeat the BF cutting cycle 3-5 times, then remove the instrument, while rotating it in a CW direction to gather and remove the cut dentin debris held in the flute spaces.

Confirm adequate lubricant in the access cavity, drop a #10 SSKF through, and re-introduce the #15 SSKF. Watch it move passively to length!

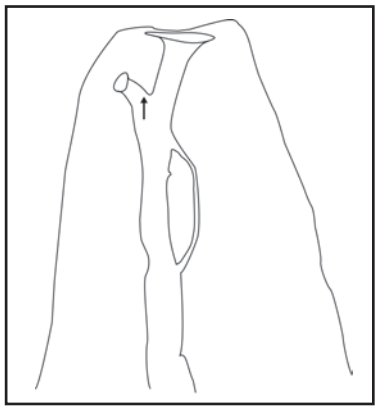
Rotary Files in Tight Canals Nitinol KF's used with the BF cutting method, are a potent, 100% safe, weapon to use when attempting to open a recalcitrant canal. Having trouble cutting a 20-.06 GT*X* Rotary Shaping file to length? Cut a #20 NTKF to length with BF, followed by the #25 NTKF a mm short, and the #30 NTKF 2 mm's short, always in the presence of a weak acid solution (Qmix [citric acid] or 17% aqueous EDTA). Get patent, irrigate again, drop the 20-.06 GT*X* File in and feel it cut easily to length.

GT Hand File Technique Despite the differences in cross-sectional geometry, GT Hand Files (GTHF) cut the same shape in canals as GT and GT*X* Rotary Shaping Files. Because of that, the 20-.06 GTHF remains one of my favorite go-to instruments when I'm hanging up short of length in in a nasty root and I fear breakage of a rotary file.

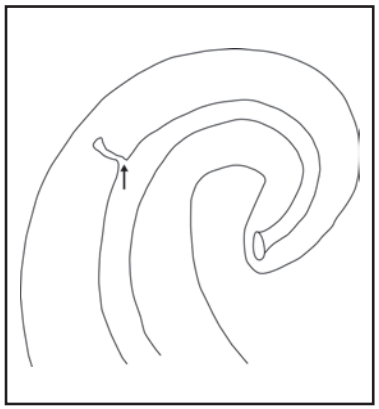
20-.06 GTHF's have a white, tapered handle designed to be used with the BF Technique, but the flutes are reversed, so a reversed-BF Technique is used to cut with them. Pushed to the binding point in the canal, the GTHF is rotated in a CCW direction until it tightens as it advances in the canal. Apply firm apical pressure and simultaneously rotate it 360 degrees, making the CW cut. The GTHF is then re-engaged by rotating it CCW, and so forth.

Dental Education Laboratories
L. Stephen Buchanan, DDS

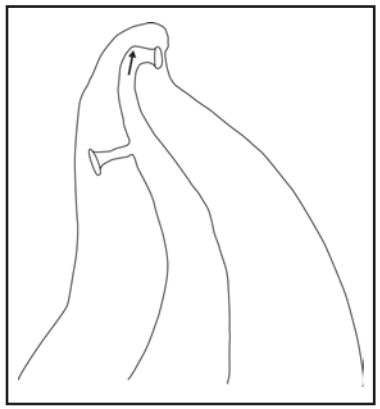
Negotiating Impediments
Sneaking around apical irregularities



Straight Canal
with Apical Irregularity



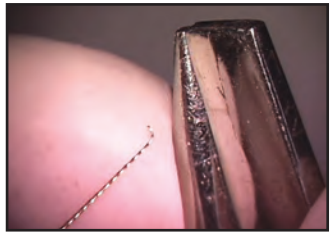
Curved Canal
with Irregularity



Abruptly Bent Canal

- Canals are never calcified apically. They just present with anatomic impediments that require cleverness and persistence to traverse. Impediments are identified by the tactile sense (felt through the file handle) of "loose resistance to apical file placement." This occurs because the tip of the instrument is hanging up in an irregularity, rather than gliding to length and beyond.

- Conversely, tight resistance to apical file placement indicates lateral binding of the file in a canal region narrower than that instrument, an indication to activate the instrument if further depth is desired.



- When an impediment to apical progress is met, remove the file, smoothly bend the very last 2mm's with a file bending plier (EndoBender by SybronEndo), align the directional mark on the stop toward the file bend, and you are ready to hunt for a path around the impediment.

- Only files bent to retain 70-90° at their tip ends will negotiate around most impediments. A careful watch-winding motion is used to advance the file through the canal to the impediment without its bent tip curling or straightening. When the impediment is met, pull back a millimeter, turn the file tip in a new direction, move it apically with a wiggle and see if it advances. If not, pull back, redirect the bent file tip and see if it drops. Repeat, if apical progress is seen, until patent.

- An apex locator is essential to check whether the terminus has been reached after an impediment is successfully traversed.

- In challenging cases, many attempts may be required before patency is achieved. As soon as the file tip moves beyond the impediment, it will drop deeper into the canal—the holy grail of impediment negotiation. During this hunting expedition, the directional indicator on the stop informs the clinician about the direction of the bent file tip as it traverses the impediment, in essence, mapping the path. Wiggle the file and move deeper, and work it, checking it with an apex locator lead until length is reached.

- Once past the impediment, avoid withdrawing the file to the impediment level as the file has inevitably straightened and will no linger traverse it without being withdrawn, rebent, and re-inserted.

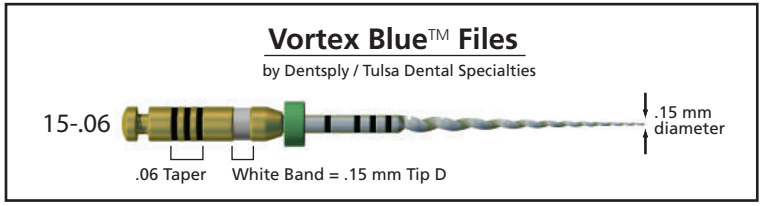
- In a canal with a double impediment of S-shaped curvature, the prebent file will drop when directed around the first bend in the canal but will again meet **loose resistance to apical file placement** as it encounters the second canal bend. In this case, pull the file back slightly, turn it 180 degrees, give it a wiggle, and see if it catches or just drops to length.

- With bent files and stop indicators, you should be able to mentally map the canal path around the impediments and thereafter easily dance around them and get the job done.

Dental Education Laboratories
L. Stephen Buchanan, DDS

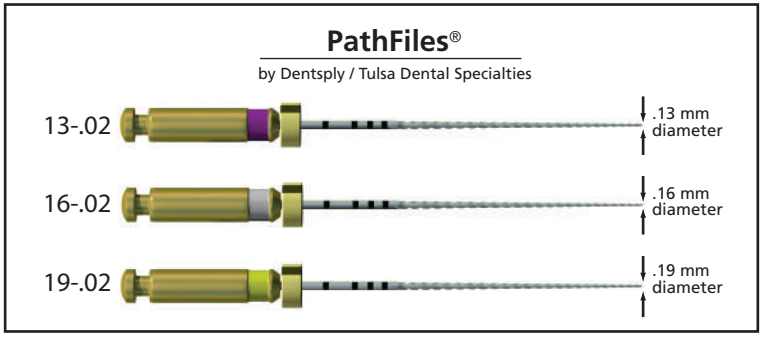
Rotary File Negotiation
with Vortex Blue and Pathfile Instruments

- Rotary negotiation can save a significant amount of time and effort when used during procedures in small canals, however clinicians must train up in extracted teeth before using these methods on patients.
- When access procedures are completed, the cavity is filled with a lubricant, a 15-.06 Vortex Blue Rotary File (VBRF) is set to estimated length of the canal.
- The 15-.06 VBRF is cut into the canal for one or two seconds, it is withdrawn a bit, and is then pressed lightly back into the canal—carefully observing whether it advances upon replacement when reaching the previous length. At the first hint of the file stalling twice at the same depth in the canal, replace the rotary file with an #08 SSKF and start watch-winding it toward the terminus. *Any further effort with a handpiece-driven file may cause ledging or separation, be careful!*
- VBRF's are heat-treated to reduce the shape memory of the wire, so the files made out of it can be pre-bent with an EndoBender or other plier without the file straightening. This is *very* helpful when placing rotary files into mesial canal orifices in molars, not an easy thing to accomplish with a 25mm instrument mounted. Bend the VBRF, insert it in the latch-grip mini-endo head, tap the foot pedal until the file is angled from distal to mesial, and with a mirror shot glide down the mesial line angles with the bent file tip and into the canals.
- Pathfiles are operated with a very light touch.
- Use an apex locator with a long straight file probe on all negotiating files, rotary or hand, as they approach estimated length.
- Rotary negotiation is only helpful in large canals if there is coronal calcification.



Vortex Blue Files
Torque and RPM Settings

File Size	Torque	RPM
15-.04	50 g-cm	300
15-.06	100 g-cm	300

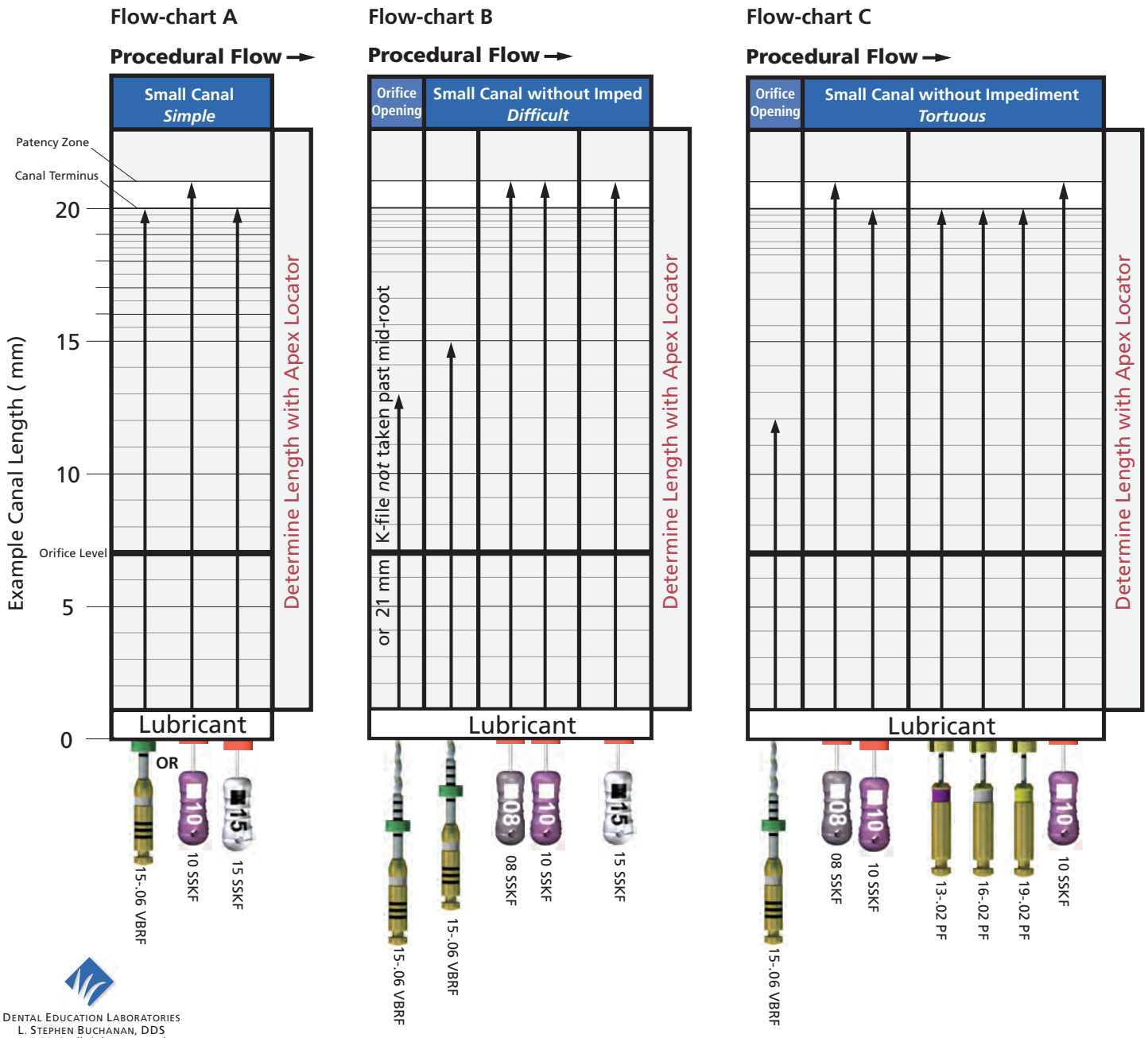


PathFiles
Torque and RPM Settings

File Size	Torque	RPM
13-.02	80 g-cm	300
16-.02	110 g-cm	300
19-.02	110 g-cm	300

Dental Education Laboratories
L. Stephen Buchanan, DDS

Rotary File Negotiation
with Vortex Blue and Pathfile Instruments



Flow-chart A.
In small molar canals, the VBRF may continue to cut apically until length is reached. Clean the flutes often.

Flow-chart B.
In difficult canals, the rotary file may resist further placement. In that case, simply bring in the #'s 08, 10, and 15 SSKF's. They will usually drop to length as the 15-.06 VBRF has removed any binding points in the coronal half of the canal.

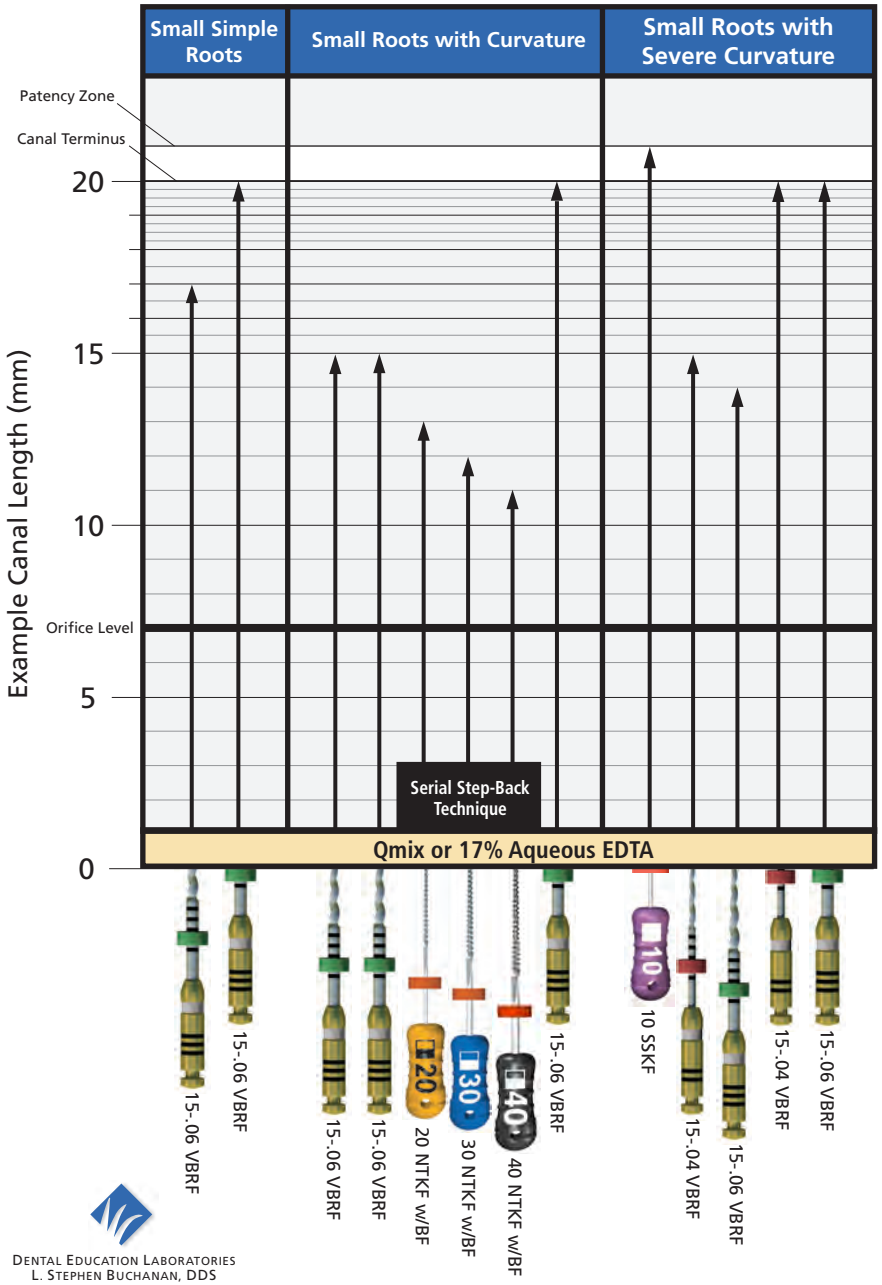
Flow-chart C.
In the most tortuous canals, the #08 and #10 SSKF may make length, but the #15 SSKF hangs up millimeters short. In this case rotary PathFile (PF) instruments, with their small increments of tip size increases—the #13, #16, #19, will usually glide to length, creating a glide path for the shaping procedures to follow.

Dental Education Laboratories
L. Stephen Buchanan, DDS

Cutting Initial Shape in Small Canals

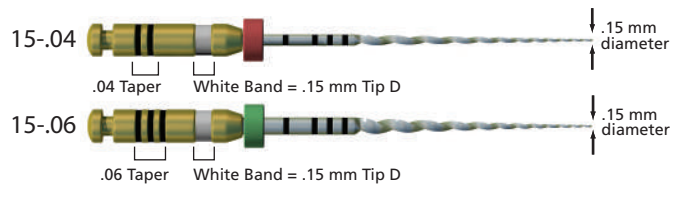
Rough-cutting with small tipped, non-landed razor files

Procedural Flow →



- The primary objective of initial shaping is to cut an .06 shape to full length in the canal with a sharp-fluted, but small-tipped rotary file so that the terminal diameter of the canal may be accurately measured (gauged) with NTKF's of lesser taper (.02 mm/mm), assuring the clinician that any binding of the KF will be only at its tip. The diameter of the canal at the depth of binding is then known as KF tips are sized by their apical diameters X 100.
- ***Prerequisite*** File paths must be established prior to cutting initial shape. Canals must first be negotiated to at least a #15 KF to the terminus with a #10 KF easily passing through.
- Initial Shaping in small canals is begun with a 15-.06 VBRF (300=RPM, TL=250 g/cm) after irrigating with a weak acid solution (Qmix [citric acid] or 17% aqueous EDTA) and leaving a reservoir in the access cavity.
- ***Cutting Initial Shape*** Insert the rotating file into the canal until a light bind is felt, then, holding a light, even pressure on the handpiece, patiently watch the file walk into the canal. Cut for 3-4 seconds and release (pull back slightly but do not remove the file from the canal). Repeat the advance/release motion 2-3 times, then remove the file and clean the flutes of debris.
- If length is not achieved in two or three cutting cycles with the 15-.06 VBRF, serially enlarge the canal with #'s 20, 30, and 40 NTKF's (with BF) in a step-back routine. Just two or three cutting cycles with each of these highly flexible, but tough hand files will usually provide the added shape around bent canals needed for the 15-.06 VBRF to safely cut to length.
- ***Respect the Danger of File Debris*** Files that stall in their apical progress must be removed and examined. If the flutes are packed with debris, wipe the debris off with an alcohol-soaked 2X2 gauze and examine it for flute derangement. Any file with deranged flutes must be replaced. Attempting to cut further, after the chip space is full, is dangerous because it increases the friction and torsional stress endured by rotary instruments, significantly increasing the chance of file breakage. Cut debris should also be wiped off the file when it is within a millimeter of full length. This will reduce the amount of debris packed into lateral anatomic spaces as length is achieved.
- ***Respect the Danger of Hidden Curvatures*** When a file has stalled in its apical progress but is not packed with debris when retrieved, it has stalled due to hidden canal curvature. This is the signal to drop in taper size to increase the flexibility of the instrument you asking to cut around significant canal curvature. Any time you fear instrument separation, get a new file of the same size or drop to a file that is smaller.
- ***The Unusual Case*** If the 15-.06 VBRF resists cutting to length after serial step-back enlargement with NTKF's, confirm patency with a #10 KF, irrigate with again with a weak acid solution, and carefully alternate the 15-.04 and 15-.06 VBRF (300RPM, 100g/cm) until the 15-.06 VBRF reaches length.

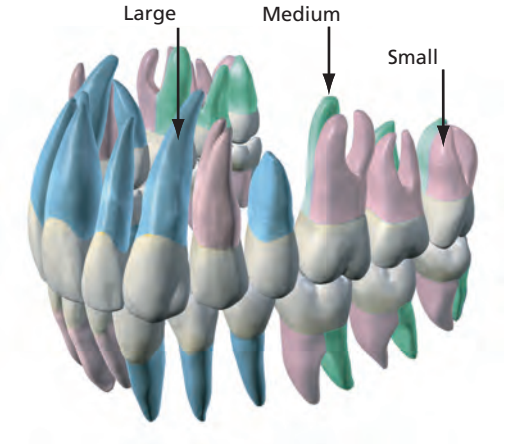
Vortex Blue™ Files



Dental Education Laboratories
L. Stephen Buchanan, DDS

GT*X* Rotary File Selection and Settings

Root Size Identification

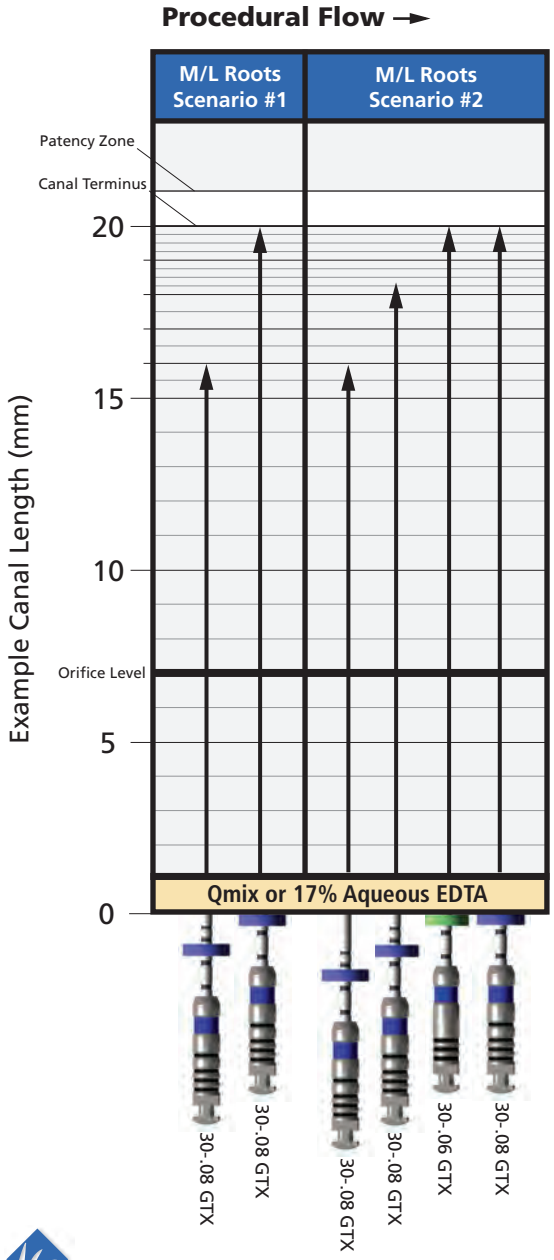


Small Roots mandibular incisors 2 & 3 canal pre-molars mesial roots of lower molars buccal roots of upper molars	20-.06  30-.06  40-.06 
Medium & Large Roots distal roots of lower molars palatal roots of upper molars lower cuspids upper anteriors single canal pre-molars	30-.08  40-.08  Optional files from *Standard GT Series* 40-.10  50-.12  70-.12  90-.12 

GTX File Size	Torque Setting	Suggested RPM
20-.04 / 20-.06 / 30-.04 	250 gcm	300 RPM
30-.06 / 40-.04 / 40-.06 	300 gcm	300 RPM
30-.08 / 40-.08 	360 gcm	300 RPM

Dental Education Laboratories
L. Stephen Buchanan, DDS

Cutting the Initial Shape in Medium and Large Canals
a 30-.08 GTX File to length



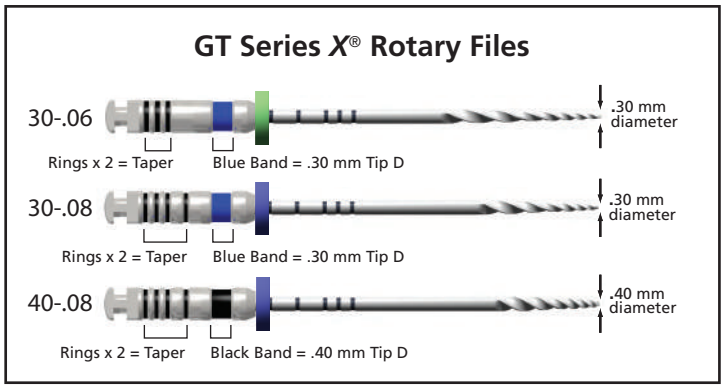
- ***Prerequisite*** File paths must be established prior to cutting initial shape. Canals must first be negotiated to at least a #15 KF to the terminus with a #10 KF easily passing through. Use a weak acid solution (Qmix [citric acid] or 17% aqueous EDTA) as irrigant.

- Cutting initial shape in medium and large canals is begun with a 30-.08 GT*X* Shaping File (300=RPM, TL=250 g/cm). This file will usually cut to length in medium to large canals in 3-4 cuts. When a 30-.08 GT*X* File resists cutting to length, it's usually because of significant curvatures, so a 30-.06 GT*X* File will usually get there.

- ***Optimal GTX File Method*** Insert the rotating file into the canal until a light bind is felt, then, holding a light, even pressure on the handpiece, watch the file walk into the canal. Cut for 3-4 seconds and release (pull back slightly but do not remove the file from the canal). Repeat the advance/release motion 2-3 times, then remove the file and clean the flutes of debris. Continue this process until length is achieved or the file stops advancing apically. In-and-out "Pecking" motions are ineffective with radially-landed shaping files.

- Cut debris should also be wiped off the file when it is within a millimeter of full length. This will reduce the amount of debris packed into lateral anatomic spaces as length is achieved.

- ***Beware!*** If the 30-.08 GT*X* Rotary Shaping File resists cutting to length in apparently straight roots, this indicates a significant hidden curvature.

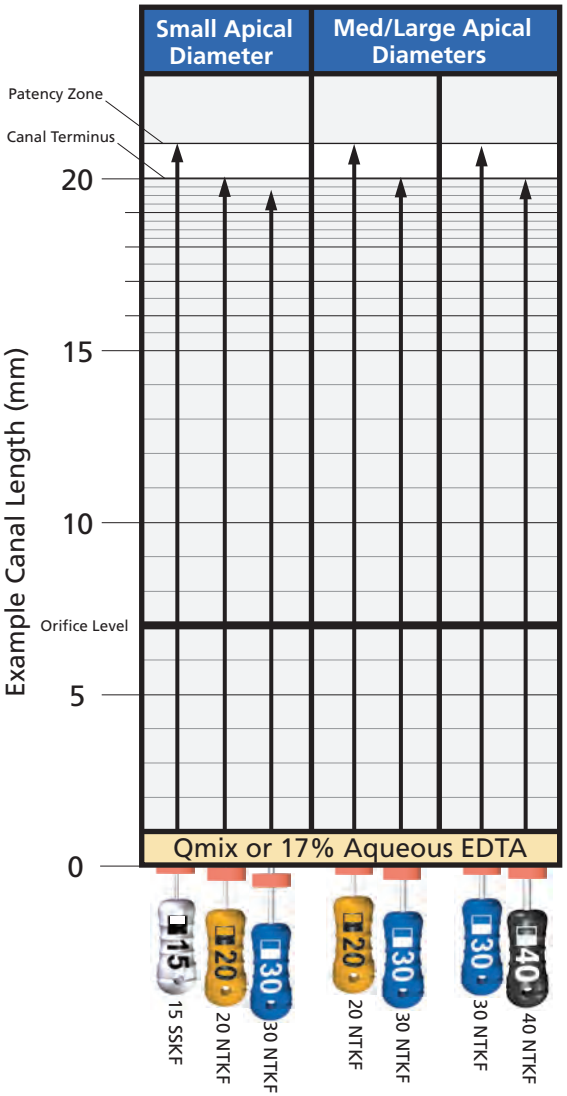


Dental Education Laboratories
L. Stephen Buchanan, DDS

Apical Gauging

Assessing the terminal diameters of canals

Procedural Flow →



- ***Objective*** The function of apical gauging is to assess the apical diameter of the canal prior to and after cutting the final shape, and to confirm or deny the presence of taper to the end of the canal. This is necessary to insure that the taper of the final preparation extends all the way to the terminus of the canal (Apical Continuity of Taper), insuring the apical accuracy of the preparation and therefore the apical accuracy of obturation.

- K-files are used as round "feeler gauges" in order to indirectly read the apical diameters of the canal. Apical gauging requires an .06 taper be cut near the apical 1/3rd—this is, in fact, the purpose of initial shaping—to ensure that only the tips of gauging files bind in the canal. Binding laterally, rather than just at the tip of the gauging instrument, lessens the accuracy of this assessment, therefore it is highly recommended that clinicians use nickel titanium K-files for this purpose due to their greater flexibility.

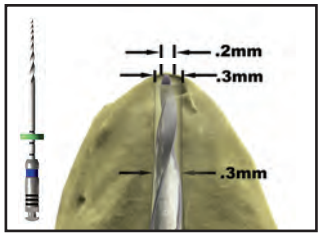
- ***Irrigation*** Always use a weak acid solution (Qmix [citric acid] or 17% aqueous EDTA) as an irrigant during gauging to remove the smear layer created during dentinal cutting procedures.

- ***Visual Gauging*** Carefully check the tip flutes of the first GT*X* File (of a given tip diameter) that cuts to length. If the tip flutes are full of cut dentin debris, most likely the taper has been cut to the terminus and shaping is finished. In this case, Do tactile gauging to confirm continuity of apical taper. If the gauging file that binds at length is tip sized the same as the last GT*X* File cut to length, shaping is finished.

- Conversely, if there is no dentin debris in the last 1-2 mm of the file, the apical diameter of the canal is most likely larger than the file tip, indicating lack of taper at the end of the canal (discontinuity of apical taper), and the need for a GT*X* Shaping File with the next larger tip diameter.

- ***Tactile Gauging*** No effort is made to cut dentin during tactile gauging. The gauging instruments are inserted straight in and pulled straight out, with no rotation, not even a wiggle. Simply test different sizes to find which drop through the terminus—they are smaller than that diameter, which size NTKF binds at length—very close to the apical diameter, and which bind short—they are larger than the terminus. The final act of the instrumentation process is the passage of a patency file to and through the end of the root canal—dispelling any last specks of collected debris—in the presence of a weak acid solution. This will do more to aid cone fitting than most anything else.

Discontinuity of Apical Taper



This canal has an original terminal diameter of .3 mm. It was shaped with a 20-.06 GT*X* Shaping File, which has a tip of .2 mm. When the #30 K-File binds at length during gauging procedures it proves there is a non-tapered segment in the end of the canal (apical parallelism).

To extend the taper to the terminus, a 30 Series GT*X* Shaping File (.3 mm tip diameter to match the terminal diameter of the canal) with an appropriate taper for that root is cut to length.

Visual Gauging

Figure 8A. Flutes full of debris at tip of first GT*X* Rotary Shaping File taken to length. This shows that the apical diameter of the canal is .20, matching the tip diameter of the GT*X* File cut to length., indicating apical continuity of taper. The shape in this small canal is finished.

Figure 8B. In this instance, there is no debris in the last few flutes of the 20-.06 GT*X* Shaping File, indicating a terminal diameter larger than .20 and a need to introduce a 30-.06 GT*X* Shaping File.

Figure 8C. The flutes of the 30-.06 GT*X* Shaping File cut to length are packed with debris, showing that shape extends all the way to the canal terminus. The shape is now complete and will be confirmed by tactile gauging.

Tactile Gauging

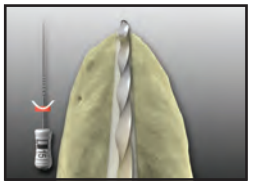


Figure 8D. In this typical small root case the #15 NTKF passively drops through the root canal terminus.

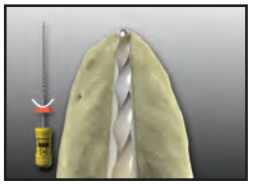


Figure 8E. In this small canal the #20 NTKF gauging instrument binds at length.

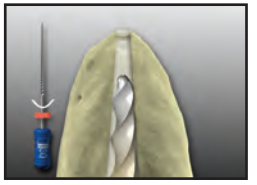
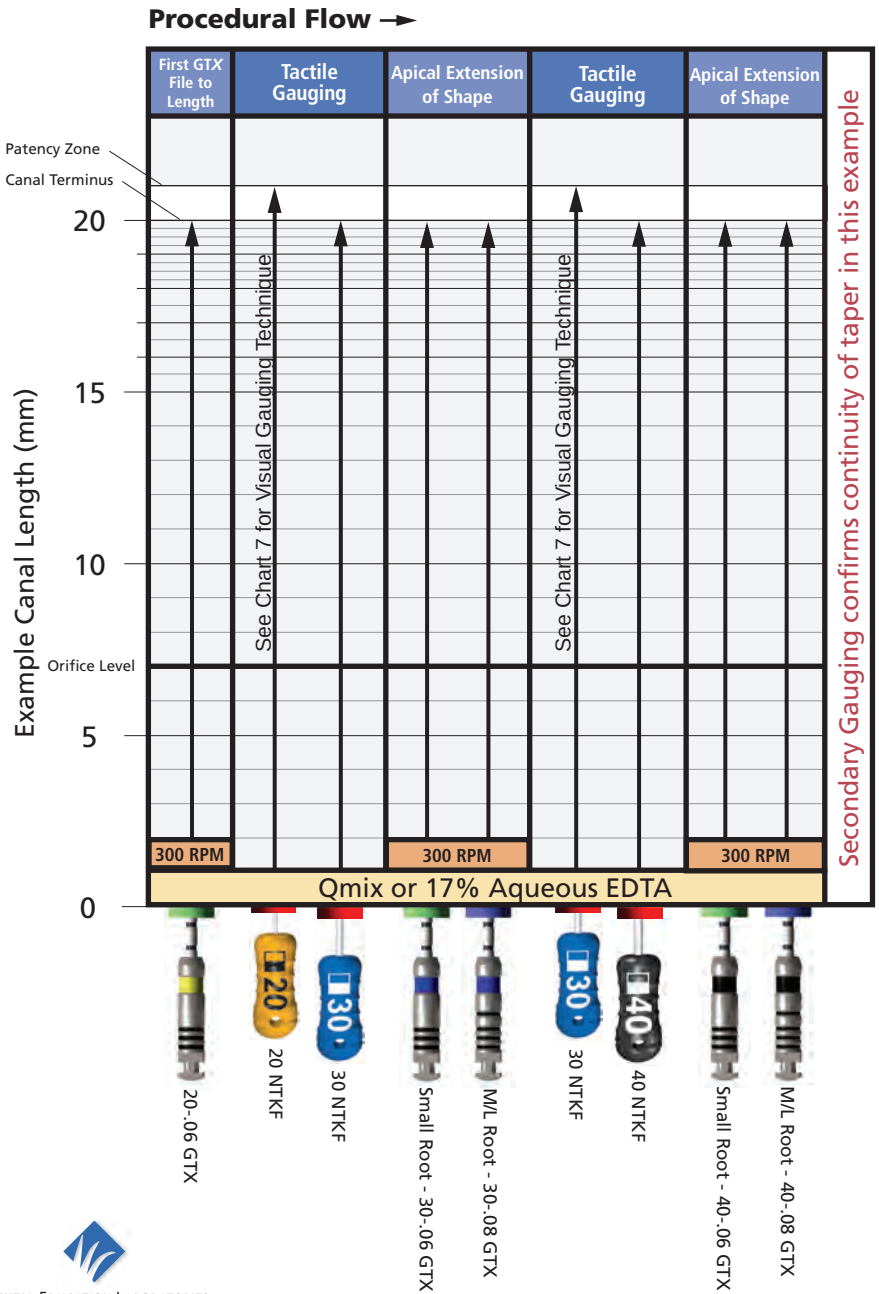


Figure 8F. The #30 NTKF gauging instrument binds .5 mm short of full length, confirming there is an apical constricture and that there is shape coronal to that point.

Dental Education Laboratories
L. Stephen Buchanan, DDS

Cutting Final Shape
GTX Rotary and GT Hand Files



- At this point in the case, most of the coronal and mid-root shape has been cut into the preparation during initial shaping procedures and the terminal diameter of the canal has been determined by gauging. The shaping requirement remaining is the apical preparation—always best done as the finale'. Radially-landed GT*X* Rotary Files are critical to this last phase of shaping, as larger, stiffer file tip sizes are often needed—an invitation to ledging and ripping when curving canal walls are met with non-landed blades that just want to cut straight.

- Final shape, like the rest of shaping, is imparted in the presence of a weak acid solution (Qmix [citric acid] or 17% aqueous EDTA).

Small Canals

- Cut A 20-.06 GT*X* Rotary Shaping File to length and check for tip debris. If the tip flutes are full of debris, the shape is very likely done. If no tip debris is seen, cut a 30-.06 GT*X* File to length and check again for tip debris—no tip debris, cut a 40-.06 GT*X* File to length. It is a rare small canal that requires a terminal shape greater than 0.4 mms, however a 40-.06 GT*X* File can be taken 1 or 2 mm long to cut the terminal shape in a small curved canal to a #46 (.4+.06=.46mms) or a #52 size (.4+.06+.06=.52mms).

- If a GT*X* Rotary Shaping File balks at cutting to length during final shaping procedures, this is usually because of significant canal curvature. Dropping down to the next smaller taper is a play to greater flexibility, usually allowing the terminus to be reached. If, for example, a 30-.06 GT*X* Shaping File is needed to finish a given canal prep but that file resists cutting to length. Dropping down to a 30-.04 GT*X* File allows the terminus to be reached, after which a 30-.06 GT*X* Shaping File will usually cut to length—its tip relieved of the torsional forces of cutting by the previous GT*X* File of the same tip diameter.

- When canal curvatures deny the 20-.06 GT*X* File cutting to final place, always consider that a GT Hand File (GTHF) cuts exactly the same shape as the 20-.06 GT*X* Rotary File and is nearly impossible to break. The white-handled 20-.06 GTHF is your get-out-of-jail card when the rotary file does not want to cut to length. Beware of files that always cut to length—they rip apically-curved canals causing overfills.

Medium and Large Canals

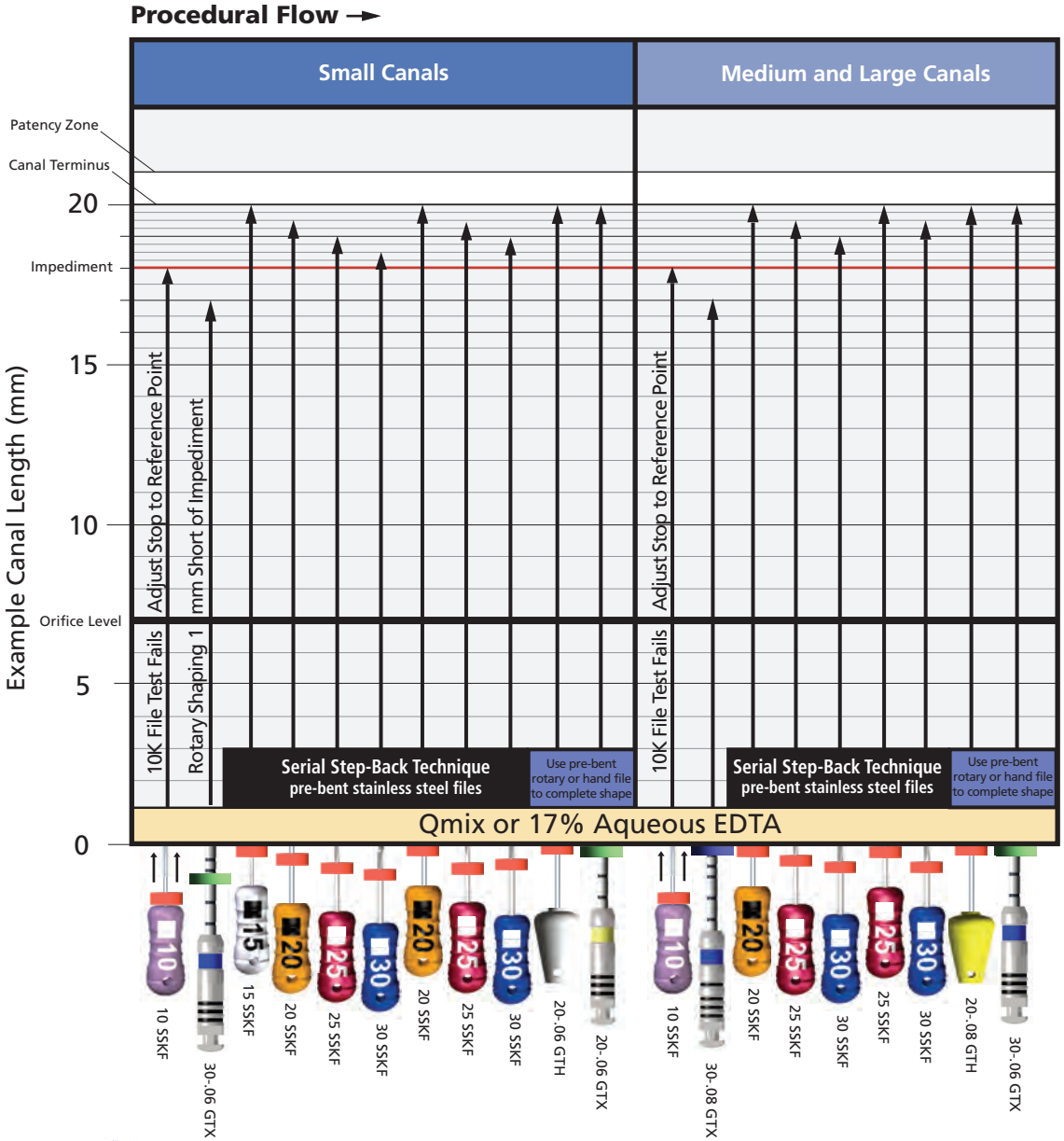
- If a medium or large canal gauges with a #30 NTKF binding at length after cutting the 30-.08 GT*X* File to length, you are done. If the #30 NTKF slips through the apical foramen, cut a 40-.08 GT*X* Shaping File to finish. About half of all medium sized canals (large molar canals) are completely shaped with just the 30-.08 GT*X* File.

- For clinicians who want to cut more apical dentin in virgin or retreatment cases, simply cut the apical preparation up to the next larger tip size than was gauged. GT*X* Files are not available in half sizes such as 25, 35, or 45 tip sizes, so when resistance is encountered to cutting up a decimal size, just BF a hand NTKF of the same tip diameter to length, then the same tip size GT*X* File usually follows.

- For canals with apical foramina larger than .4mm's, a 40-.08 GT*X* File can be cut long because of its landed blades, so if the canal gauges at .55mm's (a #55 NTKF binds at length), simply measure the 40.-08 two millimeters long and cut that new length. At an .08 taper, the file diameter two millimeters short of the tip of this instrument is .56mm's (.4+.08+.08=.56).

Dental Education Laboratories
L. Stephen Buchanan, DDS

Shaping Around Impediments
Pre-bending nickel titanium rotary files



- If an un-bent #10 SSKF "hangs up" on an impediment after negotiation procedures are completed, it must be shaped accordingly. Shorten the stop on this test file to the reference point and measure it—that's the length from the reference point to the impediment. Subtract 1 mm (for safety) from that length and cut a GT*X* Rotary Shaping File just short of the impediment.
- Use a 30-.06 GT*X* Rotary Shaping File for this routine in small canals or a 30-.08 GT*X* Rotary Shaping File in bigger canals, providing more space, coronal to the impediment, through which to pass all the pre-bent SSKF's needed to do the apical preparation beyond the impediment.
- Pre-bend SSKF sizes, #'s 10, 15, 20, 25, 30 and use them in a series of step-back enlargement routines beyond the impediment, each larger file fitting further back from its predecessor until the apical shape has been roughed-out to working length.
- At this point, coronal shape exists short of the impediment, apical shape exists beyond the impediment from the serial step-back shaping done with hand KF's, and the only remaining canal portion that remains inadequately shaped is at the impediment.
- To complete the shape, a brand new 20-.06 for small canals, or a 30-.06 GT*X* Rotary File for medium and large canals is over-bent to at least 180° with EndoBender Pliers (SybronEndo) to overcome its NiTi shape-memory, after which it will retain a residual bend of 30-45°. It is imperative that the bend is in the last 2 flutes of the file for it to be effective. Sometimes two or three attempts are required before a bend will be imparted.
- Mark the stop with a pen, aligning the mark toward the file bend and you are ready. By hand, carefully direct the bent rotary file tip around the impediment. As soon as the file tip is beyond the impediment, place the endo handpiece head onto the latch-grip of the GT*X* Rotary File in the canal and spin it to length or beyond. Single use obviously.
- Cutting this file 1-3 mm's beyond the terminus will cause no transportation (due to the landed blades) and will be more likely to remove the impediment, allowing an un-bent #10 SSKF to then smoothly translate beyond the impediment. Even when the KF won't translate past the impediment, gutta percha cones usually will. If the remaining impediment won't allow gutta percha cone fitting to length, fill with a GT*X* Obturator as the carrier will hit the impediment and stop, the sealer and warm gutta percha will move at least a millimeter or more ahead of the carrier when done correctly.

Dental Education Laboratories
L. Stephen Buchanan, DDS

Lubricants, Irrigants and Chelating Agents
Selection and use

Procedural Flow →

Procedure	Negotiation	Initial Shape Gauging Final Shape	Post-Shape Cleaning	Last rinse to flush out NaOCl prior to Obturation
Intracanal Solution	Lubricant	Qmix (citric acid) or 17% Aqueous EDTA	6% NaOCl	Qmix (citric acid) or 17% Aqueous EDTA
Procedural Objective	#15 K-file at length in all canals	During all cutting of canal wall dentin	Necrotic: 20 minutes Vital: 40 minutes or CaOH2 for 2 weeks	Patency File Flush

- Irrigate with a 30 gauge Max-i-Probe needle, leaving a reservoir of irrigant in the access cavity.
- Shaping procedures (initial shape, gauging, and final shaping) are done in the presence of a weak acid solution (Qmix [Citric acid+Chlorhexidine] or 17% aqueous EDTA) which minimizes the amount of dentin debris packed into lateral canal orifices and removes the smear layer.
- After gauging & final shape is complete, the canal is irrigated with copious amounts of 6% NaOCl and left to soak (necrotic: 20 minutes, vital: 40 minutes), freshening the solution every 5-10 minutes. Irrigation with NaOCl is critical to the outcomes of RCT. Not only is it the most effective against biofilms, it will digest pulp fragment left in lateral canal projections untouched by out negotiating or shaping instruments. The digestive characteristics of NaOCl solutions will be enhanced by:

  -Warming the solution in the syringe
  -Ultrasonic agitation
  -Sonic agitation
  -Negative pressure irrigation*

  *Negative pressure irrigation is a totally safe and effective method for drawing NaOCl irrigant into the apical thirds of prepared canals, eliminating apical oxygen bubbles that form and impede irragition efficacy. This device can be confidently used by trained assistants, thus freeing the dentist to see other patients.

- After cleaning with NaOCl has been accomplished, rinse one last time with weak acid solution (to remove residual NaOCl as chlorine inhibits setting of bonding agents), dry the canal, and you are ready for the Thrill of the Fill (see Obturation section).
- No time to adequately irrigate the canal? No worries, fill the shaped canals with CaOH2, complete the RCT two weeks later. The basic pH of CaOH2 kills bacteria and helps break down vital pulp remnants, rendering them more easily digested by NaOCl at the next appointment. CaOH2 is removed with a weak acid irrigating solution and a patency file.

Dental Education Laboratories
L. Stephen Buchanan, DDS

Max-i-Probe needles are available through Dentsply Tulsa Dental

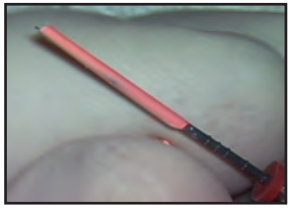
Carrier-based Obturation
GTX and GT Obturator technique

Carrier-based obturation has few steps but is more technique sensitive than many clinicians appreciate, primarily concerning sealer placement. The gutta percha is "carried" to the end of the canal by its adherence to the carrier and the lubrication of the sealer on the canal wall. Sealer is placed in the canal before insertion of the heated obturator, coating the wall ahead of the gutta percha on the carrier.

Too much sealer and you get an unsightly surplus blowout. Not enough sealer is worse. If too little sealer is applied and it is expended before the obturator reaches the end of the canal, the gutta percha will seize in the canal causing the plastic carrier to arrive at the terminus with no gutta percha or sealer—a badly compromised obturation outcome that will not be evident in the post-op imaging if the carrier was taken to full length.

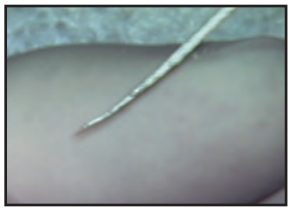
The medical grade plastic carriers inside GT*X* and GT Obturators are more tapered than those inside Thermafil, Soft Core, and GuttaCore Obturators, hence their different heating and placement times. GT*X* and GT Obturators require longer heating cycles and slower insertion times—6-8 seconds. The payoff for using a more robust carrier shape is greater hydraulic force applied to the sealer and gutta percha and therefore greater opportunity to fill lateral root canal complexities.

Step 1: Prepare the Obturator



1. GT*X* Obturator sizes matche the final GT*X* File size cut to length. Because GT*X* Files cut pre-defined shape in the canal, a size verifier is unnecessary when filling with a GT*X* Obturator.
2. Gently score and remove the gutta percha near the end of the obturator and expose the last 1-1.5 mm of the plastic carrier tip.
3. Set the stop on the plastic carrier 1 mm short of full canal length.
4. Pre-heat the oven by running it through a long heat cycle.
5. Place the prepared obturator into the notch in the oven arm, being certain to hang from the handle, not the rubber stop. Press the arm down until it clicks and holds—the preselected heating cycle will begin.

Step 2: Prepare the Canal

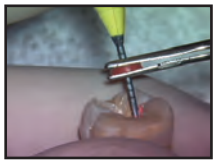


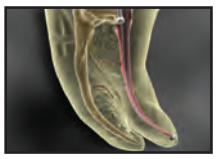
- While the obturator is cooking, dry the canal with 2 GT*X* paper points and coat the canal walls to mid-root with SybronEndo Pulp Canal Sealer on an endo microbrush or a paper point. Blot any surplus sealer with additional paper points until the paper point comes out spotted not coated with sealer.

Step 3: Insert Carrier

- When the oven signals adequate heating time, the arm is pushed down, releasing it to slowly glide up. Carefully remove the heated obturator with cotton pliers, have your assistant remind the patient to open wide, carefully insert the carrier to mid-root in the first 2 seconds, slowing down progressively as length is approached, for a total insertion time of 6-8 seconds. A gradual insertion of the carrier increases apical accuracy. Faster insertion times will cause apical extrusion of surplus.

Step 4: Remove Handle





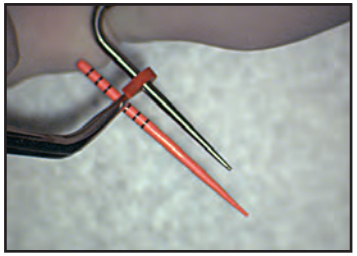
- Holding the handle in place with a finger tip, pull the stop up to the handle with cotton pliers, grasp the carrier shank under the repositioned stop, bend the handle back and forth until it separates with the stop attached. This allows more room to place another carrier in any additional canals.
- After removing the handle, use a cotton plier to gently push the carrier apically, in order to ensure the carrier has not been dislodged.
- Use a 1.2 mm Preppi Bur (dry) in a high-speed handpiece to section each carrier at the orifice level. If you must cut a carrier to make room for the next one, be certain to place paper points in all empty canals as particles of carrier plastic could block those canals.
- Spray the pulp chamber with Endo Ice to harden the sticky gutta percha that has vented coronally and use a spoon excavator to remove excess gutta percha. Clean the pulp chamber floor with a cotton pellet or a microbrush soaked in chloroform.

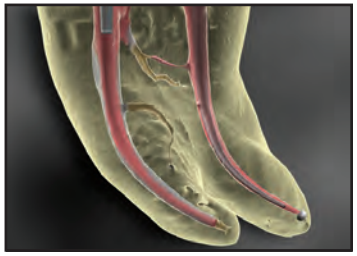
Dental Education Laboratories
L. Stephen Buchanan, DDS

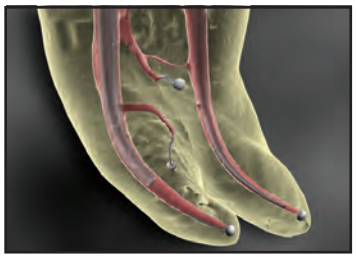
Continuous Wave Obturation Downpack

From 2D to 3D in 2.5 seconds: System B and System B/Elements Obturation Unit

Downpack







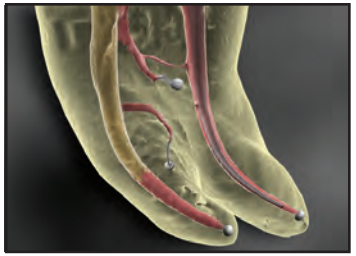
- ***The Technique*** The canal is dried and length is confirmed with GT*X* paper points, and the gutta percha cone, previously buttered with sealer, is cemented in the canal. Set the System-B heat control to 200° C, intermittent (System-B), or push the lower left downpack icon (System-B/Elements Obturating Unit). When obturating small canals, reload the gutta percha syringe and start it pre-heating. If medium or large canals are being obturated, prepare Autofit Backfilling Cones.

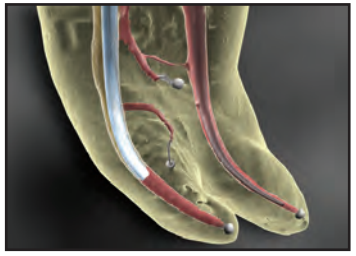
- ***2.5 Second Downpack*** Push the cold Continuous Wave electric heat plugger against the gutta percha at the orifice, hit the button and immediately drive the heated plugger smoothly through the thermosoftened gutta percha, to within 2 mm of the binding point. This single downpack stroke should take 1-2 seconds. In extremely long roots it is advised to turn the temperature up to 300° C to allow the same downpack timing.

- As the plugger moves through the canal and the stop on the plugger approaches the reference point on the tooth (the previously determined binding point), release the button about 2 mm's shy of the binding point but keep pushing apically. The Continuous Wave plugger will slow its apical movement as the plugger and gutta percha cool and the plugger will ideally stop 1 mm shy of the binding point.

- Maintain firm apical pressure ("the sustained push") on the plugger for a full 5-10 seconds, depending on the canal size. This sustained condensation stroke moves the plugger against the gutta percha as it cools and shrinks, tightening it against canal walls instead of allowing it to shrink from the walls.

One-Second Separation Burst





- ***Hot Separation - Small Canals*** If you are filling a small canal, wait for 5 seconds (one click by the EOU) and fire a burst of heat. After 5 seconds, still maintaining apical pressure, touch the button to heat the plugger for a full second. Release the button, pause for another full second, and withdraw the plugger.

- After removal of the electric heat plugger and the attached gutta percha, use the small, flexible NiTi end of the #1 (red) Continuous Wave hand plugger to condense the apical gutta percha until it has cooled and set. In medium and large canals, use the #2 (blue) Continuous Wave Hand Plugger, take care to avoid penetrating the apical mass of gutta percha, as it will leave a tubular void upon backfilling.

- After removal of the Continuous Wave plugger, introduce the small, flexible NiTi end of the Continuous Wave hand plugger and with pressure, confirm the apical mass of gutta percha has not dislodged, and that it has cooled and set.

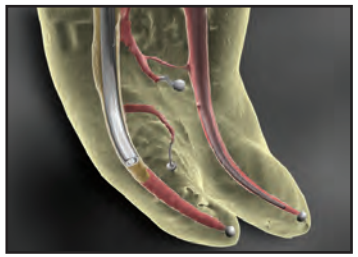
- The canal is ready for syringe backfilling, or if you intend to place a post, obturation is finished. All lateral and accessory canals have been filled during the downpack.

- ***Cold Separation - Medium and Large Canals*** In medium and large canals, wait a full 10 seconds (two clicks), add no heat, but while pressing apically, rotate the plugger to un-stick the plugger from the gutta percha it has condensed onto the canal walls. While wiggling the plugger, apply a light backpressure underneath the crook in the plugger with another instrument and carefully dislodge it without disturbing the previously-condensed gutta percha. If you look with magnification, you will see a cylindrical vacancy through the gutta percha that is the size of the plugger. You are ready for a single-cone backfill to finish. Do not bury the plugger in the apical mass of gutta percha, as it will create a tubular space — the primary cause of backfill voids.

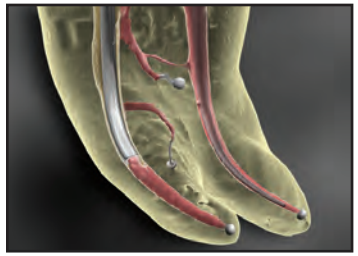
Dental Education Laboratories
L. Stephen Buchanan, DDS

Continuous Wave Obturation Backfill
Avoiding the void

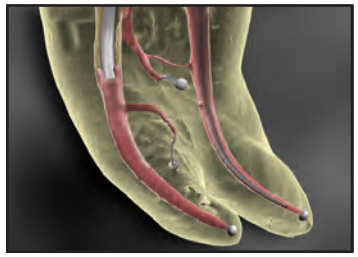
Syringe Backfill Technique



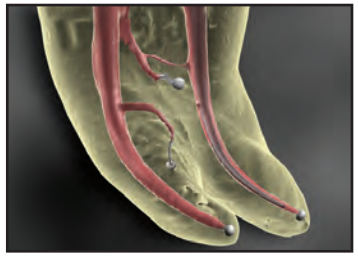
- The speed of extrusion is set on the control panel of the System-B/Elements unit. After pre-heating (45 seconds) the forward toggle switch on the handpiece is pressed until material extrudes out of the needle tip, to "prime" the needle.
- Touch the tip of the needle with sealer, place the heated needle into the canal and wait a **full 5 seconds**, allowing the needle to reheat after being cooled by contact with the dentin.



- After the 5 second pause, with the needle lightly held in place, press the forward toggle switch and begin extruding gutta percha (or, if using a gun, pull the trigger and extrude).
- After the extruded material fills the backfill space ahead of the needle, the backpressure of the extruded gutta percha will move the needle back out of the canal. Remove the needle from the canal and condense the apical mass of gutta percha with the small end (.7mm) of the #2 Buchanan Plugger.

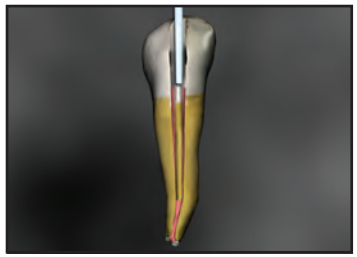


- After the apical gutta percha has cooled and set, place the needle back into the canal, wait another full 5 seconds, and repeat the process, this time allowing the needle to back out to the orifice level. It's important that you resist the temptation to pull the needle out of the canal... let the extruded gutta percha back it out.
- Using the larger stainless steel end (.9mm) of the #1 (red) Contnuous Wave hand plugger, give the gutta percha at the orifice level a very firm, sustained condensation push. You can eliminate a void mm's away if you apply enough pressure here. Using a sideways action of the orifice plugger tip against the side of the canal orifice will very neatly cut the gutta percha perfectly at that length.

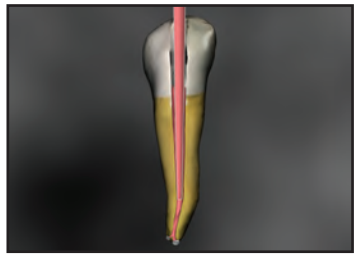


- Be careful to remove any gutta percha coronal to the CEJ.

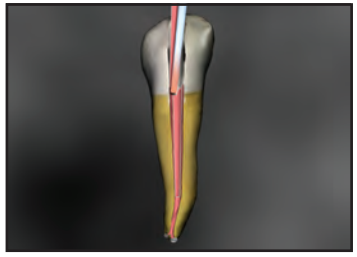
Single-Cone Backfill Technique (Ideal for Medium and Large Canals)



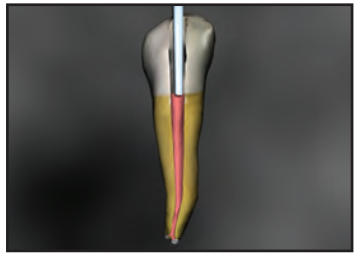
- The Single-Cone Backfill can be done by intention (see above—after a 10 second wait time), or after a separation burst of heat has been applied but the plugger comes out clean of gutta percha. This usually occurs in premolars with their laterally-projecting canal fins that act as a mechanical undercut, holding the condensed gutta percha in place despite the separation burst of heat. Attempting to remove the gutta percha and syringe backfill will often result in a backfilling void.



- Choose an AutoFit™ backfill cone the same size as the plugger used for the downpack. Cut back the tip a mm (they are slightly undersized at their tips), coat the backfill cone with sealer and place it into the space left by the plugger, working it in and out 3 -4 times to make sure that sealer coats the backfill space.
- Sear the cone off at the orifice level with the System-B/Elements electric heat plugger, place the rigid stainless steel end of the #1 or #2 hand plugger against the gutta percha, and with a firm sustained pressure, condense the coronal mass at the orifice level until it has cooled and set.



- This technique is the most effective method for removing voids left during a syringe backfill. Adjust the stop on the .06 tapered Continuous Wave heat plugger to roughly match the depth of the void and downpack through the gutta percha to the void. Typically you will feel the plugger jump ahead when its tip reaches the void. Let it cool for 10 seconds, remove the cold plugger and complete a single-cone backfill using the steps outlined above.



Dental Education Laboratories
L. Stephen Buchanan, DDS