Minimally invasive, conventional and large root canal system endodontics using a new Rotary File System – Part 1

Peet J. van der Vyver[1] and Martin Vorster[2]

Introduction

Mechanical enlargement and shaping of complex endodontic root canal systems to facilitate disinfection remain the main focus of endodontic treatment. A large variety of root canal shaping and preparation systems with different design features and advantages are available to the clinician.

The original progressively tapered ProTaper files (Dentsply Sirona, Ballaigues, Switzerland) revolutionised rotary Nickel-Titanium (NiTi) instrumentation, allowing clinicians to prepare canals with tapered shapes in anatomically straight and curved root canal systems. This six-file system comprised three shaping and three finishing files with convex triangular cross-sections and continuously changing helical angles.

The shaping files (S1 and S2) have increasingly larger tapers over the length of the cutting flutes and are dedicated to preparing a specific area of the root canal system. Shaping file S1 is designed to prepare the coronal aspect of the canal and shaping file S2 prepares the middle third of the root canal (Ruddle, 2005).

The three finishing files named F1, F2 and F3 have corresponding diameters of 0.20, 0.25 and 0.30mm at D_0 and fixed tapers from D_0 to D_3 of 7%, 8% and 9% respectively. From D_4–D_{14} each instrument has a decreasing percentage taper to ensure flexibility and to reduce further enlargement of the coronal and midroot aspect of the root canal system (Ruddle, 2005).

Shaper X is an auxiliary file used to relocate canals away from furcal danger and produce more coronal shape if needed. At D_0 the file has a modified guiding tip with a diameter of 0.19mm and at D_{14}, the diameter ends at 1.20mm.

ProTaper Gold instruments (PTG) (Dentsply Sirona) were introduced with exactly the same geometry as ProTaper Universal instruments (PTU) (Dentsply Sirona) with enhanced mechanical properties due to innovative metallurgy, which exhibits two-stage specific transformation behaviour and high Af temperatures (Hieawy et al, 2015).

The next generation of ProTaper instruments was the ProTaper NEXT (Denstply Sirona) (PTN) rotary shaping system. There are five instruments in the system but, according to

[1] Prof Peet J van der Vyver (BChD, MSc, PhD), Studio for Endodontics, Restorative Dentistry and Dental Education (www.studio4endo.com); Part-time lecturer at the University of Pretoria, Department of Odontology, School of Dentistry, University of Pretoria, Pretoria, South Africa

[2] Dr Martin Vorster (BChD, MSc), Lecturer/Dentist at the University of Pretoria's School of Dentistry, Pretoria, Gauteng, South Africa. (martin.vorster@up.ac.za) Department of Odontology, School of Dentistry, University of Pretoria, Pretoria, South Africa

the manufacturer, most canals can be prepared with the use of the first two only. The system comprises an X1 (17.04), X2 (25.06), X3 (30.07), X4 (40.06), and X5 (50.06), which are all characterised by a rotational phenomenon known as "precession" or "swagger".

This innovative off-centred rectangular cross-section claims to cause a "snake-like" swaggering movement of the files as they advance into the root canal (Scianamblo, 2011). ProTaper NEXT features a bilateral symmetrical rectangular cross-section with an offset from the central axis of rotation, except in the last 3mm of the instrument (D_0–D_3). The exception is the ProTaper X1, which has a square cross-section in the last 3mm to give the instruments a little more core strength in the narrow apical part.

According to Van der Vyver and Scianamblo (2011), the benefits of the PTN design are:

1. Further reduction in the engagement between the instrument and the dentine walls, which contributes to a reduction in taper lock, screw-in effect and stress on the file.
2. Removal of debris in a coronal direction because the off-centre cross-section allows more space around the flutes of the instrument, leading to improved cutting efficiency by continuous contact of the blades with the surrounding dentine walls.
3. The swaggering motion of the instrument activates the irrigation solution during canal preparation and improves debris removal.
4. There is reduced risk of fracture because of less stress on the file and more efficient debris removal.
5. Each instrument can perform a larger envelope of motion (larger canal preparation size) compared with a similarly sized instrument with a symmetrical mass and axis of rotation. This allows the clinician to use fewer instruments to prepare a root canal to adequate shape and taper to allow for optimal irrigation and obturation.
6. There is a smooth transition between instruments because the design ensures sequential and exponential expansion of performance.

Recently, ProTaper Ultimate (Dentsply Sirona), the latest generation of rotary files, was launched.

ProTaper Ultimate files are prepackaged, presterilised rotary instruments designed to shape root canal systems to a continuously tapering preparation with deep shape and ensure maximum preservation of pericervical dentine. Most files in the system have a maximum flute diameter of 1.0mm instead of the traditional 1.1mm, ensuring a more conservative coronal shape. The set of eight files comprises a Slider for glide path preparation, one Shaper, three Finishing files and three Auxiliary files. In the majority of cases canals can be prepared with one, two or three files, and in selected cases up to maximum of five files, which includes glide path preparation. The instruments are used in rotation at 400rpm and a torque setting of 4–5.2Ncm.

This new file system offers the clinician greater simplicity and safety, and improved cutting efficiency and mechanical properties, than previous generations of ProTaper instruments and covers a wider range of root canal anatomy. In this paper the authors discuss the design features of the ProTaper Ultimate instruments and present case reports to illustrate the clinical application and benefits of these instruments.

CLINICAL GUIDELINES AND INSTRUMENT DESIGN

1. Create adequate access

Advances in clinical dentistry have made more conservative access cavity preparations a viable option. These advances include the Dental Operating Microscope, cone beam computed tomography (CBCT), irrigation activation devices and solutions, and improved metallurgy for manufacturing endodontic shaping instruments, resulting in the increased flexibility and fracture resistance of shaping instruments (Manigandan et al, 2020; Azim, 2016).

However, studies suggest preparing more conservative access cavities rather than ultra-conservative access cavities (Ninja or Truss access). Literature presents no conclusive evidence that ultra-conservative access cavities can increase the resistance to fracture of endodontically treated teeth (Silva et al, 2021). Vieira et al (2020) also demonstrate that disinfection was significantly compromised after root canal preparation of teeth with retracted access cavities, which can negatively affect the treatment outcome of infected teeth.

Because ProTaper Ultimate files have less memory than conventional NiTi, it is possible to slightly prebend the tip of some of them to allow easy insertion into a secured canal orifice without complete straight-line access, or in cases where patients present with limited mouth opening.

Figure 1: ProTaper Ultimate SX instrument (Dentsply Sirona)

The ProTaper Ultimate SX (Figure 1), one of the auxiliary files in the system, is used to create and refine the coronal opening as it transitions into the root canals. The orifice opener is used with two to three gentle, smooth apical movements (amplitudes) of 2–5mm into the root canal. This auxiliary file can also be used to relocate canals away from furcal danger.

The ProTaper SX file has a D_0 diameter of 0.20mm and at D_{14} a maximum flute diameter of 1.20 mm. The SX has a fast increase in taper from D_0 to D_8 (for example, at D_0, D_5 and D_9 the taper is approximately 3%, 10% and 15% respectively) and then the taper decreases to about 2% at D_{12} and to 0% at D_{14}. Overall, the taper increase is slightly less than in the traditional ProTaper Universal SX instrument, providing the clinician with more conservative coronal preparation. The cross-section varies along the active part of the file, staring with a 85° acute angled parallelogram (D_0–D_4), a progressive transition from 85° parallelogram to 75° at D_4–D_7 and a constant 75° parallelogram with acute angles from D_7–D_{14}. The file is manufactured from NiTi subjected to gold heat treatment (Gold-Wire) with an offset mass of rotation design.

2. Canal negotiation, patency, working length and glide path establishment

According to the manufacturer the ProTaper Ultimate Slider, a rotary glide path instrument can be used immediately without prior negotiation of the root canal system with small stainless-steel instruments (as also advocated by other manufacturer's of rotary and reciprocating systems) in approximately 63% of cases. In the case of canal bifurcations or difficult anatomies it is still recommended to use stainless-steel hand instruments prior to the use of the Slider instrument. After many attempts to use this new technique clinically, the authors eventually blocked root canal systems and do not agree with this new concept. The authors therefore still recommend that clinicians negotiate and secure the canal with manual small stainless-steel instruments up to patency, determine a working length by means of an electronic apex locator and establish a reproducible micro glide path (RMG) (Van der Vyver, 2011).

To confirm an RMG for most root canal preparation systems, the authors recommend using manual stainless-steel instruments size 08 or 10 K-Files in a vertical in-and-out motion with an amplitude of 1mm from working length, gradually increasing the amplitude to approximately 4mm as the irregularities are removed from the dentine wall (Van der Vyver, 2011). A "super loose" size 10 K-File is the minimum requirement (Bürklein et al, 2012; Van der Vyver, 2011). To confirm that a reproducible glide path is present, a size 10 K-File is taken to full working length. The file is withdrawn 1mm and should be able to slide back to working length with only light finger pressure. Thereafter, the file is withdrawn 2mm and should be able to progress to working length using the same protocol. When the file can be withdrawn 4–5mm and slides back to working length, a RMG is confirmed.

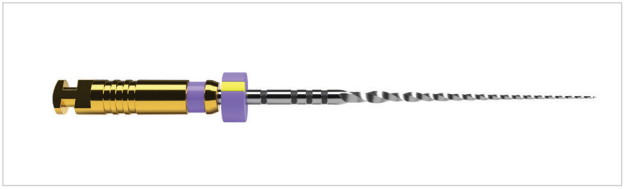


Figure 2: ProTaper Ultimate Slider (Dentsply Sirona)

The authors recommend that when using the ProTaper Ultimate Slider for glide path preparation, only a size 08 K-File can be used for canal negotiation and to prepare a RMG as outlined above, and not a size 10 K-File as well. This makes glide path preparation faster and saves valuable clinical time.

After establishing an RMG it is recommended to expand and enlarge the glide path to create a macro glide path, using the new ProTaper Ultimate Slider instrument. The Slider is used passively in the canal as long as it progresses to full working length. If it does not reach length, remove and clean the flutes of the instrument, re-irrigate the canal space and then re-insert the instrument for another pass. Repeat this until full working length is reached. The authors further recommend expanding the glide path by using the ProTaper Ultimate Slider instrument in 8–12 backstroke brushing motions in a circumferential motion after it has reached full working length for the first time.

ProTaper Ultimate Slider (Dentsply Sirona) (Figure 2) is manufactured from M-Wire, has a maximum flute diameter of 1.0mm, tip size of 0.16mm at D_0 and a taper of 2%. The taper is progressively increased to 3.2% at D_4, 5% at D_8, 7% at D_{12} and 8.5% at D_{16}. The instrument has a centred square cross-section from D_0–D_8, followed by a progressive transition to 75° parallelogram (D_8–D_{12}) up to a constant 75° parallelogram with acute angles (D_{12}–D_{16}). From D_8 to D_{16} the file presents with an offset mass of rotation design similar to WaveOne Gold (Dentsply Sirona), where every alternative millimetre moves from centred to off-centre.

3. Rotary root canal preparation

Root canal preparation is initiated with the ProTaper Ultimate Shaper instrument instead of two instruments as with ProTaper Universal and Gold (S1 and S2). This instruments features flexibility and safe cutting efficiency in the coronal two-thirds

Figure 3: ProTaper Ultimate Shaper (Dentsply Sirona)

Figure 4: ProTaper Ultimate F1 (Dentsply Sirona)

Figure 5: ProTaper Ultimate F2 (Dentsply Sirona)

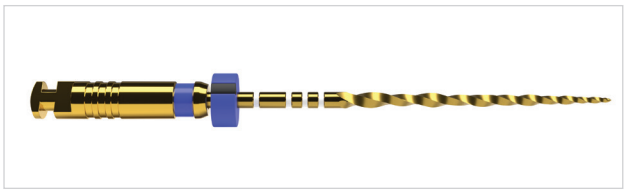


Figure 6: ProTaper Ultimate F3 (Dentsply Sirona)

of the canal. This creates a pathway to the apical one-third of the canal in order to receive the finishing files.

ProTaper Ultimate Shaper (Figure 3) is manufactured from Gold-Wire, has a maximum flute diameter of 1.0mm and tip size of 0.20mm at D_0 with a taper of 4%. The taper is progressively increased to 5.5% at D_4 and 6% at D_8 before it decreases to 4.7% at D_{12} and 1.7% at D_{16}. The cross-section from D_0–D_8 is a parallelogram with 85°, followed by a progressive transition to an 80° parallelogram with acute angles (D_8–D_{10}) up to a constant 80°parallelogram with acute angles (D_{10}–D_{16}). The entire active part of the instrument presents with an offset mass of rotation design similar to WaveOne Gold.

In the presence of an irrigation solution (typically sodium hypochlorite), the ProTaper Ultimate Shaper is allowed to advance passively downwards using backstroke brushing motions and to progress until working length is reached. In very long canals the instrument might not reach length at the first attempt; remove and clean the flutes of the instrument, re-irrigate the canal space and then re-insert the instrument for another attempt. Repeat this protocol until full working length is reached.

The last step of root canal preparation is performed with one of more of the three ProTaper Ultimate Finishing files. They have a maximum flute diameter of 1.0mm with a triangular convex cross-section (variable parallelogram of 85–78°, rhomboid shape), manufactured from Gold-Wire and have an offset mass of rotation design.

ProTaper Ultimate F1 (Figure 4), F2 (Figure 5) and F3 (Figure 6) have yellow, red and blue identification rings on their handles corresponding to D_0 diameters of 0.20, 0.25 and 0.30mm respectively. Between D_0 and D_3, the F1 has fixed tapers of 7%, the F2 has a slight decreasing taper from 8% to 7% and the F3 has a slight decreasing taper from 9% to 8%. From D_4–D_{16} each instrument has a decreasing percentage taper to improve flexibility. The F1 instrument's taper decreases to 6.5% at D_4 and then decreases to a constant taper from 3.5% up to D_{16}. The F2 instrument's taper decreases to 6.5% at D_4 and then decreases to a constant taper from 3.3% up to D_{16} and the F3's taper decreases to 7% at D_4 and then to a constant taper from 2.5% up to D_{16}.

In the presence of an irrigation solution the ProTaper Ultimate finishing files are allowed to advance passively downwards towards full working length. When working length is reached the authors recommend enlarging the apical one-third of the canal using four to five backstroke brushing motions. The final preparation file is selected on the basis that the operator can feel that it cuts dentine in the apical part of the root canal system, and not on visual confirmation of debris on the apical flutes after canal preparation. If any swaggering file is rotated in a canal filled with sodium hypochlorite, the authors hardly ever observe debris on the apical flutes. In addition, sonic activation of irrigating fluids is recommended to enhance

cleaning using either the EndoActivator (Dentsply Sirona) or EDDY Endo Irrigation Tip (VDW) driven by an airscaler (Soniflex LUX 2000L, KAVO).

Case Report 1

A 48-year-old male patient presented with irreversible pulpitis on his recently crowned first left maxillary molar tooth. A pre-operative periapical radiograph (Figure 7a) revealed a calcified pulp chamber and three roots. An axial slice of a pre-operative CBCT scan (Figure 7b) revealed the presence on a second mesiobuccal (MB2) canal. After administering local anaesthesia, a rubber dam was placed and a conservative access cavity was prepared through the zirconia crown. Three root canal systems were detected under magnification (mesiobuccal, distobuccal and palatal). A dentine shelf (Figure 8a) which was observed under magnification was removed with EndoTracer burrs (Komet) (Figure 8b) operating in an endodontic motor operating at 1000rpm. A fourth, second mesiobuccal (MB2) canal (Figure 8c) was located. It was established that the MB2 joined the mesiobuccal canal in the midroot position. A ProTaper Ultimate SX (Figure 8d) instrument was used to slightly enlarge the orifices of the located canals (Figure 8e). All four canals were negotiated to patency using Glyde Root Canal Conditioner (Dentsply Sirona) and a size 08 K-File (Figure 9a). Working length was determined using a Propex IQ Apex locator (Dentsply Sirona) and confirmed radiographically.

A RMG was prepared in all four root canal systems before expanding the glide path in all canals using the ProTaper Ultimate Slider instrument (Figure 9b), using 8–12 backstroke brushing motions in a circumferential motion. The root canal systems were irrigated with 3.5% heated sodium hypochlorite, the canals recapitulated to check patency using a size 08 K-File and the canals re-irrigated.

Figure 7. (a) Pre-operative periapical radiograph of maxillary left first molar revealed a calcified pulp chamber; (b) Axial slice of pre-operative CBCT scan revealed the presence of an MB2 canal, originating very close approximation to the palatal root canal system.

In the presence of 3.5% heated sodium hypochlorite the ProTaper Ultimate Shaper (Figure 9c) was allowed to advance passively apically into the canals, using backstroke brushing motions to progress until full working length was reached. All the canals were irrigated, recapitulated and irrigated again as described above.

In the presence of an irrigation solution, ProTaper Ultimate Shaper F1 instrument (Figure 9d) was allowed to advance passively apically towards full working length. During canal preparation it was observed that the F1 file did cut dentine apically in the combined mesiobuccal and distobuccal canals. However, due the larger size of the palatal root canal system, the F1 progressed easily to full working length without any sensation of dentine being cut. ProTaper Ultimate F2 instrument (Figure 9e) was introduced, and the tactile feedback of dentine being cut in the apical part of the canal was confirmed.

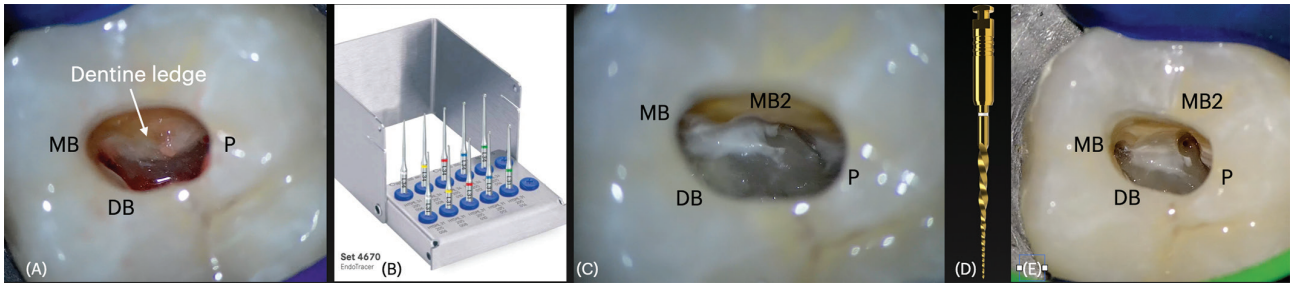


Figure 8. (a) Dentine shelf obscuring the location to the MB2 canal; (b) EndoTracer burrs (KOMET) that were used to remove the dentine ledge under magnification; (c) Orifice of the MB2 canal located; (d and e) ProTaper Ultimate SX was used to relocate the MB2 orifice and to slightly enlarge the other canal orifices

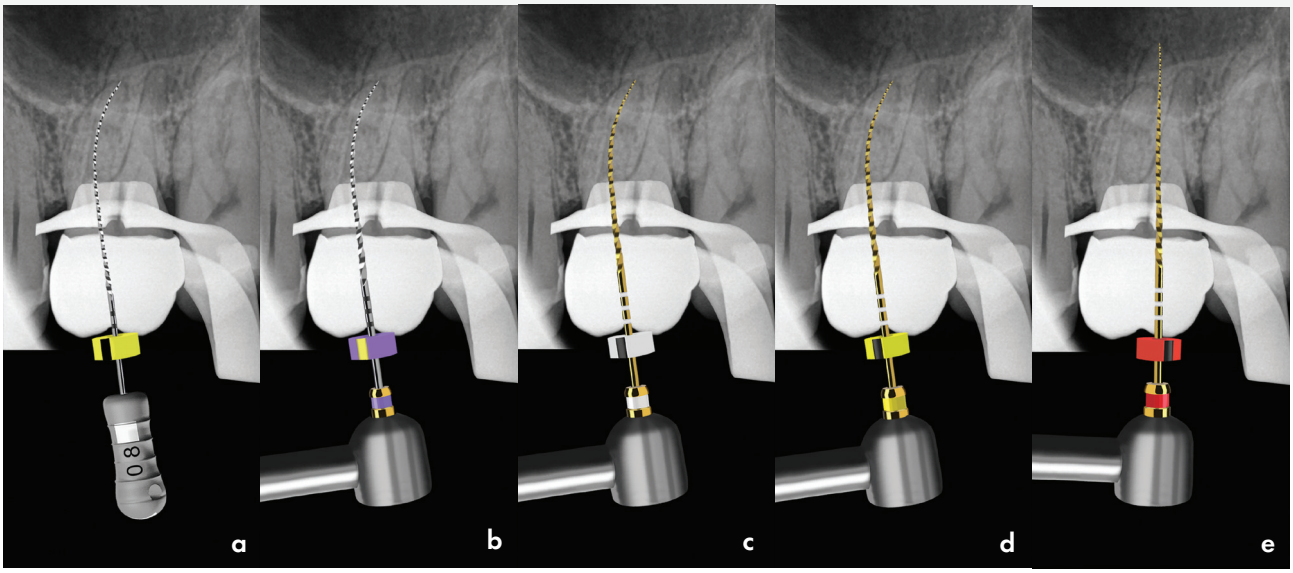
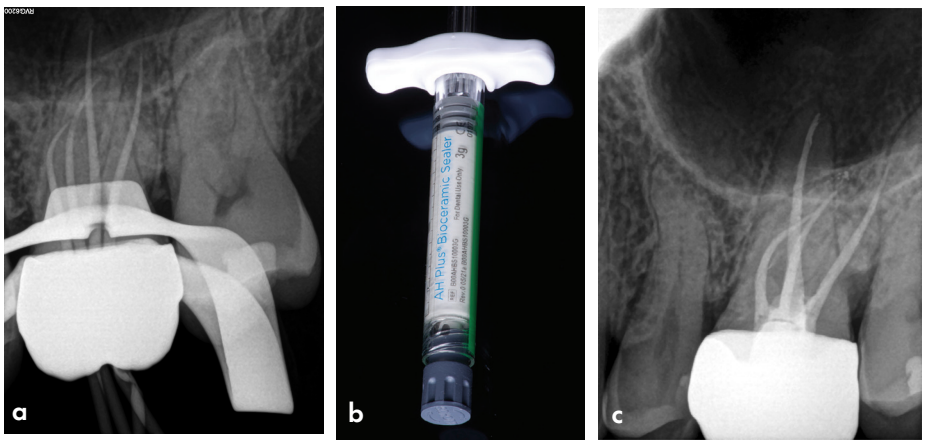


Figure 9. (a) All four canals were negotiated to patency with a size 08 K-file, working length determined and a reproducible micro glide path prepared until the size 08 K-file was "loose" in the canals; (b) ProTaper Ultimate Slider was taken to full working length in each root canal system and the micro glide paths expanded by using the instruments in five to eight backstroke brushing motions; (c) ProTaper Ultimate Shaper was allowed to advance passively downwards into the canals and cut shape in the coronal two-thirds of the root canal systems; (d) Clinically, the tactile feedback of dentine being cut in the apical parts of the combined mesiobuccal and distobuccal root canal systems was observed but not in the palatal root canal system; (e) ProTaper Ultimate F2 instrument was introduced and the tactile feedback of dentine being cut in the apical part of the canal was observed with this instrument.



Scan to see video of full case report 1

Figure 10. (a) Conefit periapical radiograph checking the fit of the ProTaper Ultimate Conform Fit Gutta-Points; (b) AH Plus BioCeramic Sealer (Dentsply Sirona); (c) Final postoperative result after obturation. Note the excellent preservation of the pericervical dentine

When full working length was reached with the selected files (F1 in the mesiobuccal and distobuccal canals and F2 in the palatal canal), the preparation was completed by performing four to five backstroke brushing motions with the file from working length coronally.

The shaped root canal systems were flooded with 17% EDTA solution activated for two minutes. Finally, 3.5% heated sodium hypochlorite was activated for two minutes with the EndoActivator (Dentsply Sirona) and by means of negative pressure using the EndoVac (Sybron Endo) system.

Figure 11: ProTaper Ultimate Manual Instruments (SX, Slider, Shaper, F1-F3)

The canals were dried with matching paper points of the ProTaper Ultimate System and the fit of ProTaper Ultimate Conform Fit Gutta Percha Points was confirmed radiographically (Figure 10a). The canals were obturated using ProTaper Ultimate Conform Fit Gutta Percha Points in conjunction with AH Plus BioCeramic Sealer (Dentsply Sirona) (Figure 10b) and the GuttaSmart System (Dentsply Sirona). Figure 10c depicts the final postobturation result. Note the excellent preservation of the pericervical dentine due the conservative coronal shapes of the canal preparations.

Manual root canal preparation

The ProTaper Ultimate System also provides a manual version (Figure 11). They can also be used in situations where the operator does not wish to complete root canal preparation with rotary instruments. It must be noted that finishing the last 1–2mm in challenging anatomy can provide a more precise preparation to the exact desired length. The instruments are used in clockwise rotation motion. The file is inserted into a wet canal and rotated clockwise with light apical pressure until in engages dentine; the cutting action is then completed by another clockwise rotation while simultaneously withdrawing the file coronally. Frequently remove the file from the canal to clean the flutes and irrigate and recapitulate the root canal system. If the apical 2-3mm of the hand files are deliberately precurved, it becomes an indispensable instrument to manage iatrogenic mishaps such as a ledge.

Case Report 2

A 29-year-old female patient presented with a large carious lesion and pain on her mandibular left second molar tooth (Figure 12a). Upon examination it was discovered that the patient was very anxious and had very limited mouth opening. After administering local anaesthesia a rubber dam was placed. The carious lesion was removed and the tooth built up with composite resin. An access cavity was prepared through the composite restoration and three root canal systems were located. During this part of the procedure, it was noticed that the patient often attempted to close her mouth, limiting the intra-oral working space despite the fact that a bite block was placed on the opposite side to keep her teeth apart. Being the last tooth in the arch with minimal working space, there is a considerable risk of file separation when using rotary or reciprocating file systems in an endodontic handpiece. It was decided to use ProTaper Ultimate manual hand instruments for this case to minimise the risk.

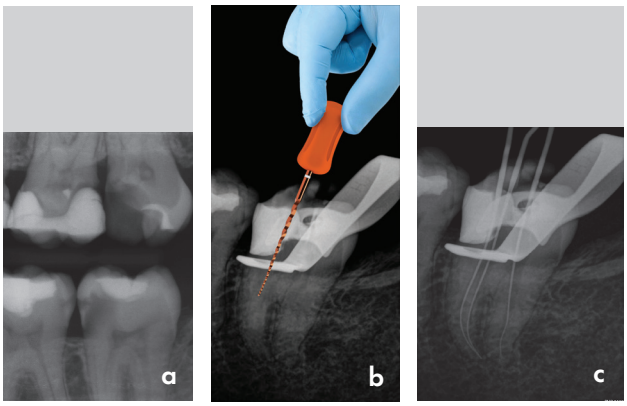


Figure 12. (a) Pre-operative bitewing radiograph showing the large carious lesion on the mandibular left second molar tooth; (b) ProTaper Ultimate Shaper X used to create more straight-line access into the two mesial root canal systems; (c) Length determination periapical radiograph

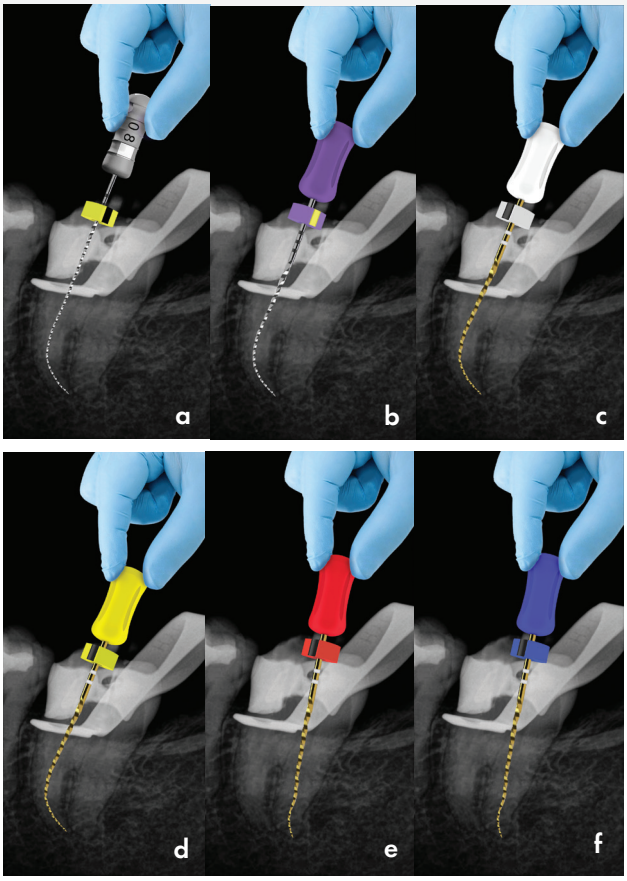


Figure 13. (a) Size 08 K-file was used to create a reproducible micro glide path; (b) ProTaper Ultimate Slider was used to expand the micro glide paths; (c) ProTaper Ultimate Shaper was used to cut shape in the coronal two-thirds of the root canal systems; (d) ProTaper Ultimate F1 instrument completed the shape for the mesial root canal systems; (e) ProTaper Ultimate F2 in the distal root canal system still did not cut dentine; (f) ProTaper Ultimate F3 completed the shape in the distal root canal system

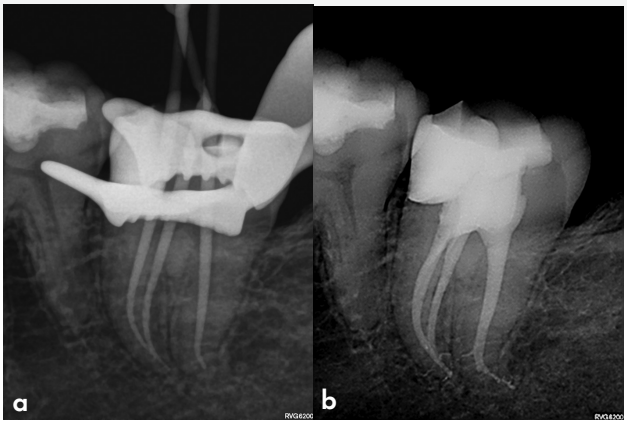


Figure 14: (a) Conefit periapical radiograph; (b) Final post-operative result. Note the apical lateral canals that were obturated with the AH Plus BioCeramic sealer

Scan to see video of full case report 2

A ProTaper Ultimate Shaper X (Figure 12b) was used to create more straight-line access into the two mesial root canal systems. This was followed by length determination (Figure 12c) and glide path preparation using a size 08 K-file (Figure 13a) and the ProTaper Ultimate Slider (Figure 13b). Canal preparation in the mesial root canal systems was completed by using the ProTaper Ultimate F1 instrument (Figure 13c). Due to the larger size of the distal root canal system, the ProTaper Ultimate F1 instrument went immediately to full working length and canal preparation was completed using the ProTaper Ultimate F2 (Figure 13d) and F3 (Figure 13e). After irrigation the fit of matching ProTaper Ultimate Conform Fit Gutta Percha Points was confirmed radiographically (Figure 14a). The canals were obturated with AH Plus BioCeramic Cement and ProTaper Ultimate Conform Fit Gutta Percha Points using vertical condensation with the GuttaSmart System. Figure 14b depicts the final postoperative result. Note the apical lateral canals that were obturated with the AH Plus BioCeramic sealer.

Auxiliary finishing files

The system also offers two larger Auxiliary Finisher files for larger and straighter root canals, for example maxillary central incisors on younger patients and some palatal or distal canals in molars. These finishers are also valuable in the event of a pathological or iatrogenic defect. These two files replace the

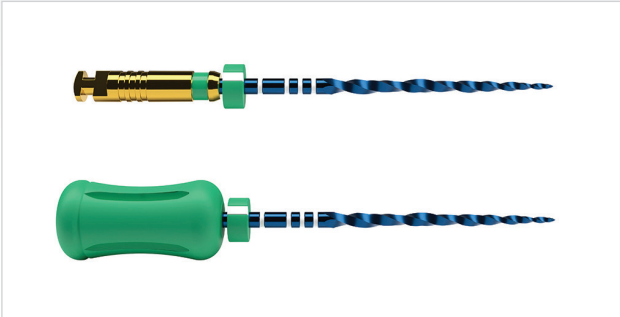


Figure 15: Rotary and manual version of ProTaper Ultimate Finisher FX (Dentsply Sirona)

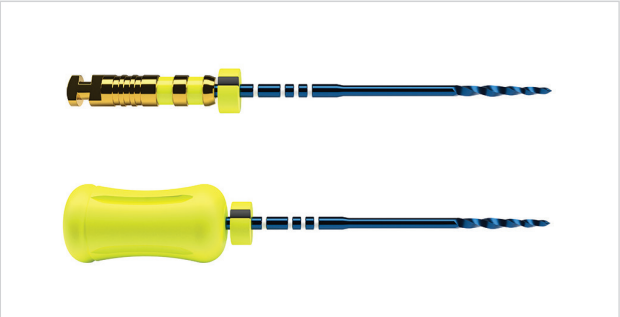


Figure 16: Rotary and manual version of ProTaper Ultimate Finisher FXL (Dentsply Sirona)

traditional ProTaper F4 and F5 instruments. ProTaper Ultimate Finisher FX (Figure 15) has a maximum flute diameter of 1.2mm, tip size of 0.35mm at D_0 with a taper of 12% (D_0–D_4). From D_5–D_8 the taper decreases to 5% and from D_9–D_{15} it decreases further up to 1% at D_{16}. ProTaper Ultimate Finisher FXL (Figure 16) has a maximum flute diameter of 1.0mm, tip size of 0.50mm at D_0 with a taper of 10%. From D_2–D_4 the taper decreases to 7% and from D_5–D_7 it decreases further to 4%. This file only has 7mm of cutting flutes. Both instruments are manufactured from NiTi with blue heat treatment (Blue Wire), have a variable parallelogram cross-section (85°–78° for FX and 85°–82° for FXL) and the active areas have an offset mass of rotation design. They are also available in a manual version of ProTaper Ultimate (Figures 15 and 16) for precise finishing of the apical one-third of large root canal systems.

Case Report 3

The patient, a 33-year-old female, presented with partial removal of previous gutta percha and placement of calcium hydroxide as an intracanal medicament on her maxillary right central and lateral incisors (Figure 17a). The remaining gutta percha was removed and length determination (Figure 17b) readings that were obtained using a ProPex IQ electronic apex locator were verified radiographically. An ISO size 30 K-File was used in the lateral incisor and a size 35 in the central incisor for length determination and to obtain accurate readings (Figure 18a). Final canal preparation was done using a Manual ProTaper Ultimate FX instrument in the lateral incisor and a Manual ProTaper Ultimate FXL instrument in the central incisor (Figure 18b). The canals were irrigated and obturated with AH Plus BioCeramic cement and matching ProTaper Ultimate Conform Fit Gutta Percha Points using

Figure 17. (a) Pre-operative periapical radiograph showing partial removal of previous gutta percha and placement of calcium hydroxide as an intracanal medicament on the maxillary right central and lateral incisors; (b) Length determination periapical radiograph

vertical condensation with the GuttaSmart System. Figure 19 shows the final postoperative result.

Conclusion

This article outlines the clinical protocol and file design features of the recently launched (2021) ProTaper Ultimate system. Its purpose is to give clinicians guidelines and to indicate the advantages of this innovative set of instruments, which allow the operator to treat a wide variety of anatomical challenges in clinical practice. The system also allows the clinician to perform minimally invasive canal preparations using selected files in the system. In Part 2 of this series the authors discuss more clinical applications of the ProTaper Ultimate system in clinical practice.

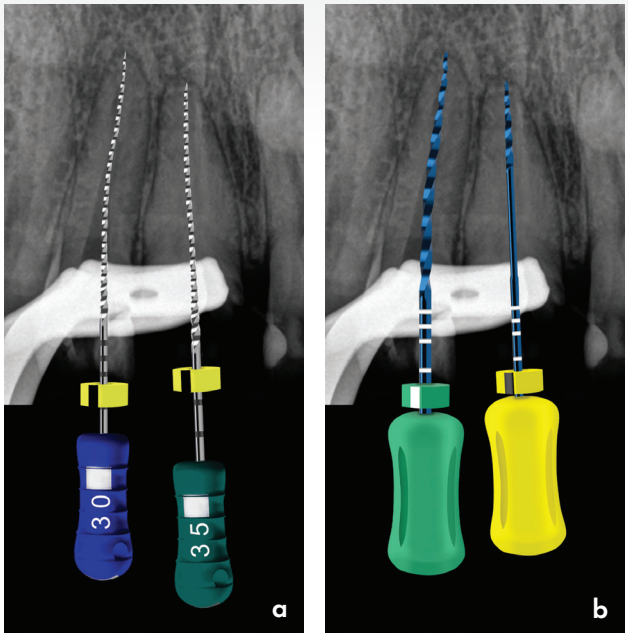


Figure 18. (a) Length determination readings were obtained an ISO size 30 K-file in the lateral incisor and a size 35 in the central incisor; (b) Final canal preparation was done using a Manual ProTaper Ultimate FX instrument (35/12) in the lateral incisor and a Manual ProTaper Ultimate FXL instrument (50/10) in the central incisor

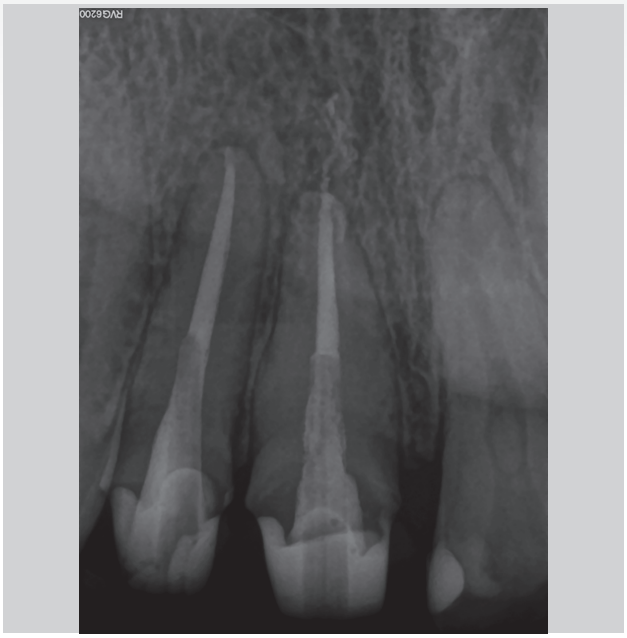


Figure 19. Final result after canal obturation and core build-up

Scan to see video of the canal preparation, case report 3

References

Bürklein, S., Hinschitza, K., Dammaschke, T., Schäfer, E. (2012) Shaping ability and cleaning effectiveness of two single file systems in severely curved root canals of extracted teeth: Reciproc and WaveOne® versus Mtwo and ProTaper. Int Endod J 45: 449-461.

Azim AA, Aksel H, Zhuang T, Mashtare T, Babu JP, Huang GT-J. Efficacy of 4 irrigation protocols in killing bacteria colonized in dentinal tubules examined by a novel confocal laser scanning microscope analysis. J Endod. 2016;42(6):928-934.

Silva EJNL, Lima CO, Barbosa AFA, Augusto CM, Souza EM, Lopes RT, De-Deus G, Versiani MA. Preserving dentine in minimally invasive access cavities does not strength fracture resistance of restored mandibular molars. Int Endod J. 2021; 54:966–974.

Hieawy A, Haapasalo M, Zhou H, Wang Z, Shen Y. Phase transformation behaviour and resistance to bending and cyclic fatigue of ProTaper Gold and ProTaper Universal instruments. J Endod. 2015; 41(7):1134-8.

Manigandan K, Ravishankar P, Sridevi K, Keerthi V, Prashanth P, Kumar ARP. Impact of dental operating microscope, selective dentin removal and cone beam computed tomography on detection of second mesiobuccal canal in maxillary molars: A clinical study. Indian J Dent Res 2020;31(4):526.

Ruddle C. The ProTaper technique: Shaping the future of endodontics. Endod Topics 2005;10:213–6.

Scianamblo M. USPTO 6942484, 7094056,7955078 and 20060228669. Attorney: Fish & Richardson P.C Current U.S Classification: 433/102, International Classification A61C005/02, 2011.

Vieira GC, Pérez AR, Alves FR, et al. Impact of contracted endodontic cavities on root canal disinfection and shaping. J Endod. 2020;46(5):655-661.

Van Der Vyver P (2011) WaveOne® Instruments: Clinical application guidelines. Endod Prac 11: 45-54.

Van Der Vyver P, Scianamblo M. Clinical guidelines for the use of ProTaper NEXT instruments (Part I). Endodontic Practice. 2013;12):33-40.