Designs Features for Commonly used Rotary Systems

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Abstract:
In modern day practice, with time being the essence, it has become a necessity to strive for newer advances in technology. Keeping this in mind utmost patient benefit is the prime goal for an endodontist. Successful endodontic treatment relies upon endodontic instruments used for cleaning and shaping of the root canal system, which ultimately determines the clinical outcome. The introduction of these new technologies has resulted in endodontics becoming easier, faster and most importantly, better. Principal among these is Nickel Titanium (NiTi) rotary instrumentation that results in consistent, predictable, and reproducible shaping. The purpose of this article is to review the design features of different rotary instruments used for pulp space preparation. Individual design features affect the performance of NiTi rotary instruments. Important mechanical features include the variability of taper, rake angle, cross-sectional geometry, and tip configuration, design of blades, helical angle and pitch. These design features influence flexibility, cutting efficiency and safety. In this review design features of commonly used NiTi rotary systems are summarized

Keywords: Rotary Instruments, NiTi Files, Taper, Rake Angle, Radial Land

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Introduction:

The main objectives of root canal preparation is to shape and clean the root canal system effectively while maintaining the original configuration without creating any iatrogenic events such as instrument fracture, external transportation, ledge or perforation. Traditionally, the shaping of root canals was achieved by the use of 0.02 tapered stainless steel hand files. However, techniques using stainless steel hand files have several drawbacks such as they are time consuming and increase incidence of canal transportation.[1-3]

In recent times there have been significant technological advancements to facilitate root canal cleaning and shaping. New instruments have been developed employing super elastic alloys and novel engineering philosophies and there has been a notable departure from the ISO standard 2 per cent taper(0.02mm per mm) instruments to greater taper instruments such as 4%,6%,10%,12%.The increased taper of these files produces a predetermined shape to the canal preparation and bind coronally early in the preparation procedure thus reducing the need for careful stepping back of instruments to produce canal taper.[4]

Over the last few years, endodontics has undergone a complete revolution with the introduction of the Nickel Titanium alloy for the manufacture of manual instruments initially and then rotary endodontic instruments[5].The advantages of rotary endodontic instruments are super elasticity, increased flexibility, shape and memory, less force require during instrumentation, superior resistance to torsional fracture which potentially allows shaping of narrow-curved canals without causing aberrations.[6] In order to improve working safety, shorten preparation time and create a continuous tapered, conical flare of preparations advanced instrument designs with non-cutting tips, radial lands, different cross-sections, superior resistance to torsional fracture and varying tapers have been developed[7,8,9].

Earlier nickel titanium files were used as multiple file system which are still in use. But these files are time consuming as series of files have to be used for the proper cleaning and shaping of the root canal. So single file system is introduced which is made up of Nickel titanium or M wire technology. Single file system is more efficient and takes less time for the biomechanical preparation. These are One shape, NEONITI, WaveOne and Reciproc. Truly Ni Ti rotary instrumentation has been one of the most significant changes in dentistry in the past 25 years.[10]

Nonetheless, understanding the basic features of these various systems will help the practitioners to use these instruments effectively and significantly reduce the errors.[11] The intention of thi article is to compare the various rotary endodontic instruments, based upon clinical performance, as dictated by their design feature.[11]

Common Design Features of a Rotary File

Tip design

A rotary cutting instrument may have an active or a non-active tip (Figure 1). Cutting tips on the rotary files make them too aggressive.[12]

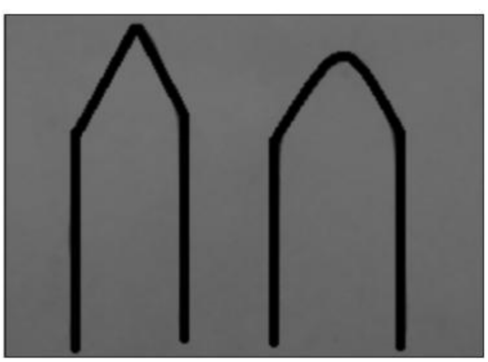


Figure 1: Tip design (active vs. non-active).

Active tips: It has cutting edges on its surface and can help to shape the narrow, calcified canals. However, it has a disadvantage of accidental apical perforation or transportation. E.g. Quantec file.

Non-active tip: No cutting edges present and create a concentric circle at the end of the root.

Eg. Profile, ProTaper, M two file, etc.

Taper

It is the amount of increase in the file diameter with each millimeter along its working surface from the tip toward the file handle. It is a very important feature of the rotary file systems and varies from 2% to 12%.

Constant taper: Instrument with the same taper but varying apical tip diameters. E.g. Profile system

Varying or graduating taper: Instrument with same apical diameter but varying taper (4-12%). E.g. Quantec system

Progressive taper: Instrument with progressive taper along the shank. E.g. ProTaper system

Rake angle[12]

• The rake angle is the angle formed by the cutting edge and a cross-section taken perpendicular to the cutting edge

• The cutting angle is the angle formed by the cutting edge and the radius when the file is sectioned perpendicular to the cutting edge

• It can either be positive, negative or neutral (Figure 2).

Positive rake angle: If the angle formed by the leading edge and the surface to be cut is obtuse, the rake angle is said to be “positive or cutting.” E.g. K3, Quantec systems.

Negative rake angle: If the angle formed by the leading edge and the surface to be cut is acute, the rake angle is said to be “negative or scraping.” E.g. Profile, ProTaper, M two, etc.

Neutral or zero rake angle: When the face of the blade coincides with the radial line it is said to be neutral or zero rake angle (planing). E.g. LightSpeed, Greater taper (GT) file systems.

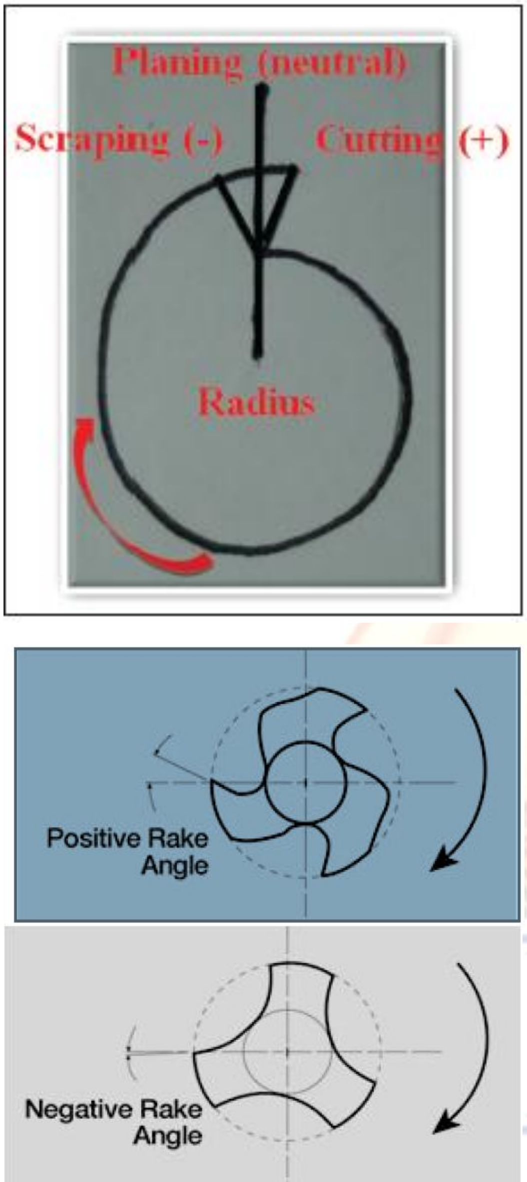


Figure 2: Rake angle

Radial land[13]

It is defined as the surface projecting axially from the central axis as far as the cutting edge between flutes (Figure 3).

Functions

- Reduces the tendency of the file to screw into the canal
- Reduces transportation of the canal
- Supports the cutting-edge
- Limits the depth of cut.

Full radial land – ProFile, GT.

Recessed land – Quantec.

Modified radial land – K3. No radial land – ProTaper, Race, Endowave, Hero 642.

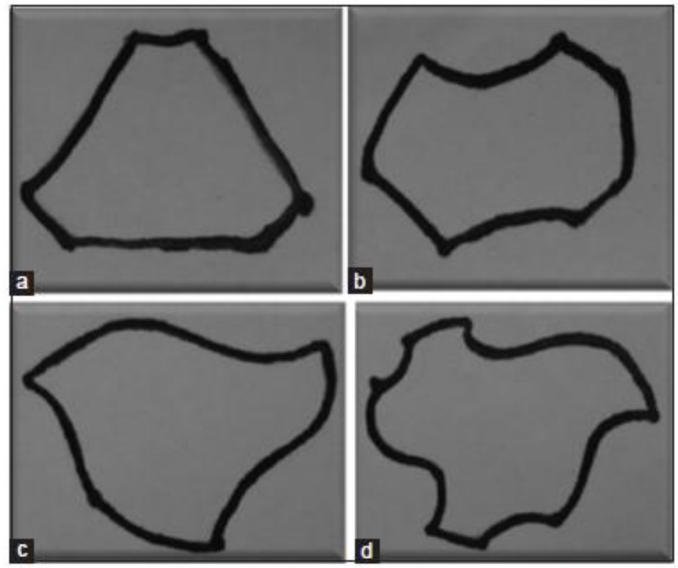


Figure 3: Radial land (RL), (a) full RL, (b) recessed RL, (c) no RL, (d) modified RL.

Helical angle[14]

It is the angle formed by the cutting edge with the long axis of the file. It can be of two types (Figure 4). Variable helical angle: Helps in moving debris up the canal and the file will be less likely to screw into the canal. E.g. RaCe, GT files, ProTaper etc.

Constant helical angle: It is more prone for debris accumulation, leading to the need for increased torque and potential separation. E.g. Profile, Quantec, etc.

Figure 4: Helical angle.

Pitch[15]

Pitch is the number of spirals or threads per unit length. Screws historically have had a constant pitch. The result of a constant pitch and constant helical angles is a "pulling down" or "sucking down into" the canal. This is particularly significant in rotary instrumentation when using files with a constant taper. K3 file has been designed with constant tapers, but with variable pitch and helical angles. The result is a dramatic reduction in the sense of being "sucked down into" the canal. Profile has a constant pitch throughout its cutting shank.The GT has variable helical angles and a variable pitch. Their variable pitched flutes provide a reamer like efficiency at the shank and K-file strength at the tip21. ProTaper has continuously changing pitch and helical angle which reduces the screwing effect. RaCe features one set of cutting edges that alternates with a second set, pitched at a different angle. Consequently, there are two different cutting edges on one file. The cutting shank employs an alternating spiral design. Naturally, this results invariable helical angles along with a variable pitch.

Various systems based upon their design features are shown. **(Table 1 and Table 2)**[17-38]

Conclusion

Rotary instrumentation is an exciting and valuable advancement in canal preparation. The concept of shaping the root canal walls and maintaining the original canal curvature and shape has now become the prime motive of designing the new generation of Nickel Titanium rotary files. Understanding the fundamentals of file designs, along with the ease of operating them and combining them with preclinical trials, aids in choosing the ideal rotary Nickel Titanium file. Better apical cleaning, the essence of successful therapy, is now possible with the latest generation of rotary nickel–titanium instruments.

References:

1. Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K. Outcome of primary root canal treatment: Systematic review of the literature - part 1. Effects of study characteristics on probability of success. Int Endod J 2007;40(12):921-39.
2. Ruddle CJ. Cleaning and shaping the root canal system. In: Cohen S,Burns RC, 9th eds. Pathways of the Pulp. St Louis: Mosby, 2006.
3. Hulsmann M, Peters OA, Dummer MH. Mechanical preparations of root canals: shaping goals, techniques and means. Endo Topics 2005;10:30-76.
4. GhassanYared :Canal preparation with only one reciprocating instrument without prior hand filling : A new concept. Yared 2010
5. Parashos P, Messer HH. The diffusion of innovation in dentistry: a review using rotary nickel-titanium technology as an example. Oral Surg OralMed Oral Pathol Oral Radiol Endod
6. 2006;10:395-401.
7. Baumann MA. Nickel-titanium: Options and challenges. Dent Clin North Am 2004;48(1):55-67.
8. Thompson SA. An overview of nickel-titanium alloys used in dentistry. Int Endod J 2000;33(4):297-310.
9. Thompson SA. An overview of nickel-titanium alloys used in dentistry. Int Endod J 2000;33:297310.
10. Koch K, Brave D. Real World Endo: Design Features of Rotary Files and How They Affect Clinical Performance. Oral Health / February 2002 :39.
11. Vaudt J., Bitter K, Kielbassa AM. Evaluation of rotary root canal instruments in vitro: Areview. ENDO 2007;1:189-203
12. Gerald N. Glickman D.D.S., M.S. and Kenneth A.Koch, DMD. 21st Century Endodontics. Journal of the American Dental Association June 2000; 131: 39 - 46.
13. Sattapan B, Nervo GJ, Palamara JE, Messer HH. Defects in rotary nickel-titanium files after clinical use. J Endod 2000;26(3):161-5.
14. Rzhanov E, Belyaeva T. Design features of rotary root canal instruments. Endo (Lond) 2012;6:29-39.
15. Rotary Instrumentation: An Endodontic Perspective. Endodontics: Colleagues for Excellence, Winter. Chicago, IL: American Association of Endodontists; 2008. p. 1-7.
16. McSpadden JT. Mastering Endodontic Instrumentation, New Jersey: Arbor Books Inc.; 2006.

Table1: The design features of the commonly used rotary files.

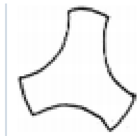
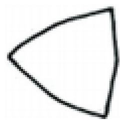
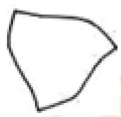
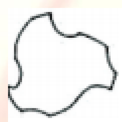
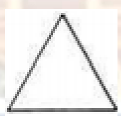
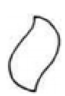
Instrument system	Manufacturer / year	Introduced by	Cross-Section/ Transverse section	Rake angle	Helical angle	Cutting surface	Tip design	Sizes	Taper	Speed
LightSpeed (LSX)	LightSpeed Endodontics,San Antonio TX/1992	Wildey& Senia	Triple U shape	Neutral	N/A	3 radial lands	Non-active	20-140	N/A	700-2000
Profile	Dentsply Tulsa Dental/1993	Ben Johnson	Triple U shape	Negative (20^0)	Open(20^0)	3 radial lands	Non-active	15-90	2,4,5,6 7,8	150-350
Quantec Sc, LX	Sybron Endo/1996	McSpadden	S-shaped design	positive	Close	2 radial lands	Active(SC) Non-active(LX)	15-45	2,3,4,5,6, 8,10,12	300-350
GT files	Dentsply Tulsa Dental/1998	Buchanan	Triple U-shape	Neutral	Variable (grows from tip to shaft)	3 radial lands	Non-active	20-70	6, 8, 10, 12	300-500
HERO 642	MicroMega/ 1999	Daryl Green	Triangular	Positive	Open	3 cutting blades	Non-active	20-45	2, 4, 6	300-600
RaCe	FKG, Switzerland/1999 -	-	Triangular or square	Negative	Variable and alternated	3 or 4 cutting Blades	Non-active	15-40	2, 4, 6, 8, 10	300-600
Flexmaster	VDW Munich Germany/2000	-	Triangular	Positive	-	3 cutting blades	Non-active	15-70	2, 4, 6, 11	300
ProTaper	Dentsply Tulsa Dental/2001	P Machtou, C Ruddle, J West	Convex triangular	Negative	Variable (grows from tip to shaft)	3 cutting blades	Non-active	17-30	Variable: Sx - 3.5-19, S1-2-11, S2-4-11.5, F1-7-5.5, F2-8-5.5, F3-9-5.5	250-350

K3	Sybron Endo/2001	McSpadden	3 asymmetric surfaces	Positive	Variable (grows from tip to shaft)	2 radial lands, 1 cutting blade	Non-active	15-60	4, 6	300
M two	VDW, Munich, Germany/2003	-	Italic S	Negative	Variable (grows from tip to shaft)	2 cutting blades	Non-active	10-40	4, 5, 6, 7	300-350
Twisted file	Sybron Endo, Orange, CA, USA/2008	-	Triangular	-	Variable	2 cutting blades	Non-active	25-40	4, 6, 8, 10, 12	500
Self-adjusting file	ReDent, Raanana, Israel/2010	Zvi Metzger	NiTi lattice	N/A	N/A	Hollow thin walled cylinder	Non-active (Asymmetrical)	1.5 and 2 mm (diameter)		3000 - 5000
Hyflex	Coltene-Endo/2011	Riacrdo Caiecedo, Stephen Clark	Double fluted Hedstroem design	Positive	Variable, accelerated flute design	2 cutting blades, no radial lands	Non-active	15-40	4, 6, 8	500

Table1:(Continued…)

Instrument system	Manufacturer/ year	Introduced by	Cross-Section/ Transverse section	Rake angle	Helical angle	Cutting surface	Tip design	Sizes	Taper	Speed
Wave-one	DentsplyTulsa Dental/2011	-	Modified convex Triangular Cross-section	Negative	Variable (grows from Tip to shaft)	3 cutting blades	Non-activ	21-40	6,8	300
Reciproc	VDW GmbH, Munich, Germany/2011	-	Double S-shaped	Negative	Variable (grows from Tip to shaft)	2 cutting blades	Non-activ	25-50	5,6,8	300
ProTaper Next	Dentsply Tulsa Dental/2013	Ricardo Machado	Rectangular (offset desigh)	-	Variable	4 cutting blades (2 active at a Time)with readial lands	Active	17-50	Variable X1-4, X2-6 X3-7, X4-6 X5-6	300
One Shape	Micromega/2013		Symetrical	-	Variable			25	6	350
Edge File	Edge Endo/2013	-	Parabolic Cross-section (annealed heat Treated)	-	-	-	Non-Active	17-40	4,6	300
Protaper gold	Dentsply Tulsa/2014		Triangular cross-section		variable	-	Non – active	19-50	2,4,6,7,8,9	300

Table 2: Cross-sectional design of various rotary systems

Instrument system	Cross-sectional design
ProFile GT LightSpeed	 Triple U-shaped with radial lands
Protaper WaveOne	 Convex triangular, no radial lands
Hero 642 Flex Master	 Triangular shape, positive rake angle, no radial lands
K3	 Positive rake angle, three radial lands with peripheral blade relief
RaCe Twisted file	 Triangular shape, no radial lands
Hyflex CM	 Double fluted hedstroem design
M two Reciproc Quantec	 S-shaped design, no radial lands

17. Young GR, Parashos P, Messer HH. The principles of techniques for cleaning root canals. Australian dental Journal Supplement 2007;52:52-60.
18. Bergmans L, Van Cleynenbreugel J, Beullens M, Wevers M, Van Meerbeek B, Lambrechts P. Smooth flexible versus active tapered shaft design using NiTi rotary instruments. Int Endod J 2002;35(10):820-8
19. Barbakow F. The LightSpeed system. Dent Clin North Am 2004;48(1):113-35..
20. Profile Catalogue: Dentsply, Maillefer Instruments Switzerland. Available from: https://www.dentsply.co.uk/ Products/Instructions-for-use.aspx. [Last accessed on 2014 Dec 29]

21. Hsu YY, Kim S. The ProFile system. Dent Clin North Am 2004;48(1):69-85.
22. Quantec™ System. Available from: http://www.endodonziamauroventuri.it/Preparazione%20rotante%20 Ni-Ti/Quantec%20System%20-%20Brochure.pdf. [Last accessed on 2014 Dec 29].
23. Bertrand MF, Pizzardini P, Muller M, Médioni E, Rocca JP. The removal of the smear layer using the Quantec system. A study using the scanning electron microscope. Int Endod J 1999;32(3):217-24.
24. Buchanan SL. ProSystem GT: Design, technique, and advantages. Endod Top 2005;10:168-75.
25. Endodontics with Micro-Mega. Available from: http://www.pattersondental.ca/brochures/January_2007/ Micro-Mega/micromega_engl.pdf. [Last accessed on 2014 Dec 29].
26. Stokes OW, Fiore PM, Barss JT, Koerber A, Gilbert JL, Lautenschlager EP. Corrosion in stainless-steel and nickel-titanium files. J Endod 1999;25(1):17-20.
27. FlexMaster the rotary NiTi system for every case. Available from: http://www.vdw-dental.com/fileadmin/redaktion/downloads/produkte/en/en-FlexMaster.pdf. [Last accessed on 2014 Dec 29].
28. Sonntag D. FlexMaster: A universal system. Endod Top 2005;10:183-6.
29. Clauder T, Baumann MA. ProTaper NT system. Dent Clin North Am 2004;48(1):87-111.
30. Gambarini G. The K3 rotary nickel titanium instrument system. Endod Top 2005;10:179-82.
31. Mounce R. The twisted file: A new paradigm in canal enlargement. Dent Clin 2008;17:33-4.
32. Hof R, Perevalov V, Eltanani M, Zary R, Metzger Z. The self-adjusting file (SAF). Part 2: Mechanical analysis. J Endod 2010;36(4):691-6.
33. Shen Y, Coil JM, Zhou H, Zheng Y, Haapasalo M. HyFlex nickel-titanium rotary instruments after clinical use: Metallurgical properties. Int Endod J 2013;46(8):720-9.
34. Webber J, Machtou P, Pertot W, Kuttle S, Ruddle C, West J. The wave one single-file reciprocating system. Roots 2011;1:28-33.
35. ReciProc one file endo. Available from: http://www.vdw-dental.com/fileadmin/redaktion/downloads/produkte/ en/en-reciproc-anwender_a5_rev6.pdf. [Last accessed on 2014 Dec 29]
36. ProTaper Next Brochure. http://www.tulsadentalspecialties.com/Libraries/Tab_Content_-_Endo_Access_Shaping/ProTaperNext_Brochure.sflb.ashx. [Last accessed on 2014 Dec 29].
37. Ruddle C. The Shaping Movement: Fifth Generation Technology, 2013. http://www.dentistrytoday.com/endodontics/8865theshapingmovementfifthgeneration technology. [Last accessed on 2014 Dec 29].
38. Edge Endo, 2013. Available from: http://www.edgeendo.com/products/edgefile/. [Last accessed on 2014 Dec 29].