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Rotary Endodontics - A Review

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Abstract
Shaping and cleaning of root canal system is one of the most important procedures in endodontic treatment. There has been a constant quest for quicker, safer and more efficient method for cleaning and shaping of root canals. Use of automated Ni-Ti instruments was a logical development to enhance the efficiency of the treatment. Over the past two decades, instrument design has been considerably modified; progress has been made in manufacturing, as well as alloy processing. Clinical procedures and ideal working parameters are still being refined as new instruments continue to be introduced to the market. Separation of instruments while preparing root canals is something that has plagued all practitioners. Therefore, an assessment of effect of speed and torque on the rotary Ni-Ti instruments is of value to the clinician. The purpose of this paper is to discuss the behavioural specific characteristic features and their properties of Ni-Ti rotary instruments. Some guidelines and usage parameters are also detailed.
Key Words
Ni-Ti instruments, precision tip and alternating cutting angle (ACA), endodontic instruments, and master apical file (MAF).

Indroduction.

Endodontic final result is a multifactorial trend. The connection is out there amid periapical diagnosis along with endodontic treatment, (level involving root channel instrumentation along with obturation along with solidity involving root filling) along with exerts a large effect on treatment final result. Maximum treatment pertaining to endodontic therapy would depend within the profitable reduction involving organisms from contaminated root pathways[1]. 1 maintaining the initial canal shape following instrumentation brings about a much better treatment[2].

Shaping in addition to clean-up the foundation canal system is recognized as becoming just about the most crucial phase in root canal treatment. It includes the removal of vital and necrotic tissues from the root canal system, along with infected root dentine and, in cases of retreatment, the removal of metallic and non-metallic obstacles. It aims at preparing the canal space to facilitate disinfection by irrigants and medicaments[3]

A continuously tapering funnel shape-with the smallest diameter at the end point and the largest at the orifice is the most appropriate canal shape for filling with guttapercha and sealer. However , endodontic preparations of curved canals represent a considerable problem for practitioners. When stainless steel instruments are used, there is a tendency for all preparation techniques to straighten the canal from its original axis.[4]

In the past times, files and reamers were made with either carbon steel or stainless steel. In 1988 Walia et al. documented that files made from nickel titanium alloy had increased flexibility in bending and torsion and increased resistance to torsional fracture than stainless steel. Ni-Ti files were marketed to the dental profession, with the claim that they have fewer tendencies to straighten curved canals. New instruments introduced to the profession should be evaluated for safety andefficacy.[9]

Nickel-titanium alloys have recently been introduced into the field of endodontics. Ni Ti is an alloy well suited for endodontic instruments. The advantage of this alloy's performance over stainless steel files has been reported to be less straightening of the original canal shape, less development of ledges, apical zipping, canal transportation, and perforations.[2]

Generations Of Rotary Instruments[5]

1st Generation: This includes from the mid- to late 1990s, with passive cutting radial lands and fixed tapers of 4 and 6 % over the length of their active blades. This generation of technology required numerous files for achieving the preparation objectives. Eg:-GT files (DENTSPLY) became available that provided a fixed taper on a single file of 6, 8, 10, and 12 %.

2nd Generation: reached dental markets in 2001.The one feature that distinguished this generation of instruments from previous ones is that they have active cutting edges and thus require fewer instruments to prepare a canal fully. In order to prevent taper lock and the resultant screw effect associated with both passive and active fixed taper NiTi cutting instruments, EndoSequence (Brasseler) and BioRaCe (FKG Dentaire) provided file lines with alternating contact points.

3rd Generation: From 2007 some manufacturers began to focus on using heating and cooling methods for the purpose of reducing cyclic fatigue in and improving safety with rotary NiTi instruments used in canals that are more curved. The intended phase-transition point between martensite and austenite was identified as producing a more clinically optimal metal than NiTi. This third generation of NiTi instruments significantly reduced cyclic fatigue. Some eg: Twisted Files (Sybron Endo), HyFlex (Coltène/Whaledent), and GT, Vortex, and WaveOne (DENTSPLY).

4th Generation: Another advancement in canal preparation procedures was achieved with reciprocation, a process that may be defined as any repetitive up-and-down or back and forth motion. Recent brands that use equal clockwise (CW) and counter-clockwise (CCW) degrees of rotation in their movement are M4 (SybronEndo), Endo-Express (Essential Dental Systems), and Endo-Eze (Ultradent). This generation of instruments and its related technology have given the hope again for a single-file technique. ReDent Nova introduced the Self Adjusting File.

5th Generation: The latest generation of shaping files have been designed in such a way that the centre of mass or the centre of rotation, or both, are offset. When in rotation, files that have an offset design produce a mechanical wave of motion that travels along the active length of the file. Like the progressively percentage tapered design of ProTaper files, this design minimises the engagement between the file and dentine.

Since decade there are many advances in various design in rotary instruments and systems to overcome the various problems in quality of shaping the root canal system like instrument fracture due to cyclic fatigue, apical transportation, inability to maintain centricity in preparation, inability to remove debris due to inadequate envelope of preparation in retreatment cases and etc,.

Here are the various modifications in rotary instruments design and their benefits of few features

1. Cyclic fatigue resistance to increase the cyclic fatigue resistance, thermomechanical treatment of NiTi instruments[6] has been carried out because the mechanical performance of NiTi alloys sensitive to their microstructure and associated thermomechanical treatment . Heat treatment or thermal processing is one of the most fundamental approaches towards adjusting the transition temperature in NiTi alloy, which affects the fatigue resistance of NiTi endodontic files.

Recently a different approach has been used to optimise the structure of the NiTi wire blanks for rotary instruments. A series of proprietary thermomechanical processing procedures has been developed with the objective of producing SE NiTi wire blanks that contain the substantially stable martensite phase under clinical conditions.

M-Wire (Dentsply Tulsa Dental Specialities) was introduced in 2007 and is produced by applying a series of heat treatments to NI Ti wire blanks. M-Wire instruments include Dentsply's Profile GT series X, Profile Vortex, and Vortex Blue. In 2008, a new manufacturing processing was also developed by Sybron Endo to create a Ni Ti endodontic instrument- Tf's

The R- phase is an intermediate phase with a rhombohedral structure that can form during forward transformation from martensite to austenite on heating and reverse transformation from austenite to martensite on cooling. It occurs with a narrow temperature range.

CM wire (Dental, Johnson city, TN) is a novel NI Ti alloy with flexible properties that was introduced in 2010. CM NiTi files have been manufactured using a special thermomechanical process that controls the memory of other Ni Ti files, as opposed to what is found with conventional SE forms of Ni Ti. Both HYFLEX and TYP are made from CM wire.

Cm Wire

Instruments made from CM wire (TYP CM and DSSS0250425NEYY CM [NEYY CM] were nearly 300-800 % more resistant to fatigue failure than instruments made from conventional Ni Ti wire with the same design in a dry condition in a 3 point bending device. The square (NEYY CM) configuration of Ni Ti instruments made from CM wire showed a significantly longer fatigue life than the triangular configuration (TYP CM). Therefore, the design of the instrument should also be taken into account because it is an important determinant of the fatigue lifetime.

Fractographically, a single crack origin is usually found in conventional Ni Ti files. CM wire instruments had a higher number of multiple crack origins than conventional Ni Ti wire files of the same design; especially NEYY CM instruments (92% files with multiple crack origins). The values of the fracture area occupied by the simple region (showing the final fracture) were significantly smaller on Ni Ti instruments made from CM wire than on instruments made from conventional Ni Ti wire. CM series files had fatigue resistance superior to that of files made from conventional Ni Ti alloy.

M WIRE:-Johnson et al. reported that instruments made from M-Wire with a Profile design exhibited nearly 400% more resistance to cyclic fatigue than SE wire instruments of the same size.

R- Phase:-The Twisted File is a Ni Ti rotary file manufactured with R-Phase alloy using a twisting method. It has been reported to have a higher fatigue resistance than ground files. The R-Phase shows good super elasticity and shape memory effects; its young modulus is typically lower than that of austenite. Thus an instrument made from the R-Phase wire would be more flexible. Also the stress hysteresis was obviously smaller for TFs than for ground files. A narrower stress hysteresis means that more austenite can be transformed during the stress induced martensitic transformation. Hence it is not surprising that a higher fatigue resistance was found in TFs than in conventional NiTi files[6].

Tip design:-Active,Partially active and Passive are various tip designs.Mostly all files have rounded tip to act as guide within the root canal. All modern day instrument tips are non aggressive they ride on the canal wall instead of gouging it.Few modifications like Safe - Cutting tip with 60 degree tip seen in Quantec safe end files as shown in **(Fig 1and 2)**[7,8]. A precision tip, by definition, is a non-cutting tip that becomes active right at D-l. In case of real world Endo sequence file.

Centring ability of rotary instruments:- To maintain the centring ability of instruments various modification has been done in various rotary systems like three edge cross section in HERO shaper rotary instrument by which even distribution of forces take places, wide radial lands in crosses section of quantec, K3**(Fig. 3, 4)**,K3XF, reverse flutes alternating with straight areas in RACE, alternate contact points(ACPs) in Real World Endo Sequence File and etc,.

Apical transportation:-it is moving the position of the canal's normal anatomic foramen to new location on external root surface to minimize few modification has been done like

non-cutting rounded guiding tip in flex

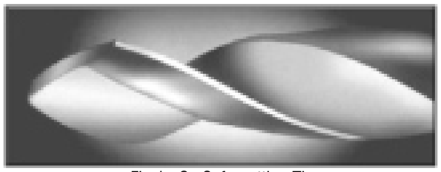

Fig 1 : Sc Safe-cutting Tip

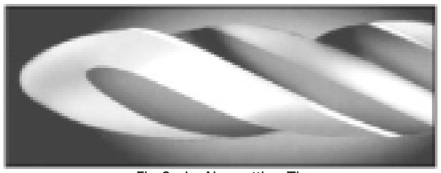

Fig 2 : Lx Noncutting Tip

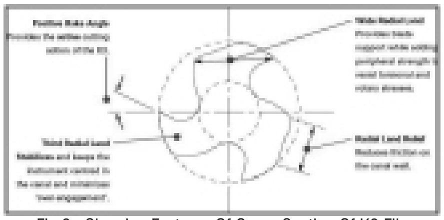

Fig 3 : Showing Features Of Cross Section Of K3 File

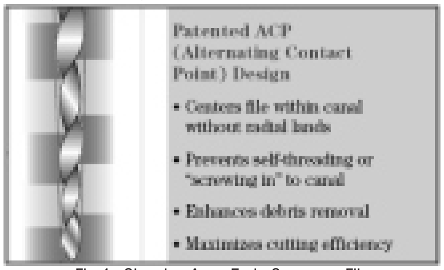

Fig 4 : Showing Acps Endo Sequence File

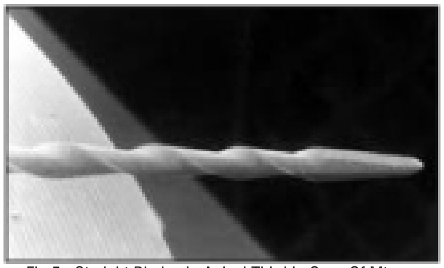

Fig 5 : Straight Blades In Apical Third In Case Of Mtwoa

Table 2 : Mean ± Sd, P-value Of Trouque Failure (Nmm) At Fracture For Electropolished And Nonelectropolished Instruments.

	Endowave	Profile	Race
Electropolished	14.7±3.2	24.2±1.6	14.9±4.9
Nonelectropolished	12.4±2.6	18.0±7.6	10.1±2.4
P Value	0.117	0.065	0.004

master, Hero shaper, QLX Non-Cutting tip and QSE Safe - Cutting tip with 60 degree tip,radial lands with a neutral rake angle in profile, two straight blades in apical third in case of MTwoA **(Fig 5.)** file, radial lands and a peripheral blade relief in k3, K3XF ,different cross sectional designs over the entire length of the working part Wave one, One shape rotary file system

Electropolishing

Electropolishing referred to a control chemical process that minimise surface defects and consequently increase file longevity. Electropolishing is hypothesized to improve torsional strength and cyclic fatigue resistance through leveling the grain boundaries and removal of surface pitting and machine grooves that act as center for fracture propagation [9]. Harold et al.[10] showed that electropolishing did not effect in inhibiting formation of microfractures, Cheung et al in 2007 found that electropolishing did not protect the instrument from low cyclic fatigue failure.[11]

Table 1 : Mean ± Sd, P-value Of Rotation To Fracture Electropolished And Nonelectropolished Instruments

	Endowave		Profile		Race	
	450	900	450	900	450	900
Electropolished	1242.7±225.6	410±70.8	5430.3±741.4	295.8±40.9	1304.4±289.6	282.5±63.9
Nonelectropolished	610.9±149.9	244.9±49.3	6624.8±2107	184.4±27.6	911.7±288.1	160.3±32.7
P Value	<0.001	<0.001	0.124	<0.001	0.007	<0.001

Discussion

The shaping of curved canals presents, a considerable problem for practitioners when stainless steel instruments are used. There is a tendency for all preparation techniques to transport the prepared canal from its original axis[12]. Dan Zhao et al 2013 studied the canal shaping properties of Hyflex CM, Twisted files and K3 nickel titanium files by using microcomputed tomography.TF showed the greatest amount of volumetric dentin removal, where as no significant difference was found in HYflex CM and k3 groups. The TF system produced significantly less transportation than the K3 system in the apical third of canals. No significant difference was found between TF and Hyflex CM instruments relating to apical transportation.[13]

However, preparation usually removes dentin somewhat preferentially toward the outside of the curvature[14]; overall, 50% or less of canal surface is mechanically prepared[15]. Rotary instruments with a radial landed design (GTX) prepare canals in a planing action and should be advanced with light pressure (approximately 1 to 3 N) to engage the perimeter of the canal and then cut dentin there. These instruments enlarge the canal path safely without creating procedural errors. Non landed instruments (eg, EndoSequence, Twisted File, Vortex) prepare canals more in a cutting action; the active blades arising from a triangular cross section can be used with lateral force toward a specific point on the perimeter. This brushing action allows the clinician to change canal paths away from the furcation in the coronal and middle root canal thirds[22] but may reduce fatigue life in larger instruments. Ricardo Castello et al .2009 compared the cyclic fatigue resistance of three nickel titanium endodontic instruments from Protaper, Wave one, and Twisted files. Reciprocating movement of Wave one showed a longer cyclic fatigue life than conventional rotary movement of TF and Protaper. The new manufacturing process of TF produced Ni Ti rotary instruments more resistant to fatigue than Protaper instruments produced with the traditional Ni Ti grinding process.[17] study conducted by Margot E. Anderson et al[16]. On fracture resistance of electropolished rotary nickel-titanium endodontic instrument a SEM study and found that on cyclic fatigue testing ; the mean number of rotation to fracture, when the instrument were rotated around a 450 and 900 angle of curvature, are present in **Table. 1** the number of rotation to failure for electropolished instrument was significantly greater across all brands of endodontic instruments tested, with the exception of profile instruments rotated around a 450 curvature, where no significance difference but there was difference between electropolished and nonelectropolished instrument was significant only for Race instrument on torsional fatigue testing when compare with Endowave and Profilewhich is given in **Table 2**.

Gao et al compared the cyclic fatigue resistance of Profile Vortex rotary instruments made of 2 different raw materials: M-Wire and regular SE wire at 2 different raw materials: M wire and regular SE wire at 2 different rotational speeds. Profile Vortex files made from M-Wire exhibited superior cyclic fatigue resistance (150 % longer fatigue life) compared with those made from regular SE wire at 2 test speeds(i.e 300 and 500 rpm). There was no significant difference in fatigue resistance under different rotational speeds of 300 and 500 rpm[18]. Hello P. et al found the mechanical properties such as cyclic fatigue, flexibility and angular deflection at failure of rotary instrument made with NiTi alloy in R-phase (K3XF) showed overall best performance when compared with files made with traditional NiTi wire (k3) and m wire (profile vortx)[19].

Creating a canal preparation whose cross-sectional diameter progressively narrows and is smallest apically allows for controlled three-dimensional obturation to the consistent drying point[20]. Clinicians must stop fretting about whether their gutta percha apically has circumferential dentin or cementum and become more concerned with eliminating the root canal system as a source of irritation, packing the root canal system in three dimensions, and promoting the health of the attachment apparatus. Consistently "finishing" the root canal preparation is the sine qua non of excellence and is confirmed by gauging and tuning procedures[21].

Conclusion

With the advent of nickel titanium, instrument designs began to vary in terms of taper, length of cutting blades, and tip design. Files traditionally have been produced according to empiric designs, and most instruments still are devised by individual clinicians rather than developed through an evidence based approach. The development of new files is a fast and market driven process. With new versions rapidly becoming available, the clinician may find it difficult to pick the file an1d technique most suitable for an individual case. Clinicians must always bear in mind that all file systems have benefits and weaknesses. Ultimately, clinical experience, handling properties, usage safety, and case outcomes, rather than marketing or the inventor's name, should decide the fate of a particular design.

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