Review Article

Rotary Endodontics: A Brief Review

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Abstract

Endodontic treatment involves cleaning and shaping the canal using stainless steel hand instruments. However, using these hand instruments made the treatment time-consuming, cumbersome for the clinician and the risk of instrument breakage is also more. To overcome this situation, rotary endodontics are introduced to increase the success of the treatment with the ease of operating rotary nickel-titanium files.

These rotary files are continually evaluating in the form of their design features, how instruments are driven such as rotary or reciprocating. The purpose of this review is to provide a knowledge base for nickel-titanium rotary use and further aims to give a brief insight into the different design and features of various rotary instrument systems enabling them to select a system that is most suitable for their needs.

Keywords: *Stainless steel, Time consuming, Nickel-titanium, rotary or reciprocating.*

Introduction

Root canal treatment is necessary to be done when the pulp of the tooth is infected due to any caries, trauma, or cracks in the enamel. If left untreated can lead to pain followed by the formation of an abscess. So, endodontic treatment includes removal of the infected pulp, disinfection of the canal, and sealing of the canal.

To clean or remove the canal include mechanical instruments and chemical methods. These can be done using traditional manual files or electrically driven rotary instruments. Treatment relies upon endodontic instruments used for cleaning and shaping of the canal, irrigation used in the canal1. The success of any endodontic treatment starts with the preparation of the access cavity to the obturation of the canal.

Rotary instruments were first described by Oltramare in 1892 in which he used a needle with a rectangular cross-section attached to the dental handpiece. The fine needles were passively introduced in the canal till the apical foramen and then rotation was done. In 1988, Walia introduced Nickel-titanium (NiTi) / Nitinol files to endodontics. However, in 1993 first rotary nickel-titanium file was introduced by NT Co and it was considered as a turning point in the field of endodontics.

Nickel-Titanium is described as an exotic metal because it does not conform to the normal rules of metallurgy. It has a property of superelasticity and has shape memory to allow it to return to its shape following significant deformation, differentiate it from other metals, such as stainless steel that sustain permanent deformation and retain the shape change. **(**2**)**

Rotary files were designed with a cross-section that has broad radial lands and not cutting edges. These properties make Nickel Titanium endodontic files more flexible and adapt them to conform to the canal curvature, resist fracture, and wear and tear less than stainless steel files. **(**3**)**

Various features affect the efficacy of rotary instruments. These include Taper, Tip design, Rake angle, Helical angle, and Radial angle.

Comparison between stainless steel and Nickel-titanium

Stainless steel	Nickel-titanium
Less flexibility	Excellent flexibility
Straightens and transport canal	Conform to canal curvature
Permanent deformation	Plastic deformation

Advantages of using rotary instrument over hand instruments:

1) Improved efficacy by its ability to collect and remove debris from the canal.
2) Improved safety and consistency of results.
3) The most advantageous is its continuous rotation that reduces the time required for instrumenting the canal.
4) Improved procedural simplicity.
5) Produces greater taper in canal preparation
6) Continuous clockwise rotation conveys debris only in a coronal direction from the canal ramifications and apical foramen4.
7) Mechanical rotation provides a constant 360-degree engagement of the file tip in the canal that forces it to follow the canal and results in better control for maintaining the central axis of the canal thus reducing the incidence of lodging or perforation5.
8) The flexibility of the nickel-titanium enables newly designed rotary instruments to optimize the preparation of curved root canals6.
9) The binding of the instruments into the root canal dentin wall is less frequent, reducing traditional stress.
10) There is less chance of instrument fracture7.
11) The reduction in the number of cycles within the root canal during preparation results in less flexural stress on the instrument.
12) They allow the shaping of narrow curved canals without causing aberrations.

Rotary Endo systems

There are various NiTi instrument systems available in the market. They can be classified according to their design, shaping characteristics, breakage potential, and clinical performance. One shape, the only nickel-titanium instrument in continuous rotation for quality root canal preparation. These rotary instruments are divided into five generations.

First-generation

This system was introduced in the mid-1990s. they have passive cutting radial land along with fixed 0.04-0.06 taper. They created a smooth root canal wall. **(**8**)** These include light-speed Endodontics, GT system Dentsply, Quantec.

Second generation

This was introduced into the market in 2001. They help in preserving the original shape of the canal

and helps in fast preparation. These include Protaper, K3-SybronEndo, I RaCe, Hero Shaper. **(**9**)**

Third generation

This system was introduced in late 2007 and was especially introduced to improve the safety of NiTi instruments in curved root canals. The file formed in this canal has M-wire and R phase technology thus making an instrument with high memory shapes and low risk of separation. This R phase technology alloy NiTi files proper heating and cooling thus helps in reducing cyclic fatigue of the files and less risk of separation. **(**10**)** It includes Profile GTX Series, Twisted, Hyflex.

Fourth generation

The modification was introduced in NiTi instruments instead of a full rotation, clockwise and anti-clockwise with the degree of rotation movements were introduced. They depend upon the Principle of Reciprocation Theory. This generation uses a single file for cleaning and shaping of the root canal. **(**11**)** This generation includes systems such as WaveOne, Self-Adjusting File (SAF).

Fifth-generation

Minor modification has been introduced in this generation that is the efficacy of shaping of the canal was improved by the off-setting center of rotation. This leads to the production of a mechanical wave of motion that improves cutting and removes the debris more effectively as compared to the central mass rotary instrument. **(**12**)**

It also reduced the screwing effect. This generation includes systems such as Revo-S, One Shape, ProTaper Next.

Hyflex

It was introduced by Ricardo Caicedo, Stephen Clark in 2012. Files have double flutter Hedstrom design cross-section with positive rake angle and two cutting blades. Their size ranges from 15-40 with a non-active tip design. They are available as Hyflex CM and Hyflex EDM. Hyflex CM has a unique feature of controlled memory NiTi and is up to 300% more resistant to cyclic fatigue compared to conventional NiTi files thus, reducing the incidence of separation. **(**13**)**

Hyflex EDM is applicable by reciprocating and continuous engine-driven handpieces. The spark generated causes the surface of the material making it more fracture resistant.

Advantages

The local use of the pulsed electromagnetic field (PEMF) during the first two weeks following maxillary cyst enucleation has a valuable effect in decreasing postoperative pain and edema but insignificantly affects bone density.

i. The controlled memory effect helps to reduce procedural errors such as Ledge Formation, perforations, and transportation.

ii. Extremely flexible so good to be used in curved canals.

iii. Increased and wider flutes prevent screwing effects into the canal.

iv. They can be used in multiple preparation techniques.

v. They have high fatigue resistance than ProTaper, ProTaper Next.

vi. They had less dentinal crack than ProTaper Universal and ProTaper Next.

Revo S

It is manufactured by Micro-Mega and is an innovative system that involves three nickel-titanium instruments (R1, R2, R3) meant for initial endodontic treatment and optimal cleaning. It has a snake-like asymmetrical cross-section that provides more flexibility and less stress for cutting edge that enables a better root canal penetration. The smallest of all the radius allows more flexibility. It also allows the choice of an apical finishing. **(**14**)**

The instrument should rotate with a speed range between 250-400 rpm. The initial penetration is with stainless steel k-file. The instrument works in a cyclic way that is cutting, clearance and cleaning. The extended helical machining up to the coronal region increases instrument flexibility.

Advantages

i. Reduction in contact lengths of the blade on the dentine reduces the stress and better debris elimination

ii. The excellent upward debris removal minimizes debris packing in the apical region and beyond.

iii. Optimal cleaning and upward removal of dentine debris.

iv. The progressive pitch avoids screwing effects that smooth the root canal walls.

v. Its equilateral section enables perfect guidance for the instrument up to the apical region of the canal.

Self-Adjusting File (SAF)

It is known as a self-adjusting file due to its unique feature of three-dimensional adaption according to the shape of the root canal. A single file can be used throughout the procedure. The file is highly compressible as it is without any central metal core and has a lattice structure which is responsible for no pressure within the file. **(**15**)**

It is highly recommended in oval, C-shaped canals.

Advantages

i. Offers effective cleaning of all the canals such as oval canals.

ii. It removes a uniform layer of dentin and hence, removes excessive intact dentin.

iii. The hollow file allows continuous irrigation of the canal with additional activation of irrigant by vibration that creates turbulence effect.

iv. In case the file gets damaged within the canal, it can be easily removed.

v. Prevent canal transportation

vi. Highly durable

vii. Remove smear layer in the apical canal

Wave-One

Introduced in 2010, especially for tapered root canal morphology. The file works on the principle of reverse balanced force cutting motion drive by pre-programmed motor. **(**16**)**

The file has a modified triangular cross-section which is convex. Three are three files in wave one single-file reciprocating system available in 21, 25, and 31mm.

The technique involves the following stages:

Access: straight-line access

WaveOne file selection

Single file shaping

Copious irrigation with 5% NaOCl and EDTA before, during, and after single-file shaping.

Advantages:

- Easy to learn and teach.
- Decrease procedural errors by using a single instrument rather than using multiple files.
- Fewer chances of instrument separation due to their property of reciprocating movement.
- Economical

Twisted File

The file was introduced with proprietary R-phase technology. The file has a grain structure of NiTi making it a stronger, fracture-resistant, and more flexible rotary instrument. Grinding into the grain of NiTi compromise the integrity of grain structure and lowers its ability to withstand torsional force thus increases the chances of instrument separation. **(**17**)**

This flexibility combined with the ability of the flutes to unwind allows the twisted file to tolerate more stress for better safety.

Advantages:

- The improved crystalline structure maximizes its flexibility.
- A one-piece design provides greater strength and structural integrity, eliminating the possibility of galvanic corrosion.
- File performs side-cutting with great efficiency while still successfully negotiating a complex curvature.
- Open new opportunities for improved file design.

ProTaper Next

These files are fewer in number as compared to ProTaper Universal files. They have a variable taper, rectangular off-center cross-section design to increase the strength**. (**18**)**

It allows achieving a fully tapered canal with fewer chances of procedural errors. It has an Asymmetric Rotary (AR) Motion to increase canal shaping efficiency. The system has a unique M-wire Nickel-Titanium alloy for increased flexibility and resistance to cyclic fatigue about 400% as compared to traditional NiTi.

Advantages:

- Asymmetric Rotary Motion reduces engagement due to the swaggering effect which decreases the undesirable taper lock.
- More cross-section space for enhanced cutting, loading, and auguring debris.

Disadvantages of NiTi rotary files:

- Instrument Failure: rotary instruments might get lock in the canal leading to the formation of high-level stress. This can cause separation of the instrument. This can be reduced using a low torque endodontic motor19.
- Increased canal preparation and increased microcrack.
- These files are more subject to structural fatigue that can lead to fracture.

Conclusion

Root canal preparation with rotary Nickel-titanium is considered an effective and safe procedure. However, it demands a thorough understanding of root canal anatomy with proper use of principles for the selection of a rotary system. These rotary instruments have evolved tremendously in the past and all file systems have their pros and cons.

So, clinical experience, handling properties should decide which system is best for a particular case. Adequate learning of the physical and mechanical properties of every rotating instrument and its wise use can spare the seat time and leads to a high success rate.

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