

## Nickel–Titanium Rotary Instruments: Development of the Single-File Systems

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Received : 24-06-18.  
Accepted : 16-07-18.  
Published : 06-08-18.

### INTRODUCTION

It was in late 1988 that Walia *et al.*<sup>[1]</sup> introduced the magic properties of a corrosion resistant alloy to the manufacturers for making the nickel–titanium (NiTi) rotary instruments. Previously, the simple hand Endo files were made of carbon steel or stainless steel. Stainless steel instruments inherent stiffness that increases as the size of the instruments increases. Hence, while preparing curved root canals using simple hand instruments, some degrees of canal transportation may happen which may also end to ledge formation and zipping perforation, if proper precurving the higher sizes of the instruments and also the recapitulation and copious irrigation of the curved canals is overlooked by the clinician. Precurving the stainless steel hand instruments inhibits them to have rotational motions inside the curved root canals, meanwhile the elasticity and flexibility of the NiTi rotary files eliminate the iatrogenic errors and Endo mishaps which may happen following improper use of the stainless steel hand Endo files in curved root canals.<sup>[2,3]</sup> From 1990s, until now, NiTi rotary instruments have undergone revolutionary changes in terms of the construction and as a result physical characteristics of the NiTi instrument. Furthermore, the design, shape, and number of instruments used in each group have highly

**ABSTRACT** Over the past two decades, the nickel–titanium (NiTi) rotary instruments have highly improved the quality of the cleaning and shaping of the root canals. The superelasticity and shape memory of these instruments reduce the possibility of the canal transportation along with saving the time for both the patients and the clinicians. Several commercial types of these instruments, produced by different manufacturers, have currently become available by modifying the characteristics of the wonder NiTi alloy and also the cross-sectional shapes, cutting edges, tapering and numbers and distances of the flutes of the instruments. Up to this date, five generations for NiTi rotary instruments have been described according to the time of introduction, properties, and method of application. The aim of this article is to review the evolution of these five generations of NiTi rotary instruments since their inception.

**KEYWORDS:** Nickel–titanium, rotary, single file

been modified. The aim of modifying and improving these instruments is to develop a NiTi rotary instrument which cuts and removes the dentin strongly and also is resistant to fracture even in most challenging narrow, curved root canals. Another purpose of modifying and improving these instruments is to simplify the cleaning and shaping stage and to reduce the number of using instruments along with preserving the original shape of the prepared root canals.<sup>[4]</sup> The most important challenge with using the rotary instruments including the NiTi files is the possibility of their separation due to cyclic fatigue, torsional stress and the clinicians, lack of knowledge and experience.<sup>[5-7]</sup>

Today, thermal treatment of NiTi alloys helps us to optimize the mechanical properties and increase the flexibility of these instruments.<sup>[8]</sup>

This article reviews the history of current existing five generations of the NiTi rotary instruments and also discusses about the benefits and weaknesses of each.

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**How to cite this article:** Kuzekanani M. Nickel–Titanium rotary instruments: Development of the single-file systems. *J Int Soc Prevent Communit Dent* 2018;8:386-90.

Access this article online	
<b>Quick Response Code:</b> 	<b>Website:</b> www.jispcd.org
	<b>DOI:</b> 10.4103/jispcd.JISPCD_225_18

## FIRST GENERATION

This category of NiTi rotary instruments were first introduced to the market during the mid-1990s. The most important characteristic of the first-generation NiTi rotary files is having passive cutting radial lands along with fixed 0.04–0.06 tapers over the full working lengths. The main important NiTi rotary instruments within this category are LightSpeed Endodontics (1992), Profile-Dentsply (1993), Quantec-SybronEndo (1996), and GT system-Dentsply (1998).<sup>[9,10]</sup> Several researches showed that all first-generation rotary instruments created smooth root canal walls which centered in the middle and caused low procedural errors.<sup>[11–13]</sup> The main deficiency of this generation of NiTi rotary instruments was requiring numerous files to achieve these goals and complexity.

## SECOND GENERATION

The second generation of NiTi rotary files was introduced into the market in 2001. These instruments had active cutting edges with greater cutting efficiency, so the number of instruments required to achieve complete cleaning and shaping was almost less in comparison with the previous generation. Notable systems in this generation are ProTaper Universal-Dentsply, K3-SybronEndo, Mtwo-VDW, Hero Shaper-Micro-Mega, I Race, and I Race Plus-FKG Dentaire.

Several studies have also approved the efficiency of these systems in fast preparation and also preserving the original shape of canals even in curved and calcified challenging cases although some researchers have reported some degrees of canal transportations along with tendency for breakage while usage.<sup>[14–19]</sup>

## THIRD GENERATION

It was in late 2007 that the manufacturers started to apply the heating and cooling technologies on NiTi alloys to improve the safety of these instruments, especially in the curved root canals.

In making third generation of the NiTi rotary files, the manufacturers have highly focused on metallurgic properties of the NiTi alloy using heating and cooling procedures on wires which results in reduction of the cyclic fatigue of the files and also reduction of the separation risk of the instruments which is highly demanded by the practitioners. Applying M-wire and R-phase technologies and electrical discharge methods make instruments with high memory shapes and low risk of separation.<sup>[19–22]</sup>

K3 XF Files-SybronEndo, Profile GTX Series–Dentsply, controlled memory (CM) Files (HyFlex CM)–Coltene, and Vortex Blue (Dentsply Tulsa) are notable files in

this group which have been exposed to heat treatments to increase flexibility and safety. The CM property helps the instrument to save the shape of the canal when it is moved out of the canal. Flex files (NeoEndo) files have been predisposed to gold thermal treatment which increases their cutting efficiency along with cyclic fatigue resistance.<sup>[23,24]</sup>

## FOURTH GENERATION

Reciprocation which is described as any repetitive back and forth or up and down motion is another philosophy in canal preparation which was first introduced by Blanc, a French dentist, in the late 1950s. Instead of full rotation, the reciprocating NiTi rotary instruments have movements in which clockwise and counterclockwise degrees of rotation are quite equal. The reciprocation theory of canal preparation has led to development of the fourth generation of NiTi rotary instruments. The use of a single file technique to achieve a thorough cleaning and shaping goals at this phase was another success which was also derived from the reciprocating philosophy in cleaning and shaping the root canal systems. Many studies have shown that the Wave One and the One Shape single-file systems can efficiently reduce the bacterial number in the root canal along with preserving the original shape of it. Wave One-Dentsply, self-adjusting file (SAF)-ReDent Nova, and Reciproc-VDW are featured instruments of fourth generation.<sup>[9,23,25–29]</sup>

## FIFTH GENERATION

In this generation, the efficiency of canal shaping has been improved by offsetting the center of rotation. The offset designed files produce a mechanical wave of motion that distributes along the full length of the NiTi file which improves cutting and removing the debris in comparison with a centered mass rotating instrument. Furthermore, this offset design reduces the taper lock or the screwing effect which causes instrument separation. HyFlex/electrical discharge machining (EDM)-Coltene, Revo-S-Micro-Mega, One Shape Micro-Mega, and ProTaper Next-Dentsply are important files of the fifth generation.<sup>[23]</sup>

Despite the reciprocating philosophy based of the fourth generation, the Revo-S and the One Shape systems of the fifth generation, both manufactured by the Micro-Mega Company, offer proper root canal shaping by continuous clockwise rotation of the instruments inside the root canal system. One Shape which is just a single number 25/0.06. Taper instrument with asymmetrical cross section along the entire blade has variable cross section and longer pitch. Using the glide path, instrument is optional in One Shape instrumentation strategy. Micro-Mega also offers optional using apical finishing files. These sterile single-use NiTi-finishing files are used after root canal

shaping with One Shape in order to enlarge the root canal diameter.

The Revo-S NiTi rotary system also manufactured by Micro-Mega simplifies and optimizes the cleaning and shaping of the root canals with only three NiTi instruments. The asymmetric cross section of the Revo-S facilitates penetration by a snake-like movement and offers a root canal shaping adopted to the biological and ergonomic imperatives[Figure 1].<sup>[30]</sup>

### SINGLE-FILE ROTARY SYSTEMS

Single-file rotary systems are classified to two groups: continuous rotating and reciprocating files, based on type of their motions.<sup>[31]</sup> Wave One–Dentsply-Maillefer, Swiss, and Reciproc–VDW, Germany, have reciprocating motions while Neoniti–Neolix, Charles-La-Foret, France, One Shape–Micro-Mega, HyFlex/EDM–Coltene, Whaledent–Swiss, and XP-endo shaper–FKG Swiss apply continuous motions. One Shape files and EDM files (HyFlex/EDM) are applicable by reciprocating and continuous engine-driven handpieces inside the root canal systems, both. The sparks generated in EDM process cause the surface of the material, melt, and evaporate and make the HyFlex EDM files stronger and more fracture resistant in comparison with CM HyFlex system. This perfect combination of flexibility and fracture resistance makes it possible to reduce the number of files required for cleaning and shaping during root canal treatment without having to dismiss preservation of the original curve and anatomy of the root canal.<sup>[25,32-34]</sup>

HyFlex EDM offers the dental clinician such an ease of mechanical preparation of the root canal system that even newcomers to endodontics can achieve reliable results easily and quickly.



Figure 1: Revo S nickel–titanium rotary system

HyFlex EDM files are produced using an innovative manufacturing process EDM. The EDM process produces a file that is extremely flexible and also fracture resistant. According to the manufacturer’s statement, HyFlex EDM files are up to 700% more resistant to cyclic fatigue in comparison with traditional NiTi files. Regarding the CM properties, HyFlex EDM files preserve the original anatomy of the canal, which significantly reduces the risk of ledging, canal Transportation and perforation. The optimum flexibility, cutting efficiency and separation resistance of the HyFlex EDM make it possible to reduce the number of files required for cleaning and shaping while preserving original anatomy.<sup>[33,34]</sup>

### HYFLEX EDM /CM FOR CURVED ROOT CANALS

The sequence of applied instruments in Hyflex EDM/CM System for curved root canals are:

1. An optional access opening file which is used at coronal 1/3
2. A no 10/05 Glide path used at middle 1/3
3. 2 Shaping files, a no(20/05 HyFlex CM and a no25( HyFlex EDM file) used to prepare the apical 1/3.<sup>[33]</sup>

### HYFLEX EDM FOR STRAIGHT CANALS

The sequence of applied instruments in Hyflex EDM System for straight root canals are:

1. An optional access opening file which is used at the coronal 1/3
2. A no 10/05 Glide path used at middle 1/3
3. A Shaping no25 HyFlex EDM file used to prepare the apical 1/3 [Figures 2 and 3].<sup>[33]</sup>

### XP ENDO SHAPER

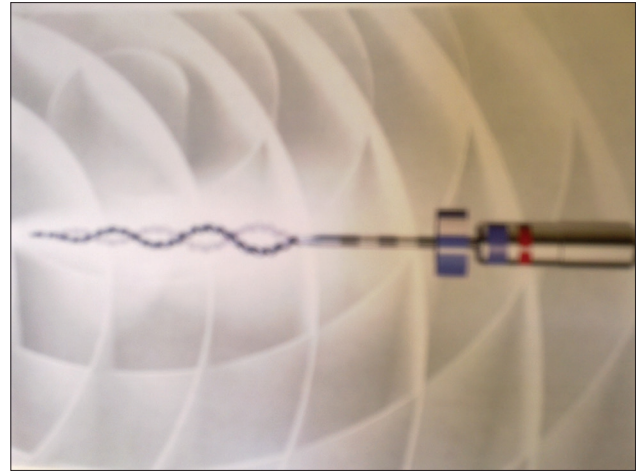
The XP-endo shaper is a truly innovative shaping instrument which can radically simplify endodontic sequences.



Figure 2: HyFlex EDM / CM nickel–titanium rotary system



**Figure 3:** A NSK. Endo It motor used along with most single-file rotary systems



**Figure 4:** XP-endo shaper–FKG Dentaire



**Figure 5:** Self-adjusting file–ReDent Nova

It starts shaping at ISO diameter 15 and achieves ISO diameter 30 and also increases the taper from 0.01 to at least 0.04. It allows to reach a canal shaping of minimum 30/0.04 with only one instrument [Figure 4].

#### SELF ADJUSTING FILE

This system uses a hollow NiTi file, without a central metal core, through which a continuous flow of irrigation is provided throughout the procedure. The SAF technology offers effective cleaning of all root canal variations such as oval canals and provides the effective disinfection and shaping of all canal morphologies. This system uses a new technology of cleaning and shaping in which a uniform layer of dentin is removed from the entire perimeter of the root canal and avoids unnecessary and excessive removal of intact dentin [Figure 5].<sup>[35–37]</sup>

#### ONE CURVE, THE ENDO DNA

One Curve is a single-use, heat-treated NiTi rotary file that enables shaping of the full length of the canal with a single instrument, directly to the apex. C. wire defines One Curve's personality traits as its own DNA:



**Figure 6:** One Curve–Micro-Mega

One Curve is a smart, efficient, and conservative instrument manufactured by Micro-Mega Company. The advantages of One Curve, single-file technology are listed below:

- Increased blade flexibility and more separation resistance resulted from C. wire heat treatment: CM of NiTi material
- Perfect taper and diameter for a final shaping that meets standards of an optimized cleaning and shaping
- Preserves the original anatomy of the root canal [Figure 6].<sup>[38,39]</sup>

#### CONCLUSION

Today, the single-file NiTi rotary systems have highly improved the quality of canal shaping along with saving the time for both the clinicians and the patients.

#### ACKNOWLEDGMENTS

We would like to thank Dr. Reza Abbasi Sardri for taking and processing the images for this review article.

#### FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

## CONFLICTS OF INTEREST

There are no conflicts of interest.

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