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

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**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). Several researches showed that all first-generation rotary instruments created smooth root canal walls which centered in the middle and caused low procedural errors.[11-13] 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.[14-19]

**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.[19-22]

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.[23,24]

**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.[9,23,25-29]

**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.[22]

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][30]

**Single-File Rotary Systems**

Single-file rotary systems are classified to two groups: continuous rotating and reciprocating files, based on type of their motions.[31] 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.[25,32-34]

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.

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.[33,34]

**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.[33]

**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].[33]

**XP endo shaper**

The XP-endo shaper is a truly innovative shaping instrument which can radically simplify endodontic sequences.
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].[35-37]

**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:

- 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].[38,39]

**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.

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**References**

1. Walia HM, Brantley WA, Gerstein H. An initial investigation of the bending and torsional properties of Nitinol root canal files. J Endod 1998;14:346-51.
2. Thompson SA. An overview of nickel-titanium alloys used in dentistry. Int Endod J 2000;33:297-310.
3. Gutmann JL, Gao Y. Alteration in the inherent metallic and surface properties of nickel-titanium root canal instruments to enhance performance, durability and safety: A focused review. Int Endod J 2012;45:113-28.
4. Hulsmann M, Peters OA, Dummer PM. Mechanical preparation of root canals: Shaping goals, techniques and means. Endod Top 2005;10:30-76.
5. Szep S, Gerhardt T, Leitzbach C, Läder W, Heidemann D. Preparation of severely curved simulated root canals using engine-driven rotary and conventional hand instruments. Clin Oral Investig 2001;5:17-25.
6. Pruett JP, Clement DJ, Carnes DL Jr. Cyclic fatigue testing of nickel-titanium endodontic instruments. J Endod 1997;23:77-85.
7. Baumann MA, Roth A. Effect of experience on quality of canal preparation with rotary nickel-titanium files. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999;88:714-8.
8. Gu Y, YeonKum K, Perinpanayagam H, Kim C, JaewonKum D, Lim SM, et al. Various heat treated nickel-titanium rotary instruments evaluated in S shaped simulated resin canals. J Dent Sci 2017;12:14 20.
9. Haapasalo M, Shen Y. Evolution of nickel-titanium instruments: From past to future. Endod Topics 2013;29:3-17.
10. Jain V, Singh A, Agrawal M, Chawla S, Verma A. Effect of taper and length of the K-file on its working length. J Conserv Dent 2014;17:401-19.
11. Bryant ST, Dummer PM, Pitoni C, Bourha M, Moghal S. Shaping ability of 04 and 06 taper ProFile rotary nickel-titanium instruments in simulated root canals. Int Endod J 1999;32:155-64.
12. Hata G, Uemura M, Kato AS, Imura N, Novo NF, Toda T, et al. A comparison of shaping ability using ProFile, GT file, and flex-R endodontic instruments in simulated canals. J Endod 2002;28:316-21.
13. Yun HH, Kim SK. A comparison of the shaping abilities of 4 nickel-titanium rotary instruments in simulated root canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;95:228-33.
14. Schäfer E, Vlassis M. Comparative investigation of two rotary nickel-titanium instruments: ProTaper versus RaCe. Part 2. Cleaning effectiveness and shaping ability in severely curved root canals of extracted teeth. Int Endod J 2004;37:239-48.
15. Javaheri HH, Javaheri GH. A comparison of three Ni-Ti rotary instruments in apical transportation. J Endod 2007;33:284-6.
16. Kuzekanani M, Walsh LJ, Youssefi MA. Cleaning and shaping curved root canals: Mtwo vs ProTaper instruments, a lab comparison. Indian J Dent Res 2009;20:268-70.
17. Azar MR, Mokhtare M. Rotary Mtwo system versus manual K-file instruments: Efficacy in preparing primary and permanent molar root canals. Indian J Dent Res 2011;22:363.
18. Kuzekanani M, Haghani J, Walsh LJ, Estabragh MA. Pulp stones, prevalence and distribution in an Iranian population. J Contemp Dent Pract 2018;19:60-5.
19. Kuzekanani M, Najafipour R. Prevalence and distribution of radix paramolaris in mandibular first and second molars of an Iranian population. J Int Soc Prev Community Dent 2018;8:240-44.
20. Shen Y, Zhou HM, Wang Z, Campbell L, Zheng YF, Haapasalo M, et al. Phase transformation behavior and mechanical properties of thermomechanically treated K3XF nickel-titanium instruments. J Endod 2013;39:919-23.
21. Shen Y, Coil JM, Zhou H, Zheng Y, Haapasalo M. HyFlex nickel-titanium rotary instruments after clinical use: Metallurgical properties. Int Endod J 2013;46:720-9.
22. Ha JH, Kim SK, Cohanca N, Kim HC. Effect of R-phase heat treatment on torsional resistance and cyclic fatigue fracture. J Endod 2013;39:389-93.
23. Peters OA, Gluskin AK, Weiss RA, Han JT. An in vitro assessment of the physical properties of novel Hyflex nickel-titanium rotary instruments. Int Endod J 2012;45:1027-34.
24. Ruddle CJ, Machtou P, West JD. The shaping movement: Fifth-generation technology. Dent Today 2013;32:94, 96-9.
25. The New Niti File Generation, Hyflex TM, A Miracle of Flexibility and Fracture Resistance. Available from: http://www.colten.com. [Last accessed on 2018 May 12].
26. You SY, Bae KS, Bae SH, Kum KY, Shon WJ, Lee W, et al. Lifespan of one nickel-titanium rotary file with reciprocating motion in curved root canals. J Endod 2010;36:1991-4.
27. Gavini G, Caldeira CL, Akisue E, Candeiro GT, Kawakami DA. Resistance to flexural fatigue of reciproc R25 files under continuous rotation and reciprocating movement. J Endod 2012;38:684-7.
28. Pedullà E, Grande NM, Plotino G, Gambarini G, Rapisarda E. Influence of continuous or reciprocating motion on cyclic fatigue resistance of 4 different nickel-titanium rotary instruments. J Endod 2013;39:258-61.
29. Nabeshima CK, Caballero-Flores H, Cai S, Aranguren J, Borges Britto ML, Machado ME, et al. Bacterial removal promoted by 2 single-file systems: Wave one and one shape. J Endod 2014;40:1995-8.
30. Micro Mega-EndoBook. Available from: https://www.medidenta.com/product/Oneshape&Revo-S-solutions-kit/. [Last accessed on 2018 May 12].
31. Moazzami F, Khajastepour L, Nabavizadeh M, Seied Habashi M. Cone-beam computed tomography assessment of root canal transportation by Neoniti and Reciproc single-file systems. Iran Endod J 2016;11:96-100.
32. Singh H, Kapoor P. Hyflex CM and EDM files: Revolutionizing the art and science of endodontics. J Dent Health Oral Disord Ther 2016;5:00182.
33. Next Generation One File Niti System HyFlex Rotary File. Available from: https://www.coltene.com/fileadmin/Data/EN/Products/Endodontics. [Last accessed on 2018 May 12].
34. Kaval ME, Capar ID, Ertas H. Evaluation of the cyclic fatigue and torsional resistance of novel nickel-titanium rotary files with various alloy properties. J Endod 2016;42:1840-3.
35. Metzger Z. The self-adjusting file (SAF) system: An evidence-based update. J Conserv Dent 2014;17:401-19.
36. Re DentNova – Self-Adjusting File. Available from: http://www.redentnova.com/products/self-adjusting-file. [Last accessed on 2018 May 12].
37. Liu Z, Liu J, Gu L, Liu W. The shaping and cleaning abilities of self-adjusting files in the preparation of canals with isthmuses after glidepath enlargement with ISO or ProTaper Universal NiTi files. J Dent Sci 2016;11:83-9.
38. One Curve – MICRO-MEGA. Available from: https://www.micro-mega.com/Accueil/Shaping. [Last accessed on 2018 May 12].
39. D’Amario M, De Angelis F, Mancino M. Canal shaping of different single-file systems in curved root canals. J Dent Sci 2017;12:328-32.