Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies *NLM ID: 101716117*

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr Indian Citation Index (ICI) Index Copernicus value = 100

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Review Article

Modern Endodontic Rotary File- A Review

Prakash Venkatrao Biradar[1], Shweta Kumari[2], Yesh Sharma[3]

[1]Specialist in Endodontics, Hatta Hospital, Dubai Health, United Arab Emirates;
[2]Intern, Pacific Dental College, Udaipur, Rajasthan, India;
[3]Associate Professor, Department of Conservative Dentistry and Endodontics, Pacific Dental College, Udaipur, Rajasthan, India

ABSTRACT:
Endodontic treatment approaches have advanced dramatically in recent decades due to the introduction of various novel techniques and devices.The introduction of newer instruments and techniques has resulted in endodontic procedures becoming easier, faster and safe. Clinicians should be versed in all the properties and capabilities of the devices that can be utilised to perform root canal therapy for choosing the ideal rotary file. The most important among the advances is Nickel Titanium (NiTi) rotary instrumentation that has resulted in consistent, predictable and reproducible shaping of the root canal system. The noticeable features of these file system include flexibility, extreme fracture resistance, controlled memory, pre sterilized modular system, cutting efficiency and safety. This article is an attempt to enlighten the design features of a newly introduced nickel titanium single file rotary system Hyflex EDM used for root canal preparation.
Keywords: Single file endodontics, HyflexEdm rotary file system,, NiTi files

Received: 04 June, 2025 Accepted: 28 June, 2025 Published: 06 July, 2025

Corresponding author: Prakash Venkatrao Biradar, Specialist in Endodontics, Hatta Hospital, Dubai Health, United Arab Emirates

This article may be cited as: Biradar PV, Kumari S, Sharma Y. Modern Endodontic Rotary File- A Review. J Adv Med Dent Scie Res 2025; 13(7):41-47.

INTRODUCTION

Endodontic procedures are based on using different instruments, starting with debridement and disinfection of the canal system ending with complete obturation. In some instances of tight canals, curved canals, commonly in old age patients treating dentists can face significant challenges.An accurate diagnosis and sufficient mechanical preparation of the pulp space for restoration are essential for a successful endodontic procedure.Over the years, the endodontic toolbox has become more complicated. Various methods of preparing roots canals have been published in the relevant literature(1).A remarkable shift in the field of endodontics was with the evolution of rotary endodontic instruments to achieve the prerequisites ofoptimal instrumentation. Stainless steel instruments have been used for canal preparations for a long time. The advent of rotary instruments has successfully revolutionised both the practise and technique of endodontics in recent years. The metallurgy, design elements, and technique of propulsion (rotary/reciprocation) of rotary files have all undergone continual alteration, resulting in revolutions both inside the canal's walls and in the field of currentendodontics.Nickel-titanium (NiTi) alloy combinations have been transforming the practise of endodontics ever since they were first introduced(2). In terms of mechanical qualities,they outperform regular stainless steel in a striking way.

HISTORY

Earlier dentists utilised carbon steel and stainless steel endodontic instruments to clean and shape canals for a very long time. These materials were less flexible and more prone to procedural errors. In the 1960s, W.F. Bueler,a metallurgist created the first NiTi alloys, which differed from other alloys in that they had unique super elastic property and good shape-memory qualities. Endodontic files made of NiTi arch wire were for the very first time invented by Harmeet Walia in 1988 and since then NiTi alloys have now grown to be a crucial component of endodontic treatment.(3)

Hyflex EDM system

EDM: Electrical discharge machining, often known as EDM, is a popular noncontact thermal erosion method in engineering that generates a corroded rough metal surface by melting the metal surface and evaporating small amounts of metals in the presence of a dielectric fluid(4). This treatment gives NiTi tools a rougher, hardersurface, which enhances cutting effectiveness.The HyFlex EDM system was introduced in 2016 and was produced using this spark-erosion technology. According to X-ray diffraction studies, the HyFlex CM system is made up primarily of martensitic NiTi alloy, while the HyFlex EDM system is made up primarily of R-phase NiTi alloy and a significant amount of martensitic NiTi alloy(figure 1).

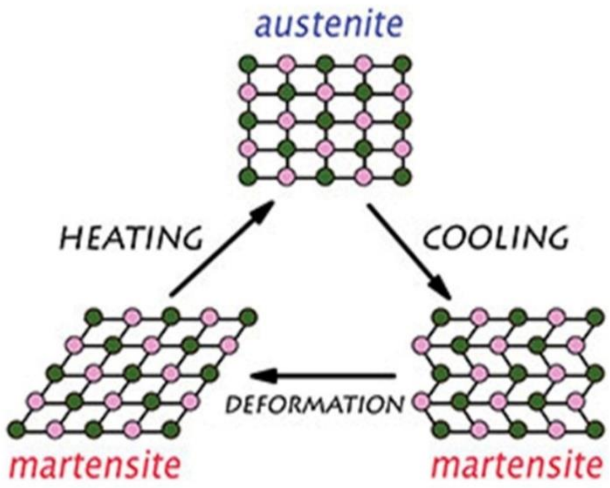

Fig.1Microstructural phases in NiTi alloys

The Hyflex EDM system is an efficient file system to shape the root canal completely to a continuously tapering funnel shape(5). It has

1. Extreme fracture resistance- The super-elasticity of the nickel titanium alloy is due to the stress-induced unstable martensite transition, which tends to return to its former shape upon unloading, to the stable austenitic (stress induced property).HyFlex EDM files are produced using an innovative manufacturing process called Electrical Discharge Machining. The EDM processresults in a file that is extremely flexible and fracture resistant. In fact, HyFlex EDM files are up to 700% more resistant to cyclic fatigue compared to traditional NiTi-Files.
2. Controlled Memory-The NiTi alloy's shape memory property is a specific heat-controlled property that is induced by a transition from a stable austenite to a stable martensite phase (martensitic re-orientation), and it does not resume its original shape upon unloading. As a result, when heated above its transition temperature, the alloy can keep its original shape.HyFlex EDM files follow the anatomy of the canal, which can significantly reduce the risk of ledging,transportation and perforation.
3. 3.Fewer Files Required-The combination of flexibility, fracture resistance and cutting efficiency of the HyFlex EDM make it possible to reduce the number of filesrequired for cleaning while preserving anatomy .
4. Pre Sterilized Modular System- Provided as a modular system of sterile instruments, HyFlex EDM includes Shaping, Glidepath, OneFile, Orifice Opener andFinishing files and may be used in combination with HyFlex CM files.

Advantages of HyFlex EDM files

1. Cyclic fatigue

Cyclic flexural fatigue is an inevitable consequence of all metals as they continuously rotate freely in a curved trajectory generating tension/compression cycles at the point of maximum flexure.The cross-sectional design has been widely shown to influence the fatigue life of many NiTi rotary systems: larger instruments undergo fracture in less time under cyclic stress than smaller ones. Cutting angles defined by the instrument cross-sectional design, the angle and radius of canal curvature, and the size and taper of the instruments strongly affect the instrument's mechanical properties(6). Moreover, it should be mentioned that the accumulation of cyclic bending fatigue, even if not to fracture, can influence the torsional static resistance of the instrument at a certain point.

2. Torsional fatigue

Torsional fracture occurs when an instrument tip or another part of the instrument is locked in a canal while the shank continues to rotate. When the elastic limit of the metal is exceeded by the torque exerted by the handpiece, fracture of the apical part becomes inevitable(7).In clinical practice, torque-controlled endodontic motors are widely used to reduce NiTi instrument fracture during root canal therapy. During shaping procedures, rotary instruments might lock or screw into canals and be subjected to high levels of stress(8). So, if a torque-controlled motor is loaded right up to the instrument-specific torque, the motor stops momentarily and starts rotating counter-clockwise (auto-reverse function) to disengage the locked instrument(9) These safety mechanisms were developed to reduce the risk of instrument fracture.

3. Off-centred NiTi instruments and minimally invasive approaches

In recent years, the diffusion of minimally invasive approaches in all the fields of dentistry, including endodontics, has increased the need for less invasive instrumentation tools (Figures 2a–2c and 3)(10). The introduction of instruments with off-centred rotation was developed to reduce the mass of metal, increase the flexibility and optimize the torsional engagement of rotary NiTi instruments, while still maintaining the same preparation size of a classic endodontic instrument rotating around its centre of mass(11&12)). The torsional stresses developed by off-centred instruments compared to regular NiTi instruments with a centred axis of rotation is more regular, thereby reducing the risk of fracture and the torque developed by the instrument during cutting in the root canal(13)) This concept has evolved toward the possibility of instruments that can clean and shape root canals, while limiting the removal of dentine as much as possible. Using off-centred cross-sections together with heat-treated alloys and the specific feature of shape memory, new geometric designs of endodontic instruments have been introduced that are able to change their shape when inside the root canal at a specific temperature, so that they can clean the root canal walls without excessive removal of hard dental tissues for access (i.e., MaxWire, Martensite-Austenite-electropolish-fileX);(14)these types of instruments generally show low torsional stress and good patterns of stress distribution during their use. Such instruments can be used even after regular instrumentation as an adjunctive procedure for root canal disinfection and debridement(15).The trend of limiting the size of the root canal preparation and using high power irrigant agitation and activation devices is increasing in the endodontic field, however, it is still not completely clear whether these clinical techniques are as efficient as traditional cleaning and shaping techniques (Figures 4 and 5).

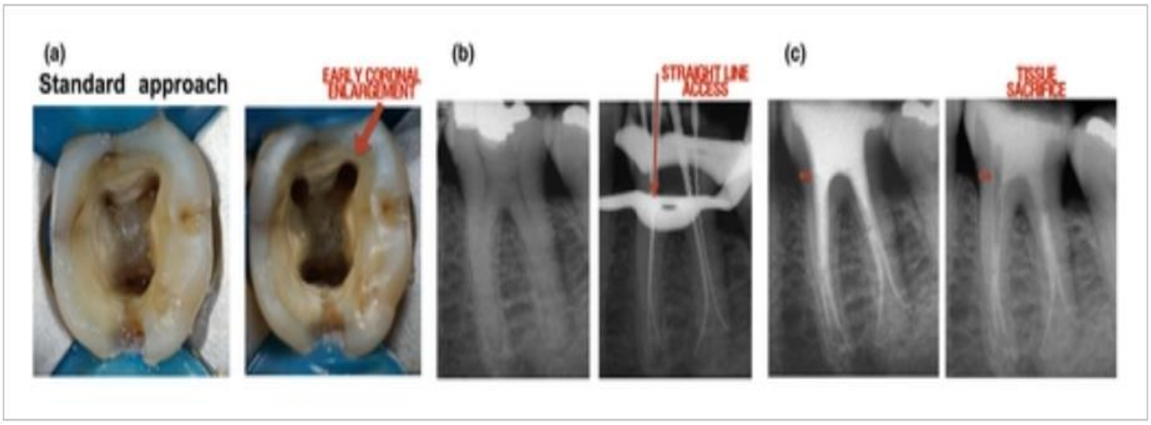

Fig. 2.(a) Standard approach in root canal instrumentation. Early coronal enlargement is achieved using an instrument with large taper or Gates Glidden burs in the early phase of the treatment. This pure crown-down approach reduces stress when approaching middle and apical thirds with smaller instruments. (b) Standard access cavity, early coronal enlargement and straight-line access that lines up the coronal and middle thirds and eliminates any stress in the coronal portion of the instrument; this type of approach is suggested for the use of stainless-steel instrumentation and old concept NiTi instruments manufactured in austenitic alloys, with less flexibility and lower cutting efficiency. (c) The standard crown-down approach reduces the thickness of dentine at the CEJ area where the complex tooth structure/restoration is subjected to higher mechanical stress, decreasing the amount of peri-cervical dentine.

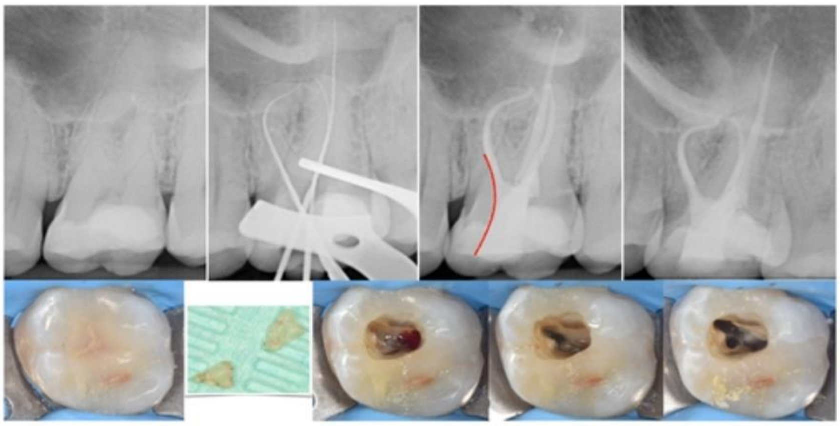

Fig. 3.Minimally invasive approach in root canal instrumentation using the single-length technique and martensitic NiTi instruments. The red line highlights the maintenance of as much peri-cervical dental hard tissue as possible without complete straight-line access from the cavity access to the middle third; in this approach, traditional early coronal enlargement is not performed and each instrument removes the amount of dental structure that is required to arrive to the working length. Note the extensive calcification in the pulp chamber with pulp stones and the increased diameter of the apical preparation that was required in this case to obtain good apical cleaning and sealing.

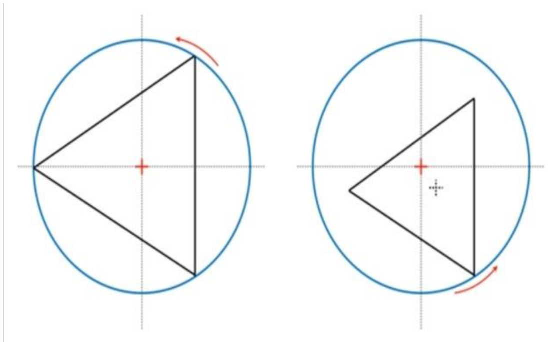

Fig. 4.Left side: illustration of standard instrument cross-section in which the centre of rotation of the instrument is located in the centre of mass. Right side: instrument with 'off-centred' rotation, the centre of mass of the cross-section does not coincide with the centre of rotation; this creates a wider preparation using less metal mass, increasing flexibility.

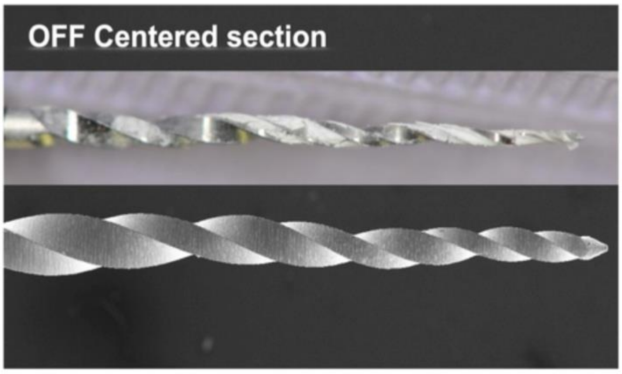

Fig. 5.SEM images of an off-centred NiTi instrument; top image after use. Note that the cutting action is not symmetrical along the length of the instrument, only the more 'external' blade touches and cuts the canal wall, thus creating less torsional binding in the root canal during use and safer action.

4. Cutting efficiency

Nowadays, manufacturers tend to increase NiTi cutting efficiency to reduce the possibility of the instrument locking inside the root canal(16). The improvement of the cutting efficiency leads to a reduction of the 'natural' torque levels, even if torque-controlled endodontic motors are still widely used in common endodontic practice especially for inexperienced clinicians. The understanding of the influence of the instrument design in terms of cross-sectional geometry,pitch length and flute angles, and tip design, has led to better efficiency in different clinical situations such as complex anatomy of the root canal, straight or curved root canals, primary treatments or retreatments (Figures 6 and 7). Regarding pitch length, increasing of the pitch reduces the tendency to screw in and the torsional load sharing(17). A constant pitch and flute angle leads to a greater retention of cutting debris in grooves, whereas the increase in the number of flutes and a decrease in the pitch improves the cutting efficiency, the bending stiffness and reduces the stress(18)

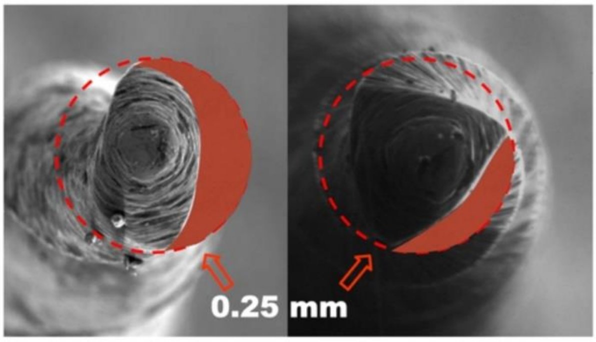

Fig. 6.2-blade (left) and 3-blade (right) cross-sectional designs with the same diameter. In the 2-blade design, there is less mass of metal, so less torsional strength but more flexibility and more space for debris removal and cutting efficiency. In the 3-blade design, there is higher torsional resistance, less flexibility, less fatigue resistance and cutting ability.

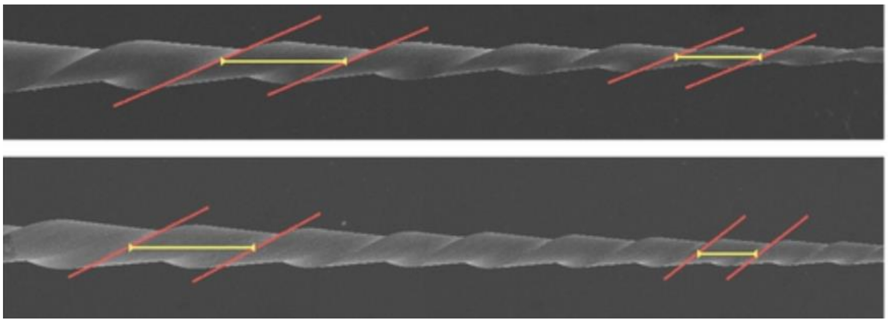

Fig. 7.SEM images of two NiTi instruments of similar size and taper but with different pitch lengths and corresponding flute angles; these two variables are strictly correlated, the shorter the pitch length (yellow line), the closer is the flute angle inclination (red line), which will change the clinical performance of the instruments, even if they have similar cross-sectional geometry and similar sizes. It is clear that in the top instrument the pitch length decreases from the coronal portion to the apical part to a lesser extent than in the instrument beneath it.

5. Reciprocating movement

Modern reciprocation is a combined movement characterized by a cutting phase in one direction of rotation followed immediately by a phase of engagement of the instrument in the opposite rotational movement(19) This kind of motion reduces the risk of torsional fracture, and reciprocating angles are different according to the instrument. The first cutting angle is always larger than the second one, generating a rotation effect that allows the instruments to advance inside the root canal(20). The kinematics of the movement by the operator's hand is different from the movement used for instruments in 360° rotation, where the apical pressure is limited, and the tendency is mainly to cut in backstroke movements and using brushing lateral pressure(21). Applying the concepts of modern reciprocating movements, it is possible to cut with the tip of the instrument even without a glide path and using a single instrument because of the features of the reciprocating movement, which decrease the risk of fracture when the instrument engages dentine thus decreasing the risk of fracture as compared with constant rotation NiTi sequences(22)

Moreover, resembling the dynamics of the Roane 'Balanced Force Technique',106 this kind of reciprocating kinematic, and the application of vertical strokes by the clinician cutting mainly with the tip of the instrument in down-strokes, produces a more centred preparation than a series of rotary instruments used with conventional kinematics (Figure 8a & 8b).

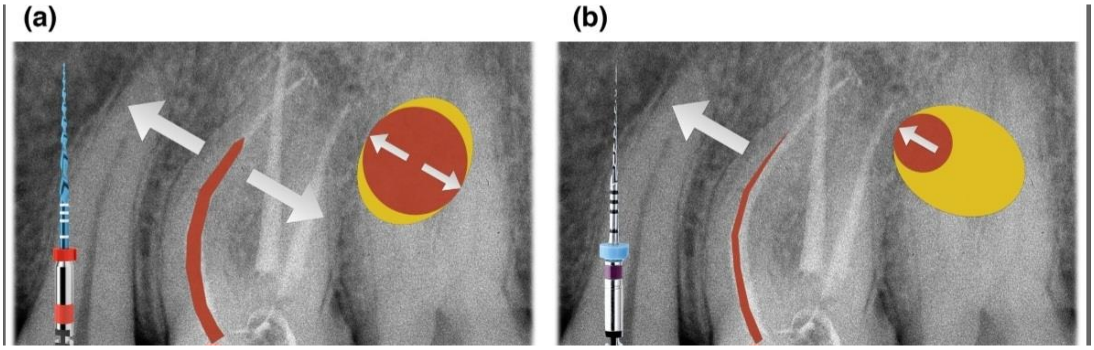

Fig.8.(a) Instrument working in a curved root canal that is smaller than its size using 'pecking' action and cutting with the tip blades; in this kinematic, the instrument will be self-centred in the root canal cutting the same amount of dentine in the inner and outer parts of the curve, resembling the balanced force technique by Roane using stainless-steel files. (b) Instrument working in a curved root canal that is larger than its size using brushing action and outstroke lateral active cutting of the blades; in this kinematic, the instrument will lean only on the external part of the curvature possibly determining the removal of dentine not centred with the original anatomical path and possibly leading to root canal transportation.

CONCLUSION

As outdated systems are replaced, new endodontic file systems for root canal instrumentation are introduced. The most reliable design elements from the past are still used in a safest, most effective way, together with the most recent technical developments. The endodontic file industry has undergone a revolution, owing toNiTi's super-elastic and shape-memory capabilities. The introduction of NiTi mechanical instruments dramatically changed clinical endodontics; the possibility of an alloy that can replicate its own dimensions to an ideal average root canal shape due to its specific mechanical properties revolutionised the basic principles of root canal instrumentation.the HYFLEX EDM rotary file may be a good alternative for biomechanical preparation of the root canal system.

REFERENCE

1. Dablanca-Blanco AB, Castelo-Baz P, Miguéns-Vila R, Álvarez-Novoa P, Martín-Biedma B. Endodontic rotary files, What should an endodontist know? Medicina 2022;58(6):719.
2. Thompson SA. An overview of nickel–titaniumalloys used in dentistry. Int Endod J 2000;33(4):297-310.
3. Gavini G, Santos MD, Caldeira CL, Machado ME, Freire LG, Iglecias EF, et al. Nickel–titanium instruments in endodontics: a concise review of the state of the art. Braz Oral Res 2018;32:e67.
4. Hou XM, Yahata Y, Hayashi Y, Ebihara A, Hanawa T, Suda H. Phase transformation behaviour and bending property of twisted nickel–titanium endodontic instruments. Int Endod J 2011;44(3):253-8.
5. Root Canal Shaping by Single-File Systems and Rotary Instruments: a Laboratory Study Khaly Bane, Babacar Faye, Mouhamed Sarr, Seydina O Niang, DioumaNdiaye,a and Pierre Machtou Iran Endod J. 2015; 10(2):135-139. Published online 2015 Mar 18.
6. Design Features Of Rotary Instruments In Endodontics Zarna Sanghvi, Kunjal Mistry The Journal of Ahmedabad Dental College and Hospital; 2011; 2(1)
7. Kim JY, Shun-Pan Cheung G, Park SH, Ko DC, Kim JW, Kim HC. Effect from cyclic fatigue of nickel-titanium rotary files on torsional resistance. J Endod 2012; 38: 527–530.
8. Gambarini G. Cyclic fatigue of nickel-titanium rotary instruments after clinical use with low- and high-torque endodontic motors. J Endod 2001;
9. Gambarini G. Advantages and disadvantages of new torque-controlled endodontic motors and low-torque NiTi rotary instrumentation. AustEndod J
10. Roda-Casanova V, Pérez-González A, Zubizarreta-Macho A, Faus-Matoses V. Influence of Cross-Section and Pitch on the Mechanical Response of NiTi Endodontic Files under Bending and Torsional Conditions—A Finite Element Analysis. J Clin Med 2022; 11: 2642.
11. .Ha JH, Kwak SW, Versluis A, Lee CJ, Park SH, Kim HC. The geometric effect of an off-centered cross-section on nickel–titanium rotary instruments: A finite element analysis study. J Dent Sci 2017; 12: 173–178.
12. Martins SCS, Garcia PR, Viana ACD, Buono VTL, Santos LA. Off-Centered geometry and influence on NiTi endodontic file performance evaluated by finite element analysis. J Mater Eng Perform 2020; 29: 2095–2102.
13. Arias A, Singh R, Peters OA. Torque and force induced by ProTaper universal and ProTaper next during shaping of large and small root canals in extracted teeth. J Endod 2014; 40: 973–976.
14. Zhang Q, Gu J, Shen J, Ma M, Wei X. Apically extruded debris, canal transportation and shaping ability of nickel-titanium instruments on contracted endodontic cavities in molar teeth. J Oral Sci 2023; 3: 203–208
15. Loyola-Fonseca SC, Campello AF, Rodrigues CR, Provenzano JC, Siqueira Junior JF, Rocas IF. Disinfection and shaping of Vertucci class II root canals after preparation with two instrument systems and supplementary ultrasonic activation of sodium hypochlorite. J Endod 2023; 49: 1183–1190.
16. Martins JNR, Silva EJNL, Marques D, et al. Characterization of four heat-treated reciprocating instruments: Design, metallurgy, mechanical performance, and irrigation flow patterns. Int Endod J 2023; 56: 1412–1428.

17. Gavini G, dos Santos M, Caldeira CL, et al. Nickel–titanium instruments in endodontics: a concise review of the state of the art. Braz Oral Res 2018; 32:e67.
18. Diemer F, Calas P. Effect of pitch length on the behavior of rotary triple helix root canal instruments. J Endod 2004; 30: 716–718.
19. Plotino G, Nagendrababu V, Bukiet F, et al. Influence of negotiation, glide path, and preflaring procedures on root canal shaping—terminology, basic concepts, and a systematic review. J Endod 2020; 46: 707–729.
20. Plotino G, Grande NM, Sorci E, Malagnino VA, Somma F. Influence of a brushing working motion on the fatigue life of NiTi rotary instruments. Int Endod J 2007; 40: 45–51.
21. Peters OA, Paque F. Current developments in rotary root canal instrument technology and clinical use: a review. Quintessence Int (Berl) 2010; 41: 479–488.
22. Malentacca ALF. Rotazionealternatanell'usodeglistrumenti in nichel-titanio. G Ital Endod 2002; 16: 79–84.