CLINICAL TECHNIQUE

A Novel Root Canal Preparation Technique Hybridizing Heat-treated Nickel-Titanium Rotary Instruments

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Abstract

Aim: This study aimed to assess the potential of the hybrid heat treatment (HHT) technique for shaping severely curved canals.

Background: This innovative HHT technique combines the use of both Ni-Ti austenitic and martensitic Ni-Ti files, with a simplified sequence, to properly utilize the different files' properties.

Case description: The operative technique started with canal scouting and determination of working length using a size 10 SS K-file. Then, a specific sequence was applied using the F1 20.06v Ni-Ti austenitic file (EdgeTaper) for the preparation of the coronal and middle parts of the canal. This step was followed by S2 20.04 and F1 20.06v martensitic Ni-Ti files (EdgeTaper Platinum) to enlarge the canal until the apex reached. No intracanal breakage of any instruments or deformation of flutes was recorded.

Conclusion: The present study describes a new HHT technique aiming at simplifying procedures and taking most of the different characteristics of the different heat treatment; the clinical cases seem to show its potentialities in terms of safety, speediness, effectiveness, and preservation of original anatomy.

Clinical significance: The cases show the advantages of the newly proposed technique over a traditional approach to properly shape complex anatomies with only a few Ni-Ti rotary instruments number.

Keywords: Endodontics, Hybrid heat treatment, Ni-Ti rotary instruments, Root canal treatment.

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Background

The introduction of nickel-titanium (Ni-Ti) has improved the simplicity and efficacy of root canal treatment (RCT).[1] Despite the rotary instruments are currently spread worldwide, there is no agreement on the "how to use" of these files, in terms of motions, sequences, and operators' related factors. The three most common approaches are derived from the stainless steel (SS) files techniques: "Step-back", "Step-down", and "Crown-down".[2–5] These techniques influenced deeply the use of Ni-Ti rotary instruments (NTRI) since the same concepts thought to be used with manual SS files were applied to Ni-Ti files with different rotational speed, different cutting efficiency, and different stress resistance. In the last decades, many improvements have been proposed with minimally invasive approaches, for both access cavity design and instrumentation.[6,7] Moreover, several techniques have been proposed where the influence of SS files was reduced or, in a few cases, completely dismissed.[8–11] Although the approach proposed were several, there is currently agreement only on some basic principles of root canal instrumentation; to understand the differences in the Ni-Ti rotary files characteristics, and perform efficient and safe instrumentation techniques, capable of both avoiding instruments separation and iatrogenic errors during the shaping procedure.[8–11]

The technique studied in this manuscript starts from these well-known advantages. Indeed, it is based on the following points:

Working in vs Working out

The inward motion is the dangerous one, the outward motion (usually called "brushing") is safer, and can be used to flare, enlarge canal diameters and touch more canal walls. Its safety allows enhancing efficiency, by increasing the rotational speed during the brushing motion.[12,13]

Strict Crown-down Approach

Dividing the canal into different segments allows to divide instrumentation stress and avoid over engagement. It can also allow safer instrumentation in complex/double curvatures. Ideally, no files must be inserted in apical curvature if the coronal and middle curvature of the canal has not been properly enlarged.

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Rationally Invasive Endodontic

The invasive endodontic is not only limited to the access cavity but also the root canal shaping, mainly in the coronal third. Selective coronal enlargement allows canal modification to facilitate the progression of rotary files and thus avoiding canal transportation and other iatrogenic errors.

Limiting the Use of SS Manual Files

The SS K-file should be used only for the patency check and the working length (WL) determination because their cutting tips and inherent rigidity may produce iatrogenic errors, such as canal transportation, ledging, and apical perforation.[14,15]

Hybridization

The NTRI currently available can be differentiated into two types related to different crystal phases at room temperature: the superelastic austenitic ones and the newer controlled-memory martensitic one. Typically, manufacturers suggest the use of a sequence made by the same type of instruments, and the clinicians' choice is between the two types. In many cases, despite the different properties, suggested operative parameters are very similar or identical. However, it was demonstrated that different heat treatments significantly influenced the flexibility and strength of the Ni-Ti instruments.

In the present study, a new instrumentation technique is proposed, the so-called hybrid heat treatment (HHT) technique, following the above-mentioned criteria and aiming at making the most of each file's characteristic. Moreover, four different RCTs have been performed using this technique (Figs 1 to 3). This innovative HHT technique combines the use of both Ni-Ti austenitic (EdgeTaper, EdgeEndo, Albuquerque, NM, USA) and martensitic NI-Ti files (EdgeTaper Platinum, EdgeEndo, Albuquerque, NM, USA), with a simplified sequence, to properly utilize the different files' properties rationally.

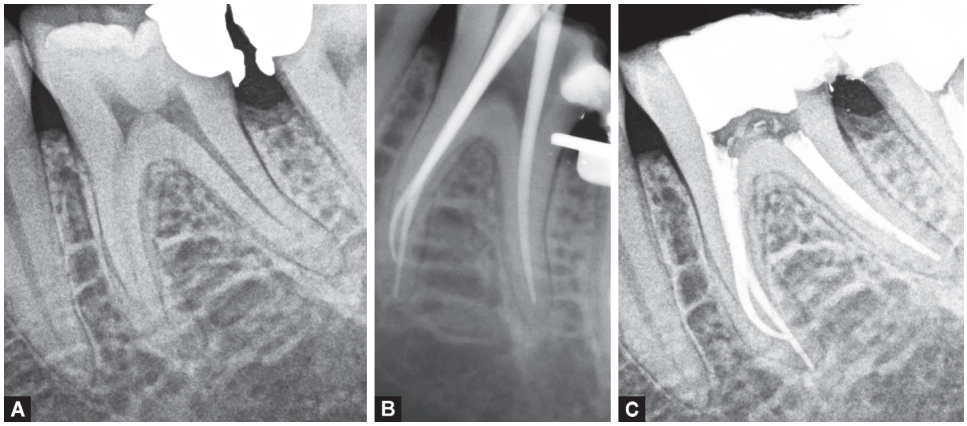
Case Description

- Hybrid heat treatment technique started initially with canal scouting and determination of WL using a size 10 SS K-file. The following steps were performed using F1 Ni-Ti austenitic (EdgeTaper), S2 20.04, and F1 20.06v martensitic NI-Ti files (EdgeTaperPlatinum):
- F1 Austenitic manually inserted and activated inside the canal with a high-speed low torque outward motion (400 Rpm, 1.5 Ncm).
- Repeat step 1 going each time more and more apical until the middle and coronal part of the canal was shaped.
- Manual 10 SS K-file for WL determination.
- Manual insertion of S2 20.04 then F1 20.06 v Martensitic, activation and light pecking motion to enlarge the canal until the apex was reached.

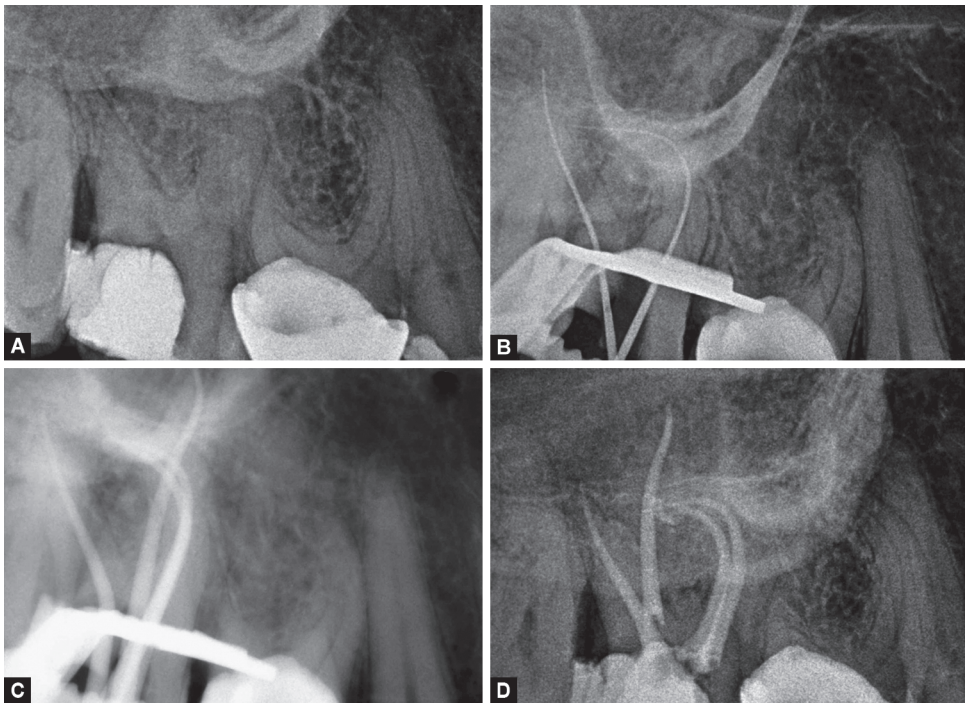
All the presented cases describe endodontic treatment in permanent adult teeth. All patients were between 25 years and 45 years old. The consent was obtained for the publication of the data without identification marks. After radiographic examination and oral examination, anesthetization, isolation, and access were then performed. All canals were prepared using the above-descripted technique, using single-use files, and the irrigation was performed using 5% NaOCl, 17% EDTA, and saline water each time an instrument was removed from the root canal system. All the RCTs were performed in a single visit under an operative microscope by the same operator. Following instrumentation, root canal obturation was performed, while restorations were performed after 2 weeks.

Case 1

This case was referred for the endodontic treatment of tooth #36 (Fig. 1A). The diagnosis was irreversible pulpitis. After anesthesia and rubber dam placement, pre-endodontic restoration was performed followed by access cavity preparation. The lower molar can have complex anatomy characterized by hidden curvatures in the mesial canals. After scouting and WL determination with K-file #10, the coronal and middle part of the canal was prepared with austenitic file F1 EdgeTaper. The WL determination was performed using an electronic apex locator (Morita, Osaka, Japan). This step was repeated four times, each time more and more apical, until the middle and coronal part of the canal was shaped. The apical part was then prepared with S2 and F1 martensitic files EdgeTaper Platinum till the WL, at a speed of 300 rpm and a torque of 3.0, with a light pecking motion to enlarge the canal until the apex was reached. The enlargement of the coronal 2/3 of the canal allowed the martensitic file to easily reach the WL (Fig. 1B). Endovac (Kerr, Brea, CA, USA) was used for irrigation during shaping and final irrigation. Solutions were then activated with Endoactivator



Figs 1A to C: (A) Preoperative radiograph of tooth #36; (B) Master cone radiograph showing important curvature in the mesiolingual; (C) Postoperative radiograph



Figs 2A to D: (A) Preoperative radiograph of tooth #17; (B) K-file was introduced till the working length showing extreme curvature; (C) Master cone radiograph showing two separate canals in the mesial root; (D) Postoperative radiograph

(Dentsply Sirona, Charlotte, NC, USA) for a total of 1 minute in each canal. The obturation was made using warm vertical compaction using medium gutta-percha cones (Fig. 1C).

Case 2

The patient was referred to the clinic for the treatment of an upper second molar (Fig. 2A). Access cavity was previously opened by the practitioner and the treatment was stopped because canals could not be localized. After anesthesia and isolation, the access cavity was modified and canals were localized under a microscope. Both mesial canals were calcified and presented a very severe radiographic curvature, >30° following Pruett's criteria (Fig. 2B). Therefore, the preparation was done using the above-described hybrid technique using the same irrigation protocol with EndoVac. The file was inserted inside the canal passively with an outward motion. The engagement of the files was over 2 mm and the flutes were cleaned using sterile compress between every step. No instruments separated during the shaping procedure and no sign of distortion was seen on the instrument surface neither using a stereomicroscope at 20×. The final irrigation was done using sodium hypochlorite, EDTA, and saline water. The solutions were activated using Endoactivator for 1 minute in each canal. The chosen obturation technique for this case was the single cone with a bioceramic sealer BC Sealer (Brasseler, Savannah, GA, USA) mainly because of the important length of the canals (25 mm) and severity of the curvatures in the mesial canals (Figs 2C and D).

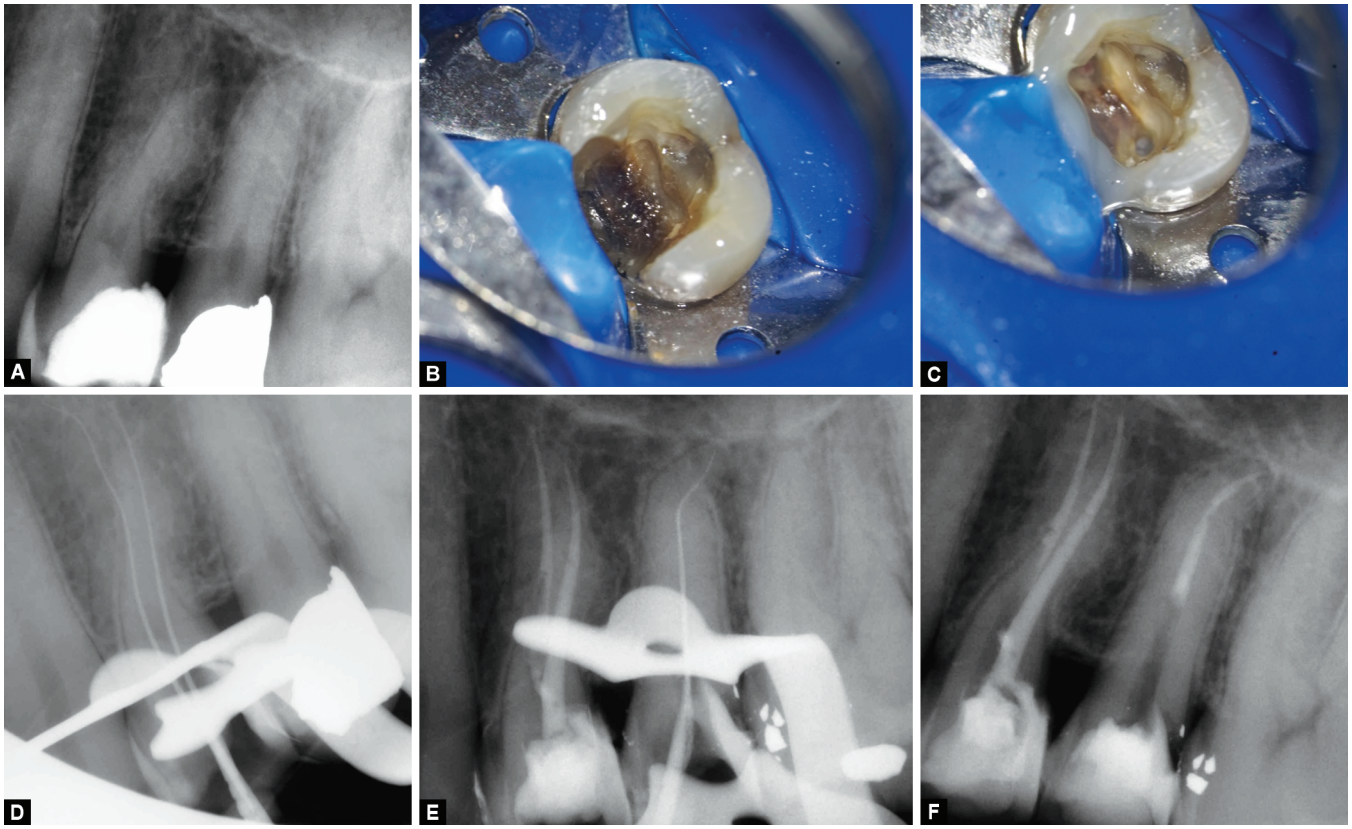
Case 3

The patient was referred to the clinic for the treatment of teeth #24 and #25 (Fig. 3A). On preoperative X-ray, both teeth presented important calcifications associated with severe curvatures. The treatment of both teeth was done in one session, one tooth after the other. The same protocol was followed for both premolars. After anesthesia and isolation, an access cavity was performed followed by pre-endodontic restoration (Figs 3B and C). WL was determined using a K-file #10 (Figs 3D and E) then preparation of the canals was done using a hybrid technique using F1 austenitic file in the coronal and middle part of the canals followed by the martensitic files S2 and F1 in the apical part until the WL was reached. Files were introduced in the canal in a slow in and small outward motion inside the canal with different speeds and torque as described previously. Between every step, files were pulled out of the canal to clean the flutes, and the canal was rinsed with sodium hypochlorite. The obturation was made using warm vertical compaction using medium gutta-percha calibrated in apical size (Fig. 3F).

Discussion

The cases showed the advantages of the newly proposed technique: the capability of the HHT technique to properly shape complex anatomies with only a few Ni-Ti rotary instruments number is easily recognizable in the postoperative X-rays (Figs 1 to 3). The postoperative X-ray images show the quality of the performed shaping, displaying a uniform path from the canal orifice to the apical foramen, properly filled by the sealer and the gutta-percha. The new technique was designed to provide a very simple and rapid approach without negatively affecting safety also in complex cases. Moreover, the proposed technique was thought to exalt the austenitic and martensitic properties of Ni-Ti rotary files.

A major feature of the HHT technique was the minimal use of manual SS K-file and the lack of glide-path Ni-Ti Rotary files. The risk of iatrogenic errors while using K-file could be often evidenced in literature: ledging, zipping, and apical blockage can also occur when medium/small K-files are used, due to the files' cutting tips.[14,15] In



Figs 3A to F: (A) Preoperative radiograph of teeth #24 and #25; (B) Photo of the tooth after the removal of the ancient restoration, and access cavity preparation (C) highlighting important calcifications; (D and E) Preoperative radiograph with K-file reaching working length; (F) Postoperative radiograph

canals with severe curvatures, canal and apical transportation may also occur, due to files' stiffness. The SS files in a curved canal, widely used in the traditional endodontic approach, tend to return to a straight position due to elastic memory. This increases the risk of transport or ledge a canal, especially with a large file.[14,15] Moreover, the numerous steps in the hand files are associated with a higher incidence of errors and it is a time-consuming procedure.[14,15] The clinical use of only one and small size hand file (10 K-file) reduces the above-mentioned risks.

The second major feature is the hybridization of differently heat-treated instruments. Martensitic files undergo thermo-mechanical treatment leading to the loss of the rebound effect after unload. This special characteristic improves the shape memory effect and increases resistance. On the other hand, Ni-Ti alloy in a martensitic state is soft, and ductile and presents a decreased microhardness and a lower cutting efficiency when compared with austenitic files.

Clinically, the increase in cyclic fatigue resistance and material flexibility of heat-treated files allow the preparation of curved canals with a reduced risk of canal transportation.[16,17] Moreover, also reduce the instrument separation risk when compared with austenitic files.[18] However, the use of the austenitic instruments was required for the selective coronal enlargement where the superelastic property and the rigidity of the file are an advantage. After coronal flaring with the austenitic file, a martensitic rotary file was used to correctly address the apical anatomy of the root canal system. The use of an instrument more flexible and more resistant to flexural stress in complex curvature was found to be beneficial, both in terms of simplicity of use and efficacy. Therefore, this hybridization allowed a safe coronal enlargement that ensured easier progression, minimizing the blade engagement of fewer cutting files, avoiding canal transportation and other iatrogenic errors during instrumentation. The comparison between preoperative and postoperative X-rays shows both the safe coronal enlargement and the apical anatomy respect. The coronal flaring was always performed in the opposite direction from the danger zone of the furcation (Figs 1 to 3). The apical third of the root anatomy, in the postoperative X-ray, is quite superimposable to the preoperative image, demonstrating the respect of the original canal trajectory (Figs 1 to 3). The above-mentioned characteristics differentiate the proposed technique from the traditional approach, which expects the use of either austenitic or martensitic files. In this way, the Ni-Ti files will not enhance their characteristics.

The third major feature of the use of different shaping techniques for the different instruments, to exalt their characteristics. The martensitic instruments were used more traditionally, with a light pecking motion and in steps, by advancing only 1–2 mm to avoid over engagement. On the contrary, the austenitic instrument, more rigid but more efficient in cutting, was used mainly in an outward motion. The use of F1 in an outward motion allowed to create proper coronal taper, without the use of orifice openers. Moreover, outward motion is safer than inward motion, allowing not only to simplify the sequence but also to perform coronal shaping with no iatrogenic errors.[12,13] During each step, the coronal flaring previously performed allowed the instrument to be always manually inserted slightly more apically than the previous step, gaining at least 1 mm each step. All these steps allowed to safely enlarge the coronal and

middle part of the canal. The use mentioned above is safe not only for the lack of debris pushed in an apical direction but overall, for the frequent irrigation that it requires. Indeed, each time the instrument is removed from the canal system, the operator irrigated the root canal leading to a proper time dedicated to the irrigation technique.

Conclusion

Despite several "single file technique" has been proposed in the last 10 years, most of them need to comply some abstruse conditions or to use a glide path file, losing the single file condition. In conclusion, the present study described a new HHT technique aiming at simplifying procedures and taking the most out of the different characteristics of the different heat treatments, showing a repeatable technique spendable in daily routine cases. The clinical cases showed their benefits in terms of safety, speediness, effectiveness, and preservation of original anatomy. Despite that, further studies with the largest sample and different operators are needed to deeper understand the potential and the controversial aspects of the proposed technique.

Clinical Significance

This technique demonstrates the potential of hybridizing Ni-Ti rotary instruments, enhancing the peculiar properties of the austenitic and martensitic phases. Despite double-blind studies with a larger sample are still needed to definitively prove the increased effectiveness of the proposed technique, it seems potential especially for a less experienced operator, who can decrease the operative time and the intracanal separation risk of the RCT.

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