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PathFiles: A New Rotary Nickel-Titanium Instrument for Mechanical Glide Path and Preflaring

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Abstract

NiTi instrument separation is a serious concern in endodontic therapy. The analysis of NiTi files after torsional fracture reveals that the majority of torsional separations occur in the last mm. of the files and in the files with lower taper and/or diameter. Consequentely, the tip of the smaller files presents the higher risk of torsional fracture and should be protected using low torque motors, reducing axial pressure and avoiding the tip from engaging root dentin ("taper lock"). In contrast, flexural fractures occur after repeated subthreshold loads have led to metal fatigue. Numerous studies evaluated the causes of stress and separation of rotary NiTi files concluding that a significant reduction of rotary instrument separation could be obtained when use of rotary file was anticipated by an initial manual preflaring and glide path. A strong evidence supports the importance of manual preflaring and glide path to reduce the frequency of rotary file separation. The initial preflaring and glide-path are normally carried out using stainless steel hand files. Unfortunately these files presents several drawbacks because of their relative stiffness and aggressive tip that in curved and/or calcified canals can cause ledges or transportation. Consequently a new kit of three NiTi rotary instruments, the PathFiles (Dentsply Maillefer) has been recently introduced for mechanical glide path and preflaring.

The PathFile is the first instrument projected for and dedicated to mechanical glide path and preflaring. The low .02 taper, the robust square cross section and the four cutting angles create a good combination of flexibility, strength and efficacy that allow a safe and fast use even in severely curved and/or calcified canals. Preliminary investigation and clinical evaluations confirmed that PathFiles represent a significant help when shaping severely curved canals allowing the creation of a smooth glide path without transportation even in case of procedural errors (short or long working length determination).

Introduction

The use of Nickel-Titanium rotary files has changed radically the root canal instrumentation techniques and the prognosis of endodontic complex cases. Many "in vitro"(1-13) and "in vivo"(14-17) investigations demonstrate that rotary NiTi instruments are superior to stainless-steel ones with regard to their shaping ability and can shape even severely curved canals with lower risk of ledging and straightening. In an "in vivo" study by Schäfer (16) 110 Canals were prepared by NiTi Rotary Files and 84 canals were prepared using hand instruments. All canals were shaped by eight experienced dentists. Preoperative and postoperative (after obturation) radiographs were taken of each tooth.

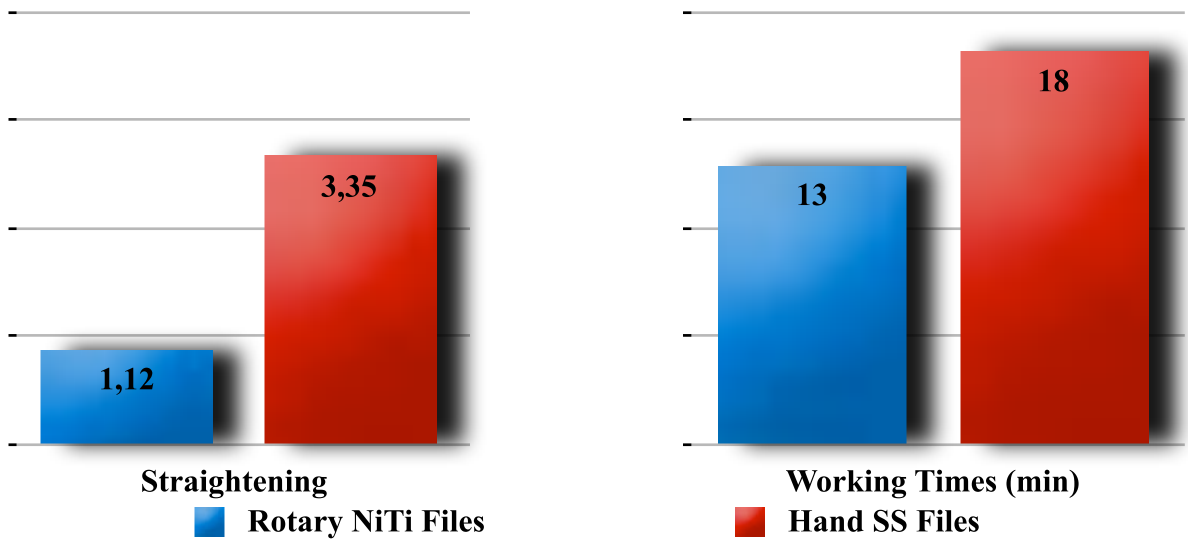

Fig.1: Risk of straightening and working times after "in vivo" root canal preparation using rotary NiTi and stainless steel files (from Schäfer et al.) (16).

Straightening of the canal curvatures was determined with a computer image analysis software. Preparation with NiTi Rotary Instruments resulted in significantly less straightening and a shorter preparation time compared with hand instrumentation (16) (Fig.1). In another "in vivo"study, Sonntag et al. (17) compared the risk of complications during root canal preparation with manual stainless steel files and rotary NiTi files. All cases were performed by students. The results demonstrated that even inexperienced operators achieved better canal preparation with NiTi files than with hand stainless steel files with significantly less zips and elbows (17). Unfortunately, the use of NiTi rotary files has a serious limitation since it is associated with a significantly higher risk of intracanal separation in comparison with stainless steel files (17,18). Suter et al evaluated "in vivo" the probability of successfully removing fractured instruments from root canals reporting a success rate of 87%. The analysis of the removed fragment confirmed that NiTi Rotary Instruments fractured with a significant higher rate than stainless steel hand instruments (18). Comparable results were reported by Sonntag et al. (16). NiTi instrument separation is a serious concern in endodontic therapy. Several studies evaluated the influence of various factors on the fracture of nickel titanium (NiTi) endodontic rotary instruments and demonstrated that file separation mainly are caused by torsional (19-25) and fatigue stresses (21,23,26-28). Torsional stresses depend on the size of the contact area between root-canal dentin and the instrument, taper and diameter of the instrument, portion of the instrument subjected to torsion, intrinsic strength (cross sectional design) of the instrument, blade design and torsional forces applied to the instrument (27,28). The analysis of the NiTi files after torsional fracture reveals that the majority of torsional separations occurrs in the last mm. of the files and in the files with lower taper and/or diameter (24,25,27,28). Consequentely, the tip of the smaller files presents the higher risk of torsional fracture and should be protected using low torque motors, reducing axial pressure and avoiding the tip from engaging root dentin ("taper lock") (27,28). In contrast, flexural fractures occur after repeated subthreshold loads have led to metal fatigue.

Bending stresses depend on curvature angle and radius of the root canal, rotation speed and flexibility of the instrument, characteristics of NiTi alloy, presence of intracanal interferences and abrupt changes in the root canal trajectory (like in case of merging or accessory canals) (27,28). Numerous studies evaluated the causes of stress and separation of rotary NiTi files concluding that a significant reduction of rotary instrument separation could be obtained when use of rotary file was anticipated by an initial manual preflaring and glide path. A strong evidence supports the importance of manual preflaring and glide path to reduce the frequency of rotary file separation: Roland et al. (29) in a study on the effect of preflaring on the rates of separation for 0.04 taper nickel titanium rotary instruments concluded that "Pre-flaring with hand files followed by rotary instrumentation) allowed more uses before separation compared with the crown-down technique recommended by the manufacturer." Peters et al. (30) investigated physical parameters for ProTaper nickel-titanium rotary instruments whilst preparing curved canals in maxillary molars in vitro, concluding that "Whilst high forces were used in some cases, no ProTaper instrument fractured when a patent glide path was present.". Blum et al. (31) after an analysis of mechanical preparation in extracted teeth using ProTaper rotary instruments determined that "A precise protocol for canal preparation should emphasize using small flexible stainless steel hand files to create or verify that within any portion of a root canal there is sufficient space for rotary instruments to follow…". Berutti et al (32) evaluated the influence of manual preflaring and torque on failure rate of ProTaper rotary instruments. In this investigation the Authors used 400 plastic simulators divided into 2 groups. All simulators where shaped with ProTaper instruments, but in one group the use of rotary files was anticipated by a manual preflaring up to a manual file # 20. Results demonstrated that after manual preflaring ProTaper instruments could shape a significantly higher number of plastic simulatore before they separated (32) (Fig.2).

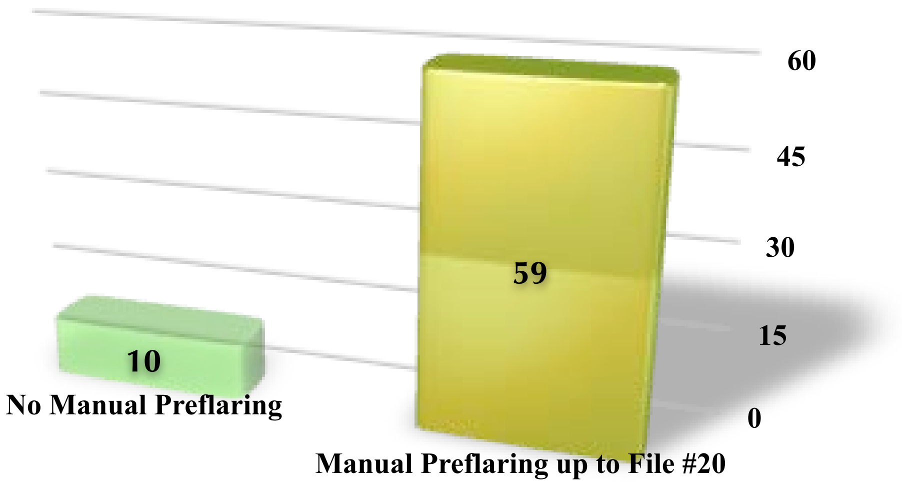

Fig.2. Number of plastic simulators shaped before ProTaper S1 breakage with or without manual preflaring up to File #20. From Berutti et al.(32)

Finally, Varela et al. (33) investigated the influence of manual preflaring on the separation rate of three different NiTi rotary files (ProFiles, ProTapers and K3) when used in curved canals of extracted teeth (curvature angle >30°). The authors demonstrated a significant reduction of the fracture rate when rotary files were used after manual preflaring. No significant differences among the three types of instruments resulted from this study (33). All the mentioned studies concluded that the favorable repercussions of manual preflaring and glide path mainly depend on a reduced risk of "taper lock" of the tip of the weaker files (28-33). Additionally, a reduction of flexure stresses should be considered to explain the lower rate of rotary file separations in curved canals whereas continuous glide path may help preventing the instrument tip file from dangerous bending. (28,30,32).

The initial preflaring and glide-path are normally carried out using stainless steel hand files. Unfortunately these files presents several drawbacks because of their relative stiffness and aggressive tip that in curved and/or calcified canals can cause ledges or transportation (34). Consequently a new kit of three NiTi rotary instruments, the PathFiles (Dentsply Maillefer) has been recently introduced for mechanical glide path and preflaring.

PathFile Features

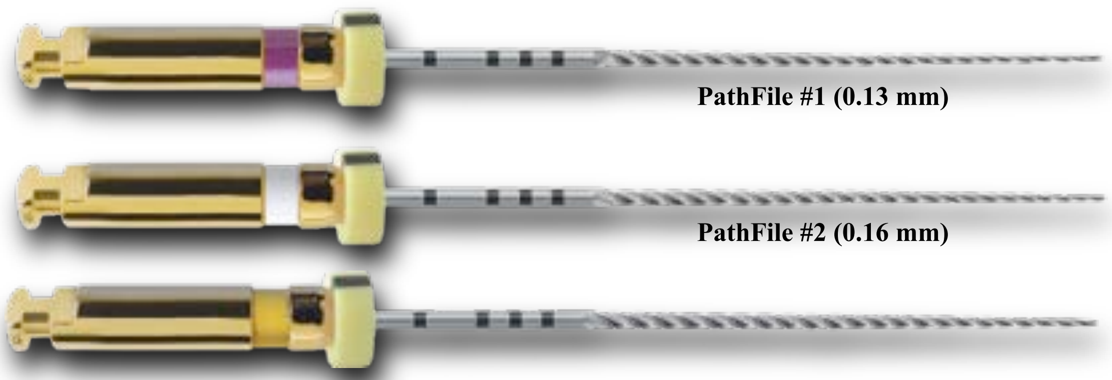

Fig.3: PathFiles #1-3 (Dentsply Maillefer).

The PathFiles consist of three rotary instruments with the following characteristics (Fig.3):

- Tip diameter: the tip diameter for the three PathFiles is 0.13, 0.16 and 0.19 mm, respectively. The gradual increase of the tip diameter (less than 30%) facilitate the progression of the files without need of using strong axial pressure.
- Tip design: The tip is rounded and not cutting to avoid ledging and zip.
- Cross section and cutting ability: PathFiles have a square cross section. This section is easy to manufacture with an essential design which has been used and thoroughly tested for a long time in hand files. This robust cross section increases the resistance of PathFiles to torsional stresses nevertheless their small diameter and taper. The four cutting angles increase the efficacy of PathFiles even in calcified and long canals.
- Pitch: The distance between two following blades has been optimize to increase the strength of the instruments.
- Flexibility: PathFiles are manufactured with a NiTi alloy. The flexibility is enhanced by the low .02 taper of the files that is also responsible of the high resistance of the PathFile to flexural stresses.

PathFile Instrumentation Sequence

The PathFile Instrumentation Sequence is very simple and can be can summarized in the following phases (Fig.4) :

1- Root canal scout and negotiation with a K-file#10 until it can move smoothly along the canal space. If necessary use a lubricant like an EDTA gel to accellerate this phase.

2- Working length determination with an electronic apex locator and/or radiograph .

3- PathFile #1 (0.13 mm) to the working length.

4- PathFile #2 (0.16 mm) to the working length.

5- PathFile #3 (0.19 mm) to the working length.

6- Start using rotary NiTi files as usual (in case of ProTapers start using S1).

All PathFiles must be utilized with a rotation speed of 300 rpm, a motor torque of approx. 5 N/cm and with delicate in/out movements until they reach the full length. Strong axial forces should be avoided. The use of a relative high motor torque is not dangerous considering the robust square section of the instrument and the results of a study of Berutti et al. (38) where the use of high torques allowed NiTi rotary instruments to shape significantly more canals before separation (38). The time needed to take the three PathFiles to the working lenght is normally very short and do not exceed 3-5 sec/file; longer working times are useless but not dangerous because the PathFiles, because of their high flexibility, do not cause transportation even in case of errors in the working length determination. Abundant irrigation after each instrument should be advisable although the PathFiles do not tend to accumulate debris and cause apical obstruction.

Fig.4: PathFile instrumentation sequence. Preoperative radiograph (4A). Working length determination for MB1 and Palatal canals (4B). Working length determination for MB2 and Distal canals (4C). Working length confirmation for MB1 and MB2 canals (4D). Master cone radiographs for MB1 and MB2 (4E) and for Distal and Palatal canals (4F). Postoperative radiograph (4G) and 1 year follow-up radiograph (4H).

Discussion

Many studies confirmed that a preflaring to a minimum size of 0,20 mm and a continuous glide path should be obtained before using rotary NiTi files (28-34). Preflaring reduces the risk of "taper lock" of the file tip whereas the glide path minimizes the bending stresses that can lead to fatigue failures. Until now preflaring and glide path have been obtained with manual .02 taper stainless steel files because proper NiTi files resulted too weak or ineffective. The PathFile is the first instrument projected for and dedicated to mechanical glide path and preflaring. The low .02 taper, the robust square cross section and the four cutting angles create a good combination of flexibility, strength and efficacy that allow a safe and fast use even in severely curved and/or calcified canals (34). Berutti et al (34) have recently compared the shaping ability of PathFiles and stainless stell K-files when used to preflare 200 plastic simulators with "S" shape canals. The simulators were divided into 4 groups and preflared to size 20 by one expert endodontist and by one student with limited experience. In the first phase of this study the authors evaluated the ability of Path File and stainless steel K-files to maintain the original canal anatomy (40). Results demonstrated that PathFiles maintained the original anatomy better than stainless steel manual files with significant lower % variations in curvature radius ($p<0.001$). No differences were observed between the two operators when PathFiles were used; indeed, the inexpert operator using the PathFiles could reach excellent results comparable to those obtained by the expert endodontist (Fig.5).

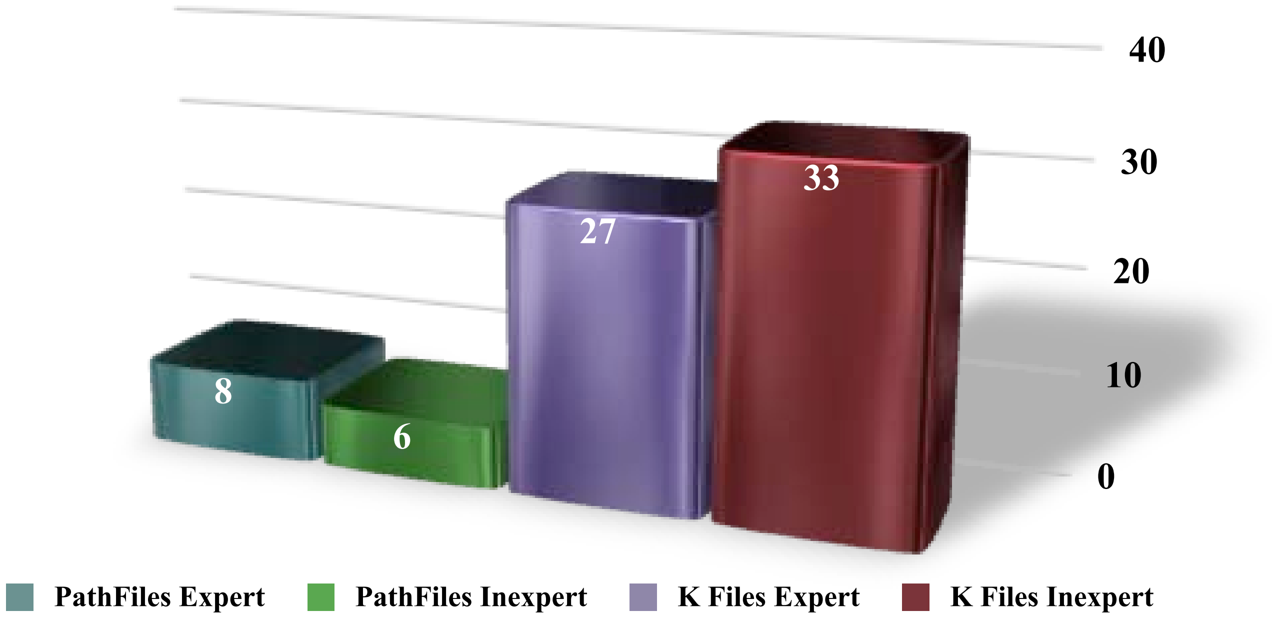

Fig.5: Percentage Variations of the radius of the apical curvature after using PathFiles and Stainless steel files. Best result in PathFiles groups when used by both expert and inexpert operator. From Berutti et al. (40).

Fig.6: Prevalence of canal aberrations (zip and ledges). SIgnificanf less aberrations in the PathFile groups (left) in comparison with the stainless steel file group (right). From Berutti et al. (40).

In the second phase of their study, Berutti et al (34) analyzed the prevalence of canal aberrations (zip and ledges) at the apical third reporting a significant higher prevalence of aberrations in stainless steel K Files groups ($p<0.001$) with a worse trend in the inexpert operator (Fig.6).

Finally, Berutti et al (34) assessed the working time needed to preflare in relation to instrument type and operator's expertise demonstrating significant lower working times in PathFiles groups ($p<0.001$) with no significant differences between the expert and inexpert operator ($p>0.05$) (Fig.7) .

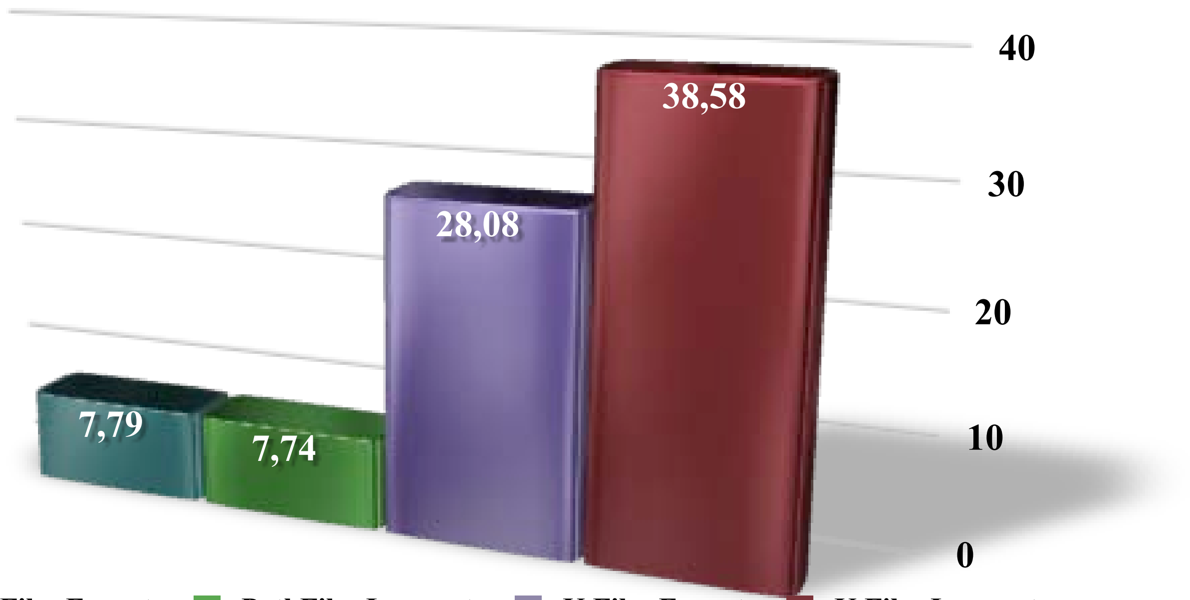

Fig.7: Working time in relation to instrument type and operator's expertise. Best results in the PathFile groups with no significant differences between expert and inexpert operators From Berutti et al. (40).

Fig.8 (A-D): Four clinical cases of maxillary and mandibular molars with severely curved canals where glide path and preflaring were obtained using the PathFiles

Summarizing the study of Berutti et al. (40) demonstrated that PathFiles can preflare and create glide path in significant less time and with reduced risk of complications (zip, ledge) in comparison with stainless steel K-files and that PathFiles allow less skilled clinicians to achieve results similar to those of more expert operators.

The results of Berutti's study correspond to preliminary clinical evaluations from dentists who tested the instruments for more than six months and confirmed that PathFiles constitute a significant help when shaping severely curved canals allowing the creation of a smooth glide path without transportation even in case of procedural errors (short or long working length determination) (Fig.8). If more clinical and research studies will confirm these preliminary results, no doubt that PathFile will represent an important advancement in the initial phases of the endodontic treatment.

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