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roots

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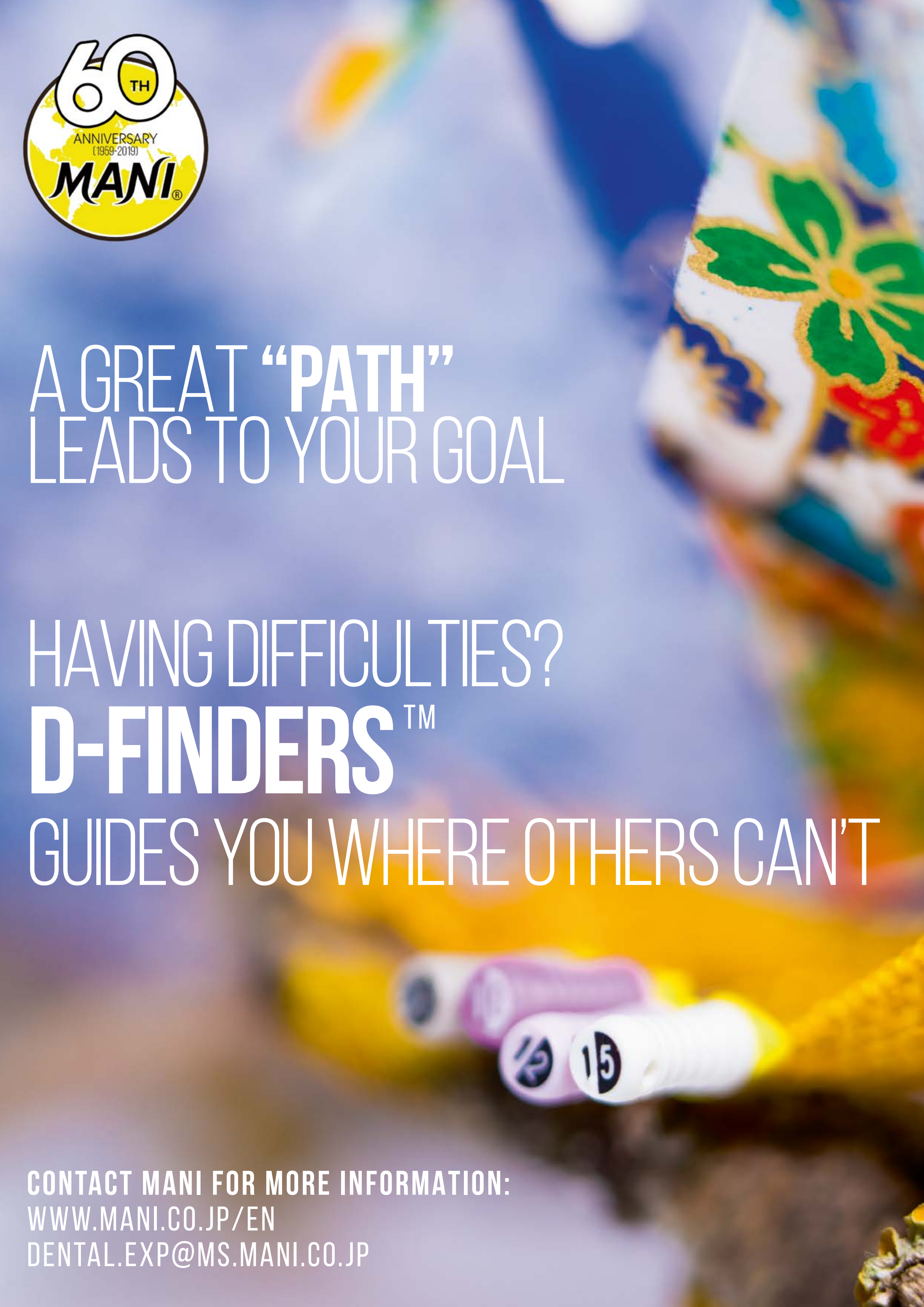
study
Torsional resistance of two nickel-titanium rotary instruments

materials
Clinical applications of mineral trioxide aggregate in endodontics

case report
Managing refractory endodontic disease with radial apical cleansing

dti] Dental Tribune International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Steve Jones

Guest Editor

Welcome to the winter issue of roots!

You are going to learn quite a bit about endodontics and enjoy this issue, which is full of excellent articles from several of the leading global endodontic speakers, including Prof. Gianluca Gambarini, who will be speaking at ROOTS SUMMIT in Prague in May 2020. You will also be treated to an interesting and clinically applicable article from Dr Antonis Chaniotis, whom we had the pleasure of learning from at ROOTS SUMMIT 2016 in Dubai. There is also a terrific article from a regular participant in our online forum, Dr Justin Kolnick. Other articles in the magazine follow the same theme in that they concern scientifically based, clinically relevant endodontics that will help you in your day-to-day practice.

As roots is the official magazine of ROOTS SUMMIT, you can expect to see more articles in subsequent issues from the people you know. We plan to feature and highlight the clinical work and academic research done by our speakers and members of the RootsEndo Facebook group. Our Facebook group has more than 28,000 members with a keen interest in endodontics, including most of the top endodontic lecturers and clinicians from around the world. Several of these members have already had articles included in various issues of roots, and we hope that they will continue to write more for us.

It has long been the feeling of the ROOTS SUMMIT committee, starting with our scientific director, Dr David E. Jaramillo, that there is a need for more places for scientific studies to be published and read. The publishers of roots agree. Starting with the next issue, Jaramillo will be publishing clinical abstracts in addition to articles by the clinicians and academics who will be on the programme at ROOTS SUMMIT. Participants who have submitted poster or case presentations will also be featured. We can all agree that there needs to be a place for this important contribution to the profession to be acknowledged, shared and absorbed.

ROOTS SUMMIT has long been acknowledged to have one of the more scientifically significant programmes in endodontics and we look forward to raising the scientific level even higher with roots.

In closing, I would like to add a few words that we hope will encourage you to consider attending our meeting. ROOTS SUMMIT is different from most other events in two ways. One, the speakers are chosen according to the theme of the programme at the entire discretion of ROOTS SUMMIT committee. The second major difference is that the lectures are held in one room, allowing all participants to enjoy the same programme. This often leads to some very lively discussions during the breaks and the evening social events. More information about our outstanding programme of hands-on workshops and extensive lecture programme can be viewed at www.roots-summit.com.

We look forward to you joining us in Prague at ROOTS SUMMIT 2020, which is going to be held from 21 to 24 May.

Steve Jones
Guest Editor

editorial

Welcome to the winter issue of roots! 03
Steve Jones

study

Torsional resistance of two nickel-titanium rotary instruments 06
Prof. Gianluca Gambarini

technique

Maximum curve control 08
Dr Antonis Chaniotis

materials

Clinical applications of mineral trioxide aggregate in endodontics 16
Drs Arnaldo Castellucci, Matteo Papaleoni & Francesca Cerutti

research

Effect of duration of Er,Cr:YSGG laser etching on dentine morphology
An *in vitro* study 22
Drs Farnaz Mahdisiar, Alireza Mirzaei, Alireza Fallah,
Saeedeh Akhoundan & Prof. Nobert Gutknecht

industry

SSP/SWEEPS endodontics with the SkyPulse Er:YAG laser 26
Dr Tomaž Ivanušič

case report

Managing refractory endodontic disease with radial apical cleansing 32
Dr Justin Kolnick

practice management

Successful communication in your daily practice
Part IX: Boosting a new employee's performance 38
Dr Anna Maria Yiannikos

feature

A visit to VDW, a true child of Munich 40

meetings

ROOTS SUMMIT 2020: Registration is now open 44

International events 46

about the publisher

submission guidelines 48

international imprint 50

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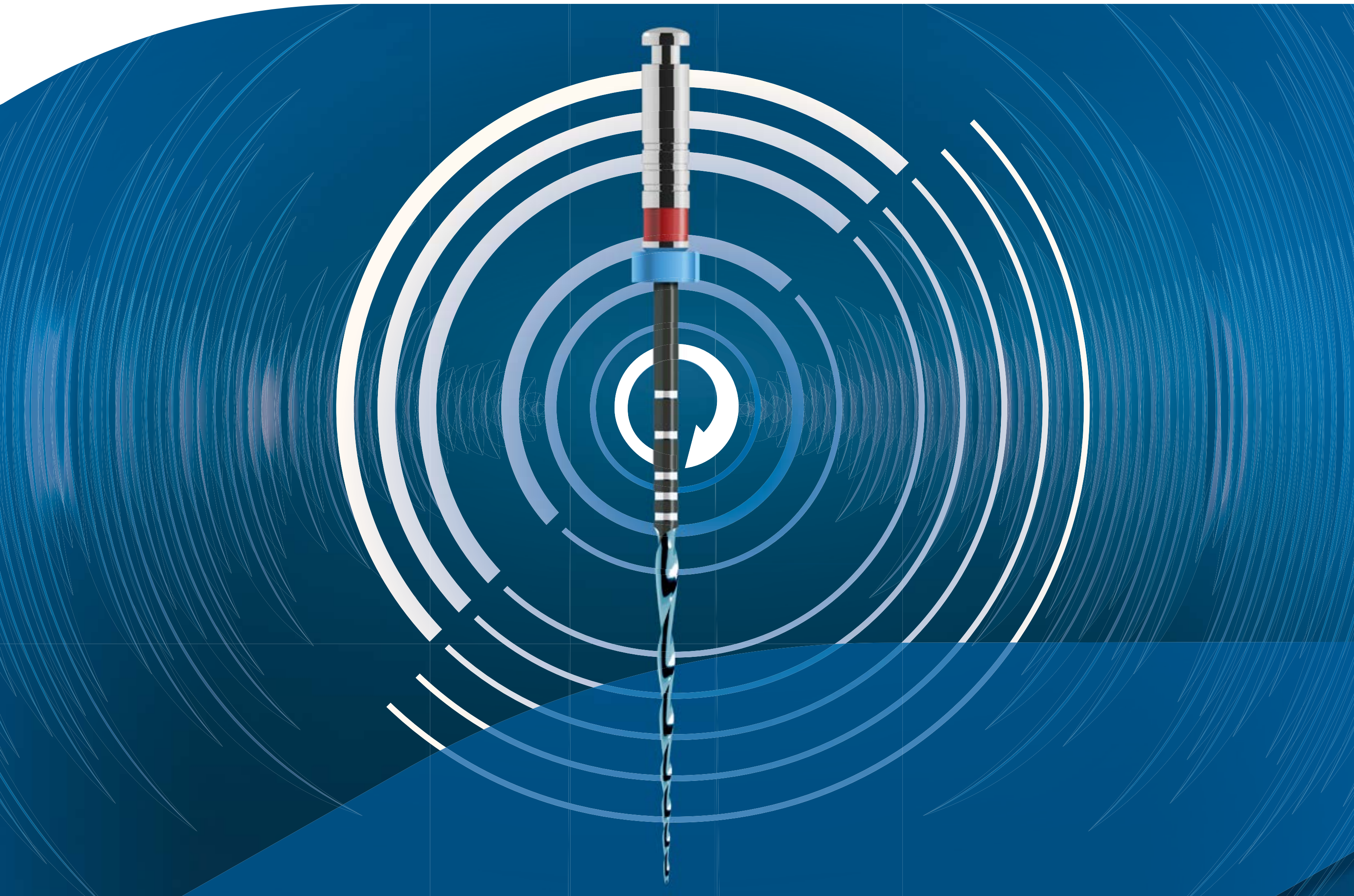

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Torsional resistance of two nickel-titanium rotary instruments: A comparative study

Prof. Gianluca Gambarini, Italy

Introduction

The main mechanisms of nickel-titanium (NiTi) endodontic instrument fracture have been revealed to be two modes of failure, one being torsional failure and the other cyclic fatigue. The former contributes to a significant proportion of failures.[1] Cyclic fatigue fracture is caused by repetitive compressive and tensile stresses on the outermost fibres of a file rotating in a curved root canal, and torsional failure occurs when the tip of the instrument binds to the canal wall, even in a straight root canal.[1]

Cyclic fatigue resistance of NiTi instruments has been assessed extensively.[2] In contrast, there is less information available on torsional fracture resistance tests.[3] The main method of testing for static rotational fracture is the comparison of the torsional resistance of the instruments as described by ISO 3630-1. According to this specification, the last 3 mm of the file tip must be fixed with brass and a rotational speed of 2 rpm applied to create a continuous torsional load until fracture occurs.[3]

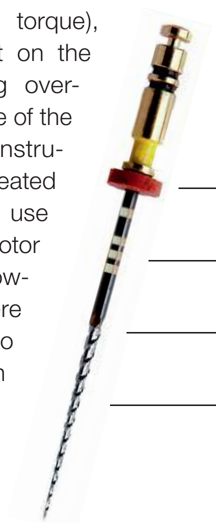
Torsional load can be limited during intra-canal rotary instrumentation by the torque-controlled endodontic motor: torque settings can be selected to prevent excessive torsional load on the instruments. It has been shown that the correct preset torque value for each instrument is very difficult to determine.[4] If too high (the same happens when the clinician applies maximum torque), safety becomes dependent on the clinician's skill in avoiding over-engagement and/or blockage of the file. If too low, the rotary instrument will be loaded by repeated locking and release through use of the torque-controlled motor or auto-reverse function. However, in narrow canals, where instruments are subject to higher torsional stresses than in wider canals, the chance of experiencing these repetitive torsional loads is increased.

To this point, torque value at failure according to the ISO test has not been commonly used to determine torque settings in torque-controlled motors. In most cases, values are higher than torque at failure. As a consequence, the concept that the use of a preset torque value is considered safe (i.e. capable of preventing shear fracture of the instrument) is not completely accurate. Therefore, NiTi rotary instruments should ideally exhibit good resistance to torsion in all cases and in curved canals should also be flexible and resistant to cyclic fatigue.

Many factors can affect resistance to torsion, including design, dimensions, manufacturing process and motion.[5] In the present study, two NiTi rotary instruments, similar in dimension and design, were tested to compare torque at failure. The null hypothesis was that differences related to the different manufacturing processes would be found.

Methodology

Instruments from the following two different systems were tested and compared: ProTaper Next (Dentsply Maillefer) and EdgeFile X7 (EdgeEndo). For each system, ten



File system	Maximum torque at failure in Ncm (mean ± SD)	Time to failure in seconds (mean ± SD)
EdgeFile X7	0.57 (± 0.10)	0.42 (± 3.50)
ProTaper Next	0.51 (± 0.10)	0.39 (± 2.90)

Table 1: Results.

17/.04 instruments were subjected to a repetitive torsional test. The test was performed using a torque-controlled endodontic motor (MASTERsurg, KaVo). The motor allowed precise recording of torque values during the instruments' use. The accuracy and reliability of the device had been validated in a previous study.[6] To perform the test, the apical 3 mm of each file was firmly secured, embedded in a resin block produced with a mixed auto-polymerising resin (DuraLay, Reliance Dental Manufacturing). Each file was then rotated clockwise at a speed of 300 rpm until fracture occurred. The torque limit was set at 5.5 Ncm, to ensure recording measurements ranging from 0.1 to 5.5 Ncm. The torque values at failure were recorded by the integrated software of the motor and analysed using spreadsheet software. The data was analysed using one-way analysis of variance and a Tukey test with a significance level of $\alpha = 5\,\%$.

Results

Table 1 shows the results from the present study. The ProTaper Next files demonstrated no significantly different resistance in terms of maximum torque at failure compared with the EdgeFile X7 files ($p < 0.05$). Similarly, no statistically significant differences were found between the two instruments in terms of time to failure ($p < 0.05$).

Discussion

The ISO torsional resistance static test was developed more than 50 years ago to test manual stainless-steel instruments and is probably not ideal for testing rotary instruments that rotate at speeds much higher than 2 rpm or for the specific motors with torque control and auto-reverse mode.[5] Therefore, in the present study, torsional resistance was assessed by using a different speed: the clinical one (300 rpm).

The tested instruments were similar in dimension and design, but had been produced through different manufacturing processes (alloys and heat treatments). According to the manufacturer, EdgeFile X7 files exhibit a higher flexibility and a greater resistance to cyclic fatigue than competitors' instruments do. In stainless-steel instruments, flexibility and torsional resistance are usually inversely proportional. This is mainly due to the mass and/or dimensions of the instruments. The greater the mass, the more rigid and resistant to static torsion the instrument is.[7,8] In the present study, mass and dimensions were very similar and torsional resistance too was similar, showing no statistically significant difference between the two instruments. The null hypothesis was therefore rejected.

Hence, the present study showed that heat treatment does not significantly influence torsional resistance, in contrast to the high increase in flexibility and fatigue resistance derived from heat treatment as reported in many published articles.[9,10]

Editorial note: A list of references is available from the publisher.

about

Prof. Gianluca Gambarini is head of endodontics and restorative dentistry at the Sapienza University of Rome in Italy and director of the dental school's master of endodontics programme. He maintains a private practice limited to endodontics in Rome, where his focus is on endodontic materials and clinical endodontics.

As an international lecturer and researcher, Gambarini has held more than 500 presentations at the world's most renowned international congresses and universities. He has also received several awards and led research projects funded by national and international grants. In addition to that, Gambarini is an active consultant in the development of new technologies, surgical procedures and materials for root canal therapy. Furthermore, he holds patents concerning endodontic technologies he has developed. Currently, Gambarini serves as Chairman of the Clinical Practice Committee of the European Society of Endodontology.

Maximum curve control

Dr Antonis Chaniotis, Greece

The ultimate aim of endodontic therapy is the prevention of periradicular disease and the promotion of healing. To achieve these objectives, mechanical instrumentation and chemical disinfection are considered the basic principles,[1] and the former essentially determines the efficacy of all subsequent procedures.[2]

For gutta-percha fillings, the shaping of the canal should satisfy the following criteria:
- the shape of the main root canal should resemble a continuously tapering funnel from orifice to apex;
- the cross-sectional diameter of the main canals should narrow apically;
- preparation should follow the original shape;
- the position of the apical foramen should be preserved;
- the dimensions of the apical opening should be retained as far as possible.[1,3]

The biological objectives of root canal instrumentation are:
- confinement of instrumentation to the limits of the roots themselves;
- avoidance of extruding necrotic debris into the periradicular tissue;
- removal of all organic tissue from the main and lateral canals; and
- creation of sufficient space to allow irrigation and medication by simultaneously preserving enough circumferential dentine for the tooth to function.[3]

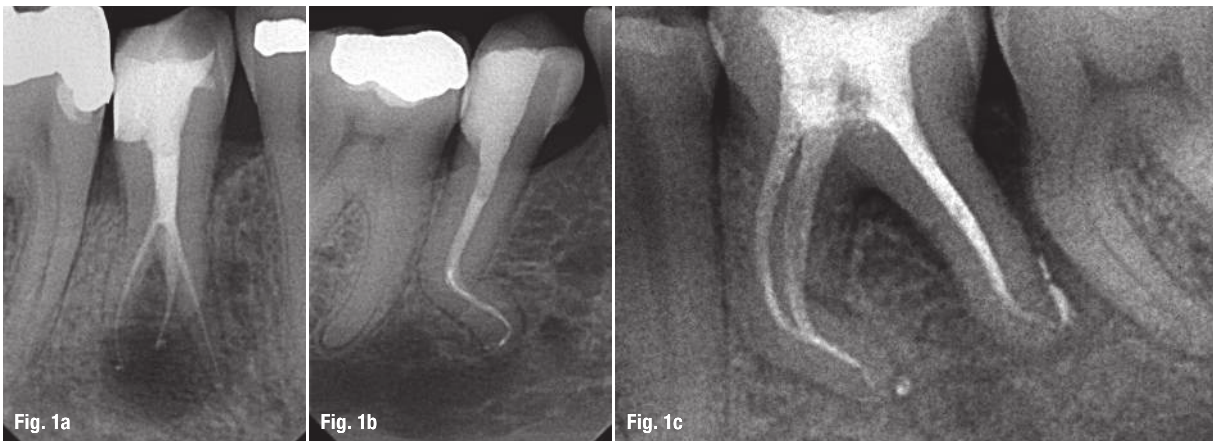
Achieving the aforementioned objectives in straight canals is considered a straightforward procedure. However, the internal anatomy of human teeth often consists of a highly complicated network of multiplanar curved and anastomotic canals. Reaching the biological and design objectives of root canal instrumentation in severely curved canal systems thus might be extremely challenging. Problems arise when canals are severely curved or even bifurcated and anastomotic (Fig. 1). In such teeth, the basic endodontic techniques and instrumentation protocols might be challenging to follow. For a safer and more predictable instrumentation, a newly introduced NiTi file sequence can be applied in the TCA technique.

Curved canal management

Based on canal curvature, Nagy et al. classified root canals into four categories:[4]
1. straight or I-shaped (28 % of root canals);
2. apically curved or J-shaped (23 %);
3. entirely curved or C-shaped (33 %); and
4. multi-curved or S-shaped canals (16 %).

Schäfer et al. found that 84 % of root canals studied were curved, while 17.5 % of them presented a second curvature and were classified as S-shaped. Of all the curved canals studied, 75 % had a curvature of less than 27°, 10 % a curvature with an angle between 27 and 35°, and 15 % a severe curvature of more than 35°.[5]

Traditionally, root canal curvatures were described using the Schneider angle: root canals presenting an angle of 5° or less were classified as straight canals, root canals



Figs. 1a–c: Complex root canal anatomies.

with an angle of between 10 and 20° as moderately curved and canals with a curve of greater than 25° as severely curved.[6] Decades later, Pruett et al. reported that two curved root canals might have the same Weine angle, but totally different abruptness of curvature.[7] In order to define the abruptness, they introduced the radius of a curvature: the radius of a circle passing through the curved part. In rotary instruments, the number of cycles before failure significantly decreases as the radius of curvature decreases and the angle of curvature increases.

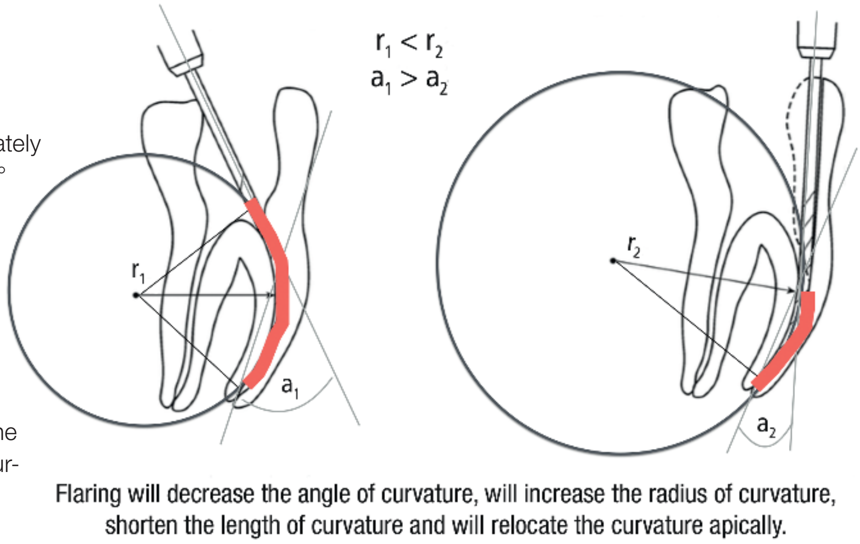


Fig. 2: The effect of flaring in the curvature parameters.

Further attempts to mathematically describe curvatures in 2D radiographs introduced parameters such as the length of the curved part[8] and the location as defined by curvature height and distance.[9] Recently, Estrela et al. described a method for determining the radius of root canal curvatures using CBCT images analysed by specific software.[10] Three categories were classified: small ($r \leq 4$ mm), intermediate ($r > 4$ mm and $r \leq 8$ mm) and large ($r > 8$ mm). The smaller the radius of a curvature is, the more abrupt the curvature becomes. All these attempts to describe the root canal curvature had one goal: to preoperatively assess the risk of transportation and unexpected instrument separation.

Canal transportation and instrument separation

According to the *Glossary of Endodontic Terms*, "transportation" is defined as the removal of the canal wall structure on the outside curve in the apical half owing to the tendency of files to restore themselves to their original linear shape.[11] For stainless-steel hand files and conventional hand- or engine-driven NiTi files, the restoring force of a given instrument is directly related to its size and taper. The larger the size or taper, the larger the restoring force, owing to the increase of the metal mass of the instrument. If instruments were constructed precisely on the dimensions of root canals, transportation would not be a problem: instruments would be well constrained inside the root canal trajectories. Unfortunately, instruments are not precisely shaped to fit canal dimensions. As a result, each instrument may follow its own trajectory inside a curved canal guided by its restoring force, thus transporting the canal.[12]

Usually, dentinal removal towards the outer apical curve becomes more excessive if a greater increase in apical enlargement is attempted to be created.[13] Consequently, the inner curvature widening can become excessive too. To avoid these complications, dentists sometimes tend to increase flaring and reduce apical instrumentation size in severe curves.[14] Increasing flaring under such circumstances often results in the reduction of the angle of curvature, shortening the length, increasing the radius and relocating the curvature apically (Fig. 2). Smaller apical preparations in highly curved canals would be preferable for two reasons: (a) smaller-diameter preparations are related to less cutting of the canal walls, less file engagement and, consequently, a lesser likelihood of undesirable cutting effects; and (b) small-diameter files are more flexible and fatigue-resistant and therefore less likely to cause transportation during enlargement.[14]

The aforementioned instrumentation approaches, although safer, have inherent disadvantages. Unfortunately, flaring the canal entrance in order to achieve easier negotiation to the apical third of curved canals will result in unnecessary removal of dentinal structure that is irreplaceable. Moreover, smaller apical preparations may result in increased difficulties in delivering irrigating solutions to an appropriate depth. In highly curved canals, the ability of irrigating solutions to reach the critical apical third depends directly on the ability to create adequate apical preparations and the selection of appropriate delivery techniques.[15] Adequate apical preparation for disinfection without over-flaring the coronal part of highly curved canals is one of the great challenges in endodontics—especially according to the current concepts of dentinal preservation and minimally invasive dentistry.

Moreover, the risk of unexpected instrument separation of engine-driven NiTi files poses significant problems to canal management. Two mechanisms have been identified: cyclic fatigue and torsional failure. When an engine-driven instrument is activated inside a curved canal, continuous tensile and compressive stress at the fulcrum of the curvature may lead to instrument separation because of cyclic fatigue. If the tip of an engine-driven instrument is locked inside a canal and the shaft keeps on moving, it may exceed an applied shear moment, resulting in torsional failure. As the complexity of the curvature increases, the number of cycles before failure decreases.