R-phase advantages in shaping curves

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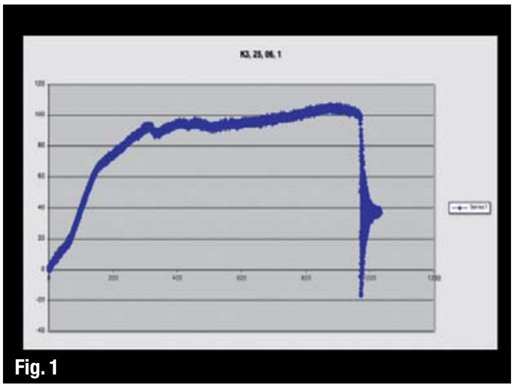

Fig. 1

Fig. 1_Graph showing the stress test result of a K3 file conducted with a torque metre. It shows the austenite phase, yield point and the martensite plateau before file separation.

_**Every dentist and endodontist dreams** that all root canals could be straight and large. Unfortunately, in reality they are often everything but. On a daily basis, we are faced with new challenges in curved and narrow root canals. While NiTi rotary files have changed our world significantly, our first experiences were not so encouraging.

We were faced with file separation owing to anatomical considerations of the root-canal system and our poor knowledge of the files, the alloy and the way to use the files properly.

Much research has been conducted in order to better understand the properties of the alloy and the files. Researchers have used a torque metre to study the files (Fig. 1). However, we realised that different data was required with regard to stressed or used files. Further research demonstrated that the yield, which is the point beyond the austenite phase, is stable regardless of the dimension and the size of the file (Figs. 2 & 3). The major difference is in the torque value and the behaviour of the martensite phase. Deformation in the martensite phase is irreversible and leads to file separation. Some file deformation can be seen clinically and it is a safety property of files that they have a longer deformation period under stress in the martensite phase.

There are two types of clinical stresses on a file in curved canals: bending and torsional stress (Figs. 4 & 5). Bending stress occurs when the file passes inside a curve and is subjected to stresses at an equal level: stretching on the outer part of the curve and compression of the alloy structure from the internal part of the curve. This kind of stress cannot break a file, but it can lower its torsional stress by at least 30 % from the first few seconds that the file is active inside the curve.

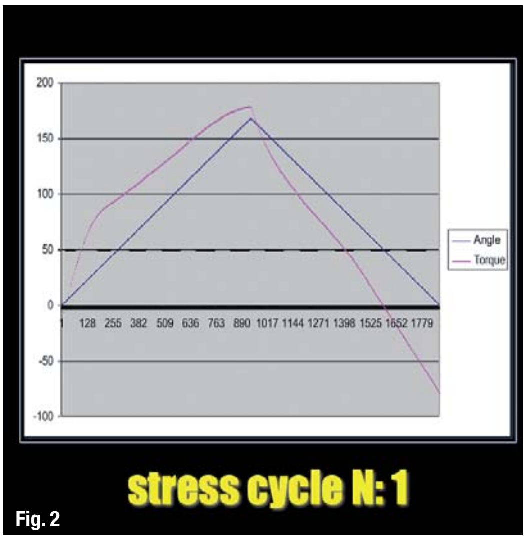

Fig. 2

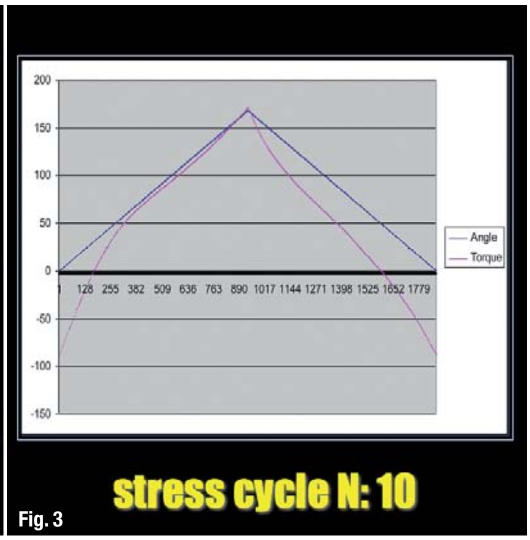

Fig. 3

Figs. 2 & 3_Graphs showing the difference between stress cycle #1 (Fig. 2) and 10 (Fig. 3). The yield is fairly stable and the austenite phase decreased in torque value.

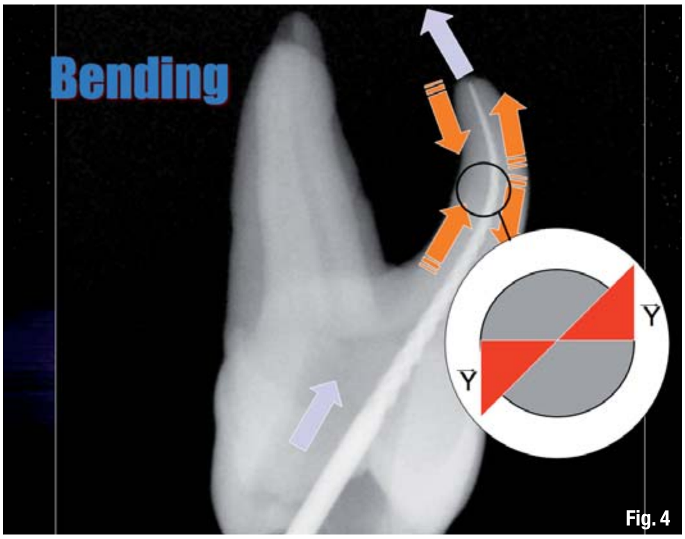

Fig. 4

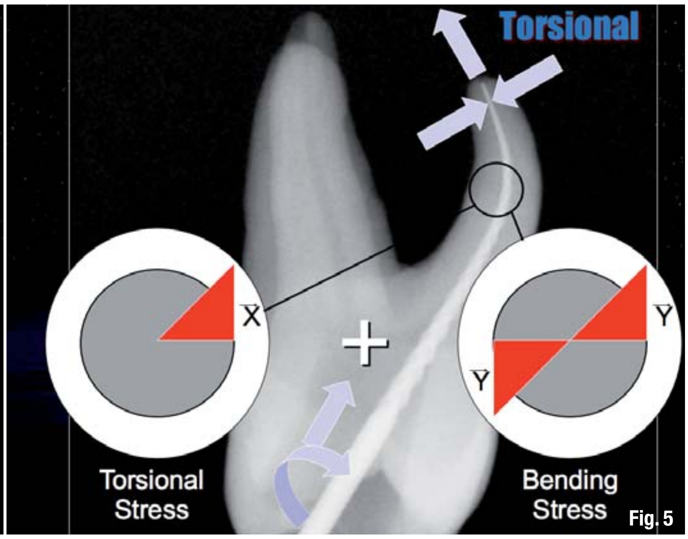

Fig. 5

Torsional stress is more dangerous. It occurs when the tip or any other section of the file is locked inside the canal while the rest of the file is still rotating. This can lead to instant file separation. Torsional stress can occur anywhere inside the canal and can be even more dangerous when it is combined with bending stresses inside the curvature of the canal (Fig. 5). This can be the perfect trap for rotary files.

Combining the two essential features of a file—security and flexibility—was not possible with the NiTi alloy available. Therefore, some manufacturers focused on the flexibility of the files while compromising security, and others focused on security while compromising flexibility. Intensive research was conducted into changing the crystalline structure and obtaining a dual-phase structure as its main characteristic. The dual phase is a mix of austenite and the R-Phase. The R-phase has the advantage of being able to cope with increased pressure while increasing the torque value (Fig. 6). It appears after the austenite phase and still increases in torque until the ultimate deformation point. There is then a short martensite phase prior to separation. During the R-phase, there are actually two kinds of R-phases: R1 and R2. According to thermal cycling tests under various constant stresses, the transformation strain of R2 is greater than that of R1. With constant stress increasingly applied, the latter strain increases and the former decreases. However, the total strain of both R1 and R2 is almost constant irrespective of the amount of stress. R1 will start immediately after austenite, and then R2 will take over in the middle of the transition area until the ultimate deformation point, where martensite will be formed. With the R-phase, shaping curves will be much easier and safer as the files produced with the modified NiTi alloy are much more flexible than any other file with the same dimensions. This allows the file to cope with the pressure of shaping the curves safely.

As for the clinical applications, we must ensure that we do not place a very large file in a curve, such as a 0.10 or 0.08 taper, but pay attention to the severity of the curves, for two reasons:

Fig. 4_Illustration of the bending stress to which a file is subjected inside the curve.

Fig. 5_Illustration of the torsional stress and the load of stress that a file will take at the tip of the root canal or inside the curve, which will lead to file separation.

Fig. 6_Graph showing the stress test result of a TF file using a torque metre.

Fig. 7_M4 handpiece.

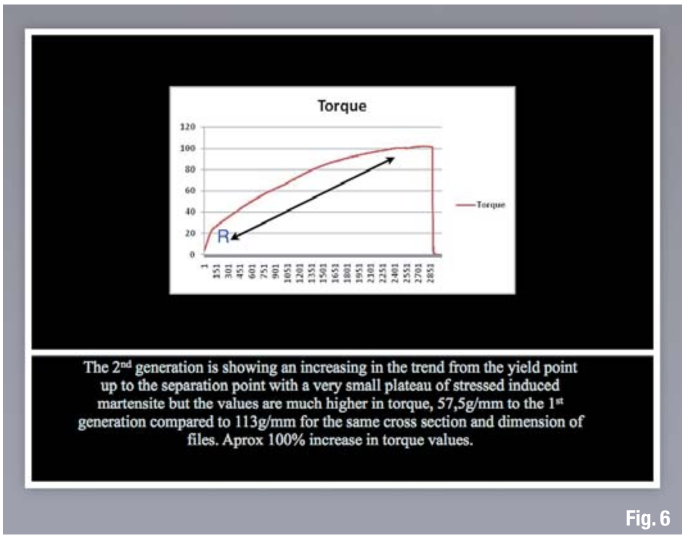

Fig. 6

Fig. 7

Figs. 8–11_Clinical cases.

Fig. 8 Fig. 9 Fig. 10 Fig. 11

1. in order to avoid a taper lock, which can lead to file separation or damage in severely curved canals; and
2. in order to avoid a strip perforation caused by aggression of the files.

We must carefully analyse the preoperative X-ray to determine the location of the curve. This can be achieved by inserting a size 10 K-file, which will take the impression of the canal. It gives us a good idea of the curve or curves, as well as the shape of the canal, thereby helping us determine a strategy regarding the depth to which we can go with our large files and then switch to a lesser taper. This is a simple clinical tip that is helpful in avoiding serious complications in shaping curved canals.

The sequence I personally follow with Twisted Files (TF; SybronEndo) is as follows. After checking root-canal patency and taking the impression of the canal with a size 10 K-file, I use my M4 handpiece with a size 20 SS file for 15 seconds in each canal (Fig. 7). It does not have to go to length. I only take it as deep as it will go with a simple push and pull movement and use sizes 15 and 10 SS files, if required, after the size 20 in a crown-down method. After achieving patency, I use the rotary files in order to clean and shape the root-canal system. I start with a size 25 with taper 0.08, taking it to the beginning of the curve. I limit its insertion to this point. I then usually switch to a size 25 TF with taper 0.06, depending on the severity of the curve. If the curve is normal to medium, a size 25 TF with taper 0.06 should be able to enlarge it safely. If the curve is severe, which will show on the size 10 K-files and from the resistance of the previous file, I use a size 25 TF with taper 0.04 to full working length. The apical enlargement will follow the crown-down, which has opened a safe way to the apical area, or the last 3 mm for enlargement. I use a size 40 TF with taper 0.04 whenever I am able to for optimal cleaning of the apical area, as well as for reducing the colony formation unit and preparing the dentine for obturation using RealSeal (SybronEndo) according to proper irrigation protocol.

Achieving step-by-step root-canal preparation is the gold standard of care that we can offer to our patients without any negative surprises along the way. Respecting a few simple rules and not letting ourselves be carried away by our temptation to work more quickly can lead to excellent clinical results.

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