

WaveOne— First experiences of third-year students

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Rotary root-canal instrumentation with NiTi files has been very successful over the last 20 years. Starting with ProFile (DENTSPLY Maillefer) in 1994, the time-consuming and complicated hand instrumentation of root canals, which had dominated endodontic procedures for more than a century, was replaced with a totally new approach.

In the beginning, that is the 1990s, there was a debate about the advantages and disadvantages of the new NiTi files and about an initially high fracture rate. Before long, knowledge about the behaviour of the new material, correct handling, auxiliary support of specific endodontic motors with torque-control mechanisms and the understanding of cyclic versus torsional fatigue, the advantage of a crown-down approach and many, many more details led to a breakthrough in this new area. The initial fears—that a rotary instrument would screw into the root dentine too deeply and become stuck or fractured—led to a radial land design.

Table I Results of the study by Roane and Sybala (1984), showing that most fractured K-files in daily practice result from use in CW motion.

	Number	Percentage
Complete separation CCW	29	5.9
Complete separation CW	37	7.5
Partial separation CCW	0	0
Partial separation CW	21	4.3
Distortions of the flutes CCW	13	2.6
Distortions of the flutes CW	393	79.7
Fractures CW	451	91.5
Fractures CCW	42	8.5
Total	493	100

Table I

At the turn of the millennium, the first files with sharp edges, such as FlexMaster (VDW) and ProTaper (DENTSPLY Maillefer), were introduced to the market and the triangle cross-section was diversified, ranging from two sharp edges to three (which still is the most frequently used type), four or five. In addition, a variety of sizes and tapers were introduced.

In 2008, Ghassan Yared published his idea of using only one file from the ProTaper system, the F2 (#25 at the tip and 0.08 taper in the first 3 mm), in the ATR motor, which enabled the user to programme the file movement in a reciprocating file motion at self-defined angles and time. This idea goes back to Roane, who discussed clockwise (CW) and counter-clockwise (CCW) movement of K-files¹ and introduced the balanced force technique in the early 1980s.²

In 1984, Roane and Sybala evaluated 493 used K-files from an endodontic practice. In a preliminary test, new K-files were rotated CW and CCW until they broke and exhibited a special, totally different and characteristic fracture pattern for each movement. This pattern had been delineated by Chernick et al.³ Roane and Sybala concluded that file damage predominantly occurred when the K-files were used in a CW motion (91.5%), whereas the CCW motion caused distortion or separation in less than 10% of cases (Table I).

“This observation is explained by the fact that counterclockwise rotation unthreads the instrument, decreasing its load and releasing its cutting edge. Clockwise rotation threads the instrument into the canal and increases its load until its cutting edges cease to rotate. At that point, the instrument shaft must either distort or separate unless the operator terminates the rotation.”¹



Fig. 1 WaveOne files: Small, primary and large.

With these facts in mind, Roane et al. published another article in the following year, describing the 'balanced force' concept for instrumentation of curved canals, in which they state: "Its concepts use force magnitudes in order to create control over undesirable cutting associated with canal curvature. Rotation is promoted as the means for maintaining magnitude as a control and CCW direction of rotation provides finite operator control."² They thus suggested combining CW and CCW motion in root-canal instrumentation to prevent breakage of K-files and preserve curved canals much better than before. To obtain this result, they introduced a new K-type file with a parabolic tip, expecting that the load would be distributed and reduced to below the regular cutting magnitude.

Today, the balanced force concept is taught in many dental schools and is well known all over the world. When the new NiTi instruments appeared in the early 1990s, the constant rotation of files at a speed of 250 to 350 min⁻¹ appeared to be the gold standard over the next few decades. With Yared's idea⁴—combining CW and CCW when using NiTi files, namely the ProTaper F2—both ideas were unified.

Yared suggested the use of a #8 stainless-steel hand file to negotiate the canal to working length using an apex locator and #10 or 15 files only in severely curved canals. This is followed by the 25.08 ProTaper F2. The CW rotation is greater than the CCW rotation. In this manner, a CW motion screws the file into the canal and a CCW motion unscrews it. As CW is greater than CCW, the file automatically passes more deeply into the canal and the user is warned to avoid apical pressure that will force the instrument deeper still.

Yared's idea triggered the design of a new instrument and motor that would fulfil the requirements

of a reciprocating technique, the WaveOne system. WaveOne is available in three sizes—21.06, 25.08 and 40.08 (Fig. 1)—and comes with the WaveOne motor, which is programmed to move the file in the special reciprocating motion. The main advantages of WaveOne are:

WaveOne enables the realisation of the one-file concept

Only one file is needed for a single tooth. In some cases, molars demand two WaveOne files, namely the small or primary for the buccal and the large for the palatal canals. This replaces the use of numerous files necessary in the past. The files may be used as disposable instruments because of a lower price, which may be accepted more easily by the patient than the higher prices of a complete set of files used with other systems.

WaveOne lowers the fracture risk

The fracture risk of NiTi files is low, with a deformation rate of 0.75% for ProFile and 2.9% for ProTaper. Instrument separation occurs in 0.26% for ProTaper and 0% for ProFile.⁵ Nevertheless, practitioners still fear file breakage. The reciprocating motion respects the fatigue threshold of NiTi alloys (Fig. 2) far better than a constant rotary motion, which leads to a lower fracture risk than with conventional NiTi files.

WaveOne reduces the risk of prion transmission

"The risk of vCJD transmission through endodontic procedure compares with other health care risks of current concern, such as death after liver biopsy or during general anaesthesia. These results show that

Fig. 2 Relationship between torque (gcm) and angle of rotation (degrees). A NiTi file tolerates about three to four complete rotations before it fractures. When used in a reciprocating motion, the angle of rotation always stays within a rotation of no more than 360°.

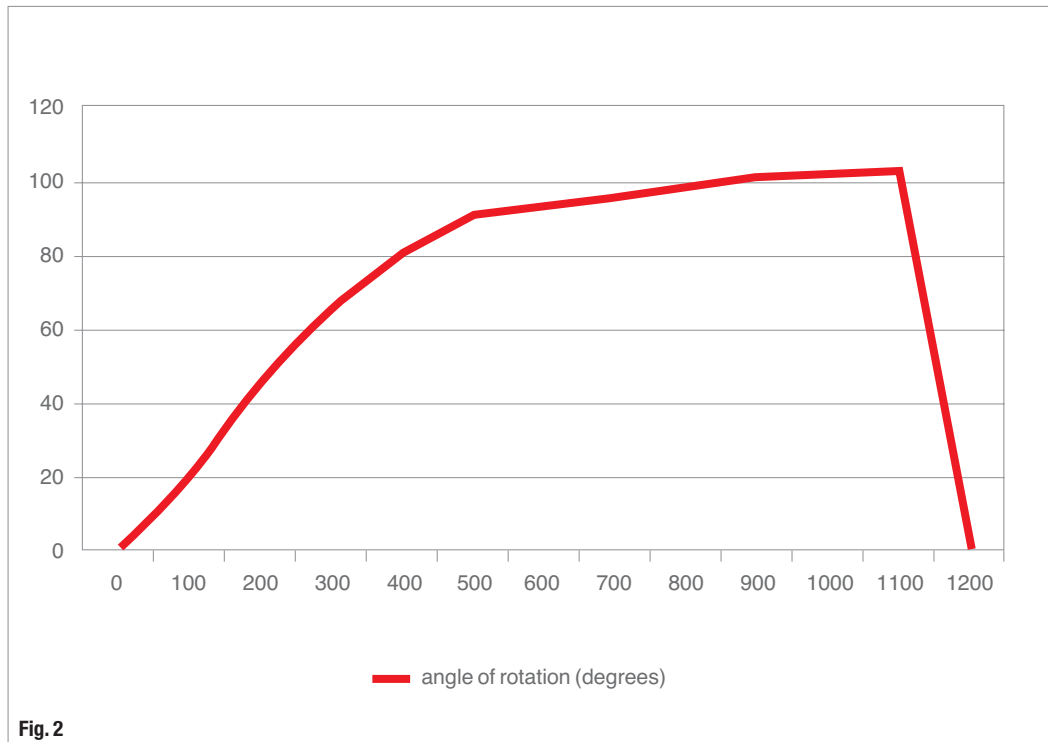


Fig. 2

single instrument use or adequate prion-decontamination procedures like those recently implemented in dental practice must be rigorously enforced.”⁶ The prion decontamination of endodontic instruments appears to be an extremely difficult procedure. Instruments cannot be cleaned through NaOH, NaOCl or guanidine thiocyanate immersion for 24 hours or through steam sterilisation. “Uniformly, debris could not be completely removed. [...] Based on these findings, single use of nickel-titanium rotaries appears to be beneficial.”⁷ This finding led to the recommendation by the Department of Health in the UK in 2007 and some manufacturers of dental instruments to use disposable (single-use) instruments:

“The transmission of vCJD via dentistry is considered to be low risk! However, the Department of Health (DoH) has recently advised dentists to ensure that as a precautionary measure endodontic reamers and files are treated as single-use in order to further reduce any risk of vCJD transmission.”⁸

In contrast, Julian Webber, the editor of *Endodontic Practice*, sent a letter to the editor of the *British Dental Journal* published in June 2007, requesting less “draconian advice.”⁹ Webber stated that no prions had been found in the dental pulp^{10,11} and that there was no proof for the iatrogenic transmission of CJD in dentistry.¹²

Schneider et al.¹³ conducted a study with knockout mice and human teeth using three methods: immunohistochemistry, cell culture and SEM. They state, “In human teeth, cementoblasts and odontoblasts showed prominent staining for PrP (Prion Protein) at levels comparable to those of nerve fibers. [...] Periodontal and pulpal tissue exposed by disease or trauma might represent a clinically relevant entry point for prions incorporated orally and thus a possible mode of infection.” This means they did not find prions in teeth but a staining of pulpal cells in several tissues, which indicates that prion-like proteins can be found physiologically in the dental pulp.

In an initial trial with the aim of collecting information about the routine use of WaveOne files, third-year dental students at the University of Cologne,

Table II Instrumentation time using WaveOne and hand files.

	WaveOne (time in s)	Hand files (time in s)
	30	251
	25	210
	38	223
	41	129
	22	299
	14	346
	12	163
	17	328
	34	224
Total time	233	2,173
Mean	23.3	217.3

Table II



Fig. 3a, b A plastic block instrumented with WaveOne (#020) and another after hand instrumentation (#023). In the middle, the dark/black area indicates the original canal and the surrounding grey silhouette shows the root-canal geometry after shaping. With WaveOne, a sharp, continuous and smooth shape was created. In contrast, a canal instrumented with a hand file is disrupted and has a more transported shape with zipping and ledging.

Germany, were given the opportunity to work with the WaveOne primary file (25.08). These students have little experience with root-canal treatment because they only work on six teeth (two incisors, two bicuspid and two molars) and a plastic block during their sixth term. Instrumentation is taught through the initial use of hand files up to #15 for creating a glide path and using ProTaper or FlexMaster in a constant rotary motion with the ATR motor.

At the end of this course, ten students were selected to participate in a pilot study. The students were introduced to the handling of WaveOne files and the balanced force technique. The students then instrumented endodontic plastic blocks with WaveOne files and other blocks with hand instruments (K-files) using the balanced force technique with the #30 AMF and with step-back to #50 to reach comparable sizes with the 25.08 WaveOne file (Fig. 3).

The results show that the mean instrumentation time (without file exchange and rinsing) for WaveOne with 23,3s was much more shorter than for hand instrumentation with 217,3s (Table II). The students were nearly ten times faster with WaveOne than with hand instrumentation (between 129 to 346 seconds). No instruments were fractured, which suggests that even inexperienced students were able to instrument plastic blocks easily and quickly (between 12 and 41 seconds). In addition, the resulting shape with WaveOne was much better, smoother and without zip, elbow or ledge formation.

In summary, upon initial observation, WaveOne is a promising system that is easy to learn for first-time users, results in less breakage and allows the use of one single-use instrument.

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

_about the author

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