ENDO TRIBUNE

Reality check on electronically controlled endodontic motors

Prof. Dr. Liviu Steier and Dr. Giampiero Rossi - Fedele

One of the most impressive changes in Endodontics was certainly the introduction of mechanical preparation using rotary files.

Rotary files designed for mechanical root canal shaping are mostly manufactured out of NiTi alloys. Special properties of NiTi alloys such as: super elasticity and memory effect are due to transition ability (known as twinning) from austensitic to martensitic which is complimented by reduction in strain. When comparing ultimate tensile and yield strength among NiTi and stainless steel, the former shows lower values and proves a tendency to fracture under lower load.

Parashos et al researched "Rotary NiTi Instrument Fracture and its Consequences" (JOE – Volume 32, Number 11, November 2006).

Sattapan et al. classified NiTi file fractures "as a result of cyclic flexural fatigue or torsional failure". (J Endod 2000;26:161–5.).

NiTi rotary file fracture is commonly attributed to "Taper torque".

Air is the most common drive mechanism in dentistry. Such motors are called air motors. Air motors used in dentistry work by converting compressed air in to mechanical movement to generate rotary motion. They are characterized by greater power ratio.

Wagner et al., when researching mechanical root canal preparation procedures found that "air driven motors caused excessive vibration and, consequently, lead to less control of instrumentation and more operator fatigue." (Braz Dent J (2006) 17(1): 10-14).

Electrically driven motors differ in this regard and proved to be efficient with NiTi rotary files and mechanical shaping of root canals. A DIRECT CURRENT (DC) motor is a fairly simple electric motor that uses electricity and a magnetic field to produce torque, which turns the motor.

Gambarini reviewed the "Rationale for the use of low-torque endodontic motors in root canal instrumentation" (Endod Dent Traumatol Department of Periodontics-Endodontics, Dental 2000; 16: 95–100.) He concluded:

"The step-motor was found to be helpful in reducing the risk of instrument fracture. Irreversible material damage (plastic deformation) and instrument fracture were rarely seen. Low-torque instrumentation also increased tactile sense and, consequently, mental awareness of rotary instrumentation."

Different taper, dimensions and design influence the elastic and fracture limits of rotary files. Rotary file manufacturers managed to precisely define adequate versus maximal torque values requested for each individual instrument to maximize cutting performances and reduce risk of failures. As a consequence manufacturers of motors introduced fine precision adjustments for torque control and speed.

When performing mechanical shaping (either using hand files or a rotary approach) of a root canal, POWER will be applied to perform WORK using TORQUE at predefined SPEED.

One may want to understand the following definitions, criteria and formulae before starting to apply torque controlled motors in Endodontics:

• TORQUE can be defined as a FORCE around a given point, applied at a RADIUS from that point.

• SPEED can be defined as rate of rotation around an axis, usually expressed in revolutions per minute (RPM).

• POWER can be defined as the measure of how much WORK can be done in a specified TIME.

The mutual relations between Power – Torque and RPM can be defined as:

• POWER (the amount of WORK) is dependent on TORQUE and RPM.

• TORQUE and RPM are the measured quantities of the motor output.

• POWER is CALCULATED from torque and RPM, by the following equation:

$$HP = \frac{T \times N}{5252}$$

Where T = Torque (lbft)

N = Speed (rpm)

Formula to determine the Braking torque of a motor:

$$T = \frac{5252 \times HP}{rpm}$$

T = full-load motor torque (inlb-ft)

5252 = constant (33,00 divided by 3.14x2 = 5.25)

HP = motor horsepower

rpm = speed of motor shaft

(http://www.elec-toolbox.com/Formulas/Motor/mtrform.htm)

Full-load torque is the torque to produce the rated power at full speed of the motor. The amount of toque a motor produces at rated power and full speed can be found by using a horsepower-to-torque conversion chart.

Formula applied to calculate the motor full - load torque :

$$T = \frac{HP-5252}{rpm}$$

T = torque (in lb-ft)

HP = horse power

5252 = constant

rpm = revolutions per minute

(http://www.elec-toolbox.com/Formulas/Motor/mtrform.htm)

One should understand that torque will drop with higher RPM

→ DT page 12

← DT page 11

(SPEED). The formulae shown below will explain the rationale behind:

Power [kw] = {torque [N-m]*pi*rotational speed in RPM }/30000

Power [kw]*30000 =torque [N-m]*pi*rotational speed in RPM

TORQUE = {Power[kw]*30000}/ pi*rotational speed in RPM

Fuentes et al. (2002) researched dentin hardness at different depth and concluded that "differences in dentin hardness as a function of depth exist."

How does this affect mechanical shaping protocols and requirements for different torque electric motors?

Dentin with a higher hardness requires more POWER and of course higher TORQUE valued electric motors.

Reroot canal treatment (ReRCT) will as well require more POWER and higher TORQUE motors to allow for the removal of previously firmly condensed obturation materials.

Rotary files and electric motors

Triangular triple - helix NiTi rotary files own a higher flexibility when compared to U-flute ones. Turpin et al. and Berutti et al. identified the higher weakness to torsional stress of the U - flute design files when compared to the triangular triple - helix design. (J Endod 2000;26:414 –7. &. J Endod 2003;29:15–9.)

When starting to use rotary files the author was introduced to the TCM Endo motor manufactured by Nouvag. The 5th generation of this technology is t available today. One has to appraise the special features this electric motor designed for use in Endodontics presents. The author uses today a TCM Endo III unit.

TCM Endo III (Nouvag)

I. Three reduction ratios are available and will request the same ratio contra angles:
a. 1 : 1
b. 16 : 1
c. 18 : 1

II. Torque control modes:
a. AL indicates automatic limiter mode at 5 Nmm of torque. This mode allows for torque development even once the maximal torque has been reached and the file does not advance further.
b. AP indicates that the motor generates up to the selected torque and will reverse direction for two revolutions at the same level of torque before resuming forward rotation.

In AP mode the reduction ratio will accommodate different torque ratios:
a. 1 : 1 torque can be adjusted from 1 to 19Nmm
b. 16 : 1 torque can be adjusted from 5 to 100Nmm
c. 18 : 1 torque can be adjusted from 5 to 100Nmm

AP mode does not function in reverse mode.

TCM Endo III has an 18by 61 mm display with a red LED. The keypad incorporates eight buttons in two groups of aligned keys:

- Motor
- Speed up
- Speed down
- Rev / Fwd: for change of direction
- 1 : 1 for handpiece 1:1
- 16 : 1 for handpiece 16 : 1
- 18 : 1 for handpiece 18 : 1
- ATC to set AL and / or AP mode.

The motor comes with a footswitch.

Two different handpieces can be attached:
a. The W&.H SE 18:1 – push button.
b. The Anthogyr 18:1 - latch head.

Later in his career the author added the Endo Mate DT (NSK) as well as multiple units of the Endo Mate TC2 to his clinical armamentarium.

Endo Mate TC 2 (NSK)

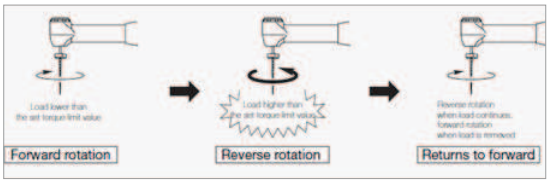
The Endo Mate TC2 is a cordless hand piece which is 20 cm. long.

Up to five programs can be set and these program settings can be memorized. Four gear ratio settings, 4:1, 10:1, 16:1 or 20:1 can also be selected.

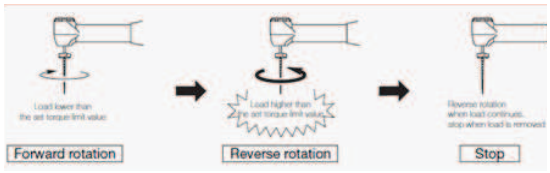
Different geared heads can be fitted to the handpiece. The manufacturer offers: 20: 1, 16 : 1, 4 : 1 heads.

The author's favourite set up is:

Programme	Torque	Speed
1	_ _ _	550 RPM
2	3.0	500 RPM
3	2.5	450 RPM
4	2.0	400 RPM
5	1.0	300 RPM



Picture by NSK



Picture by NSK

Programme		Speed
1	_ _ _	650 RPM
2	6.5	250 RPM
3	5.0	250 RPM
4	4.0	300 RPM
5	4.0	500 RPM
6	3.0	500 RPM
7	2.5	450 RPM
8	2.0	400 RPM
9	1.0	300 RPM

The NSK Endo Mate TC 2 runs in 3 different operational modes:

1. Auto reversing
2. Auto stop
3. Auto reverse off

AUTO REVERSING
The handpiece stops when the file has engaged the walls of the canals and it has reached the preset Braking Torque of the file, the file then rotates in reverse. Once the file disengaged, it will return to normal rotation (forward rotation) automatically.

AUTO STOP
The motor handpiece starts in forward. Once disengaged (load is removed), the motor handpiece stops. If one wants it to rotate (forward-rotate) again, re-press the ON/OFF Key or re-step.

AUTO REVERSE OFF
The motor handpiece stops without reverse rotation. The preferred operational mode is auto reverse.

Endo Mate DT (NSK)
This is an electric motor consisting of a contra angle handpiece attached to a control unit. Operating mode is controlled either by foot switch or a button on the handpiece.

Endo Mate DT has been awarded 5 stars by RealityEndo (www.realityesthetics.com).

Up to nine programs can be set, and these program settings memorised. Four gear ratios, 4:1, 10:1, 16:1 or 20:1 can also be selected.

Different geared heads can be fitted to the handpiece. The manufacturer offers: 20 : 1, 16 : 1, 4 : 1 geared heads.

Endo Mate DT (NSK

Endo Mate TC 2 (pictures by NSK)

The Endo Mate DT runs in 3 different operational modes as explained above:
1. Auto reversing
2. Auto stop
3. Auto reverse off

Torque options vary from 0.8 to 6.5.

Comparison
Major differences between the two manufacturers are distinct speed differences as well as torque. The TCM Endo unit is recommended wherever higher POWER and / or higher SPEEDs are required. Whilst Endo Mate DT and Endo Mate TC2 are excellent units, highly recommended for gentle and delicate use by average skilled practitioners involved in the treatment of less difficult root canals.

Conclusions and indications
General dental practitioners perform root canal treatment on teeth diagnosed with reduced difficulty. These cases can be performed with hand files, rotaries or a combined technique. When rotary files are chosen electric motors are best indicated. These clinical cases will require reduced WORK (POWER). The use of a light weight cordless electric motor like the Endo Mate TC2 is best recommended.

General practitioners with advanced clinical skills and knowledge, solving root canal treatment cases demonstrating moderate difficulty are recommended to use an electric motor like the Endo Mate DT.

Specialist Endodontists treating cases of advanced difficulty will need to operate at an in-

	DT	TC2	TCM Endo
Weight of the handpiece	920 Gram	138 Gram	217 Gram
Charging time 0-100 per cent	5 hours	1.2 hours	-
Mac time of use	2.5 hours	1 hour	continuous