Contemporary Root Canal Preparation

Innovations in Biomechanics

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KEYWORDS

• Nickel titanium • Heat treatment • Glide path • Cyclic fatigue • Corrosion
• Outcomes

KEY POINTS

- *Instrument design:* Current innovations include modifications in helical angle, taper, and longitudinal shape as well as kinematics. The intended improvements are prevention of threading in, less canal transportation, better canal wall preparation, and less fatigue accumulation.
- *Nickel titanium alloy:* There is a trend toward more martensitic (ie, more flexible alloy modifications), which is realized by varying heat treatment, specifically after grinding, so that the martensitic finish temperature for recent instruments is often greater than room temperature.
- *Testing methods:* In the absence of clinical evidence, most information discerning current root canal preparation instruments stems from various in vitro experiments, notably assessment of canal transportation, cyclic fatigue, and corrosion.

INTRODUCTION

Engine-driven instrumentation is a mainstay in root canal therapy as it serves the goal of canal shaping while reducing the number of procedural errors.[1,2] The last decade in instrument development can be characterized by several key strategies:

- The use of more flexible alloys, which not only promise better canal negotiation but also extended fatigue life

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- The introduction of reciprocation motion and the reduction of the number of instruments used per patient
- The design of instruments that physically touch and instrument a larger section of canal wall surface and at the same time decrease the need for coronal flaring

Although nickel-titanium (NiTi) alloy has been in use for root canal instrument manufacturing for more than 25 years, only relatively recently were manufacturing strategies diversified beyond microgrinding that was used for steel burs before (**Table 1**). Heat processing, either during forming the raw NiTi wire or after grinding, have established so-called controlled memory (CM) instruments with high martensitic crystal content may be dead soft and very flexible but only permit about 2% linear strain before nonrecoverable plastic deformation occurs.[3] With these differences in flexibility, distinct differences in fatigue resistance are observed: martensitic files have significantly extended life spans.[3]

Currently most practitioners use electric motors to power rotary instruments. These motors are also undergoing development. The ability to set a torque limit is common to most electric motors, but many models now allow reciprocating action.[4] Although this is not entirely new,[5] several NiTi instruments have been developed entirely for reciprocation motion with unequal angles of rotation. Reciprocation movement has been shown to be efficient and safe.[6] In particular, fatigue life span is extended with reciprocation.[7]

Irrigation effect of infected root canal systems can be facilitated by mechanical forces[8] and perhaps a scraping action of instruments along the canal walls,[9] several techniques were initiated in the last years, beginning with the so-called self-adjusting file[10] and most recently the irrigation enhancement device XP-Endo (FKG, La-Chaux-de-Fonds, Switzerland).

Root canal treatment is frequently discussed in terms of treating apical periodontitis; however, clinical functionality of a tooth for an extended period is an important

Table 1
Summary of current innovative nickel-titanium root canal preparation instruments

Name	Manufacturer	Key Innovations	Production Process
HyFlex EDM	Coltene	Manufacturing process	Electrical discharge machining
ProTaper Gold	Dentsply Maillefer	Alloy	Grinding, heat treatment
ProTaper Next	Dentsply Maillefer	Off-center cross section	Grinding, heat treatment
SAF	ReDent Nova Henry Schein	Longitudinal design, concept, manufacturing	Laser cutting, heat treatment
TRUShape	Dentsply Tulsa Dental	Longitudinal design, concept	Grinding, heat treatment, form pressing
Vortex Blue	Dentsply Tulsa Dental	Alloy, variable helical angle	Grinding, heat treatment
WaveOne Gold	Dentsply Maillefer	Alloy, variations in rectangular cross sections	Grinding, heat treatment
XP-Endo	FKG/Brasseler	Manufacturing process, concept	Grinding, heat treatment, form pressing