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Efficacy of 3D conforming nickel titanium rotary instruments in eliminating canal wall bacteria from oval-shaped root canals

Eduardo A. Bortoluzzi [a,1], *Daniel Carlon Jr.* [b,1], *Mohamed M. Meghil* [b], *Ahmed R. El-Awady* [b], *Lina Niu* [c], *Brian E. Bergeron* [b], *Lisiane Susin* [b], *Christopher W. Cutler* [b], *David H. Pashley* [b], *Franklin R. Tay* [b,*]

[a] *Discipline of Endodontics, Department of Dentistry, Federal University of Santa Catarina, Florianópolis, Santa Catarina, Brazil*

[b] *College of Dental Medicine, Georgia Regents University, Augusta, GA, USA*

[c] *State Key Laboratory of Military Stomatology, Department of Prosthodontics, School of Stomatology, The Fourth Military Medical University, Xi'an, China*

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ABSTRACT

Objectives: To evaluate the effectiveness of TRUShape® 3D Conforming Files, compared with Twisted Files, in reducing bacteria load from root canal walls, in the presence or absence of irrigant agitation.

Methods: Extracted human premolars with single oval-shaped canals were infected with *Enterococcus faecalis*. Teeth in Group I ($N = 10$; NaOCl and QMix® 2in1 as respective initial and final irrigants) were subdivided into 4 subgroups: (A) TRUShape® instrumentation without irrigant activation; (B) TRUShape® instrumentation with sonic irrigant agitation; (C) Twisted Files without irrigant agitation; (D) Twisted Files with sonic irrigant agitation. To remove confounding factor (antimicrobial irrigants), teeth in Group II ($N = 10$) were irrigated with sterile saline, using the same subgroup designations. Specimens before and after chemomechanical débridement were cultured for quantification of colony-forming units (CFUs). Data from each group were analyzed separately using two-factor ANOVA and Holm-Sidak multiple comparison ($\alpha = 0.05$). Canal wall bacteria were qualitatively examined using scanning electron microscopy (SEM) and light microscopy of Taylor-modified Brown and Brenn-stained demineralised sections.

Results: CFUs from subgroups in Group I were not significantly different ($P = 0.935$). For Group II, both file type ($P < 0.001$) and irrigant agitation ($P < 0.001$) significantly affected log-reduction in CFU concentrations. The interaction of these two factors was not significant ($P = 0.601$). Although SEM showed reduced canal wall bacteria, bacteria were present within dentinal tubules after rotary instrumentation, as revealed by light microscopy of longitudinal root sections.

Conclusions: TRUShape® files removed significantly more canal wall bacteria than Twisted Files when used without an antibacterial irrigant; the latter is required to decontaminate dentinal tubules.

Clinical significance: Root canal disinfection should not be focused only on a mechanistic approach. Rather, the rational choice of a rotary instrumentation system should be combined with the use of well-tested antimicrobial irrigants and delivery/agitation techniques to establish a clinically realistic chemomechanical débridement protocol.

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* *Corresponding author at*: Department of Endodontics, College of Dental Medicine, Georgia Regents University, Augusta, GA 30912-1129, USA. Tel.: +1 706 7212606; fax: +1 706 7218184.
E-mail address: ftay@gru.edu (F.R. Tay).

[1] These authors contributed equally to this work.

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1. Introduction

One of the aims of instrumentation of infected root canals is to remove the inner layer of biofilm-covered intraradicular dentine with dentinal tubules that are infected by bacteria.[1,2] Most nickel titanium rotary instruments are designed to rotate concentrically along a straight axis, thereby creating only a small "surface of revolution".[3] The mechanical débridement efficacy of these instruments is low because of their inability to optimally contact all the canal walls during rotation.[4–8] Thus, the capacity of these instruments to reduce intracanal bacteria load is not significantly different from what may be achieved using hand filing.[9–12] To date, the general consensus is that antibacterial irrigants have to be delivered to the instrumented canal space via agitation techniques, after the use of rotary instruments, to further reduce the intracanal bioburden.[13–15] Whilst it is beyond doubt that canal instrumentation facilitates delivery of irrigants to the apical third of the canal space, unnecessary removal of intraradicular dentine may occur during shaping of oval-shaped canals by these nickel titanium rotary instruments.[16–19]

These limitations led to alternative nickel titanium rotary instrument design concepts that are targeted at conforming to the cross-sectional shape of the canal space during shaping procedures. One example is the Self Adjusting File System (ReDent-Nova, Ra'anana, Israel) that incorporates an expandable/collapsable stent design.[20] Apart from being more conservative in removing intraradicular dentine,[20–23] these files were reported to promote better cleaning[24,25] and disinfection of canal wall biofilms.[26,27] Nevertheless, other studies were unable to demonstrate the superiority of these canal-conforming files over conventional nickel titanium rotary instruments in reducing intracanal bacteria load.[28,29]

A more recent rotary instrument design concept incorporates an S-curve in the instrument's longitudinal axis to produce a generatrix (line/curve whose motion generates a surface/solid) that establishes a larger surface of revolution in the Euclidean space.[30] Known as TRUShape® 3D Conforming Files (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA), this system is available in three file sizes, each with a variable regressive 0.06 taper to a maximum flute diameter of 0.80 mm (Fig. 1). According to the manufacturer, these instruments enable dentine preservation during root canal shaping to maintain the integrity of the root structure.

Because of their perceived increase in the surface of revolution, TRUShape® files have the potential to reduce intracanal bacteria load more effectively than conventional nickel titanium rotary instruments. The present study examined the efficacy of this canal-conforming file system in eliminating bacteria from the walls of oval-shaped canals. The null hypothesis tested was that there is no difference between a canal-conforming file system and a conventional nickel titanium rotary instrument system in eliminating canal wall bacteria, in the absence or presence of sonic irrigant agitation.

2. Materials and methods

Ninety extracted caries-free human single-rooted maxillary premolars with oval-shaped canals were stored in 0.9% sodium chloride containing 0.02% sodium azide at 4 °C. The use of extracted human teeth without patients' identity for biomedical research was approved by the human assurance committee of Georgia Regents University. Each tooth was radiographed mesiodistally to confirm the presence of a single oval-shaped canal. After access, a size-15 stainless steel file was used to establish a glide path to working length. Each canal was irrigated with 6.15% sodium hypochlorite (NaOCl) delivered via a 30-gauge side-vented irrigation probe (ProRinse®; Dentsply Tulsa Dental Specialties). The teeth were stored in 10% sodium thiosulphate ($Na_2S_2O_3$) for 4 h and sterile saline for 20 h to neutralise the substantivity effect of NaOCl. The apical foramina of each root were covered with sticky wax to simulate a periapical lesion (Fig. 2-i). Each tooth was mounted in polyvinylsiloxane (Fig. 2-ii); after removal of the wax, the tooth was autoclaved at 121 °C and 15 psi for 20 min.

Enterococcus faecalis derived from the root canal of a pulpless tooth (ATCC 4082; American Type Culture Collection, Manassas, VA, USA) was chosen as the test microbe because it is

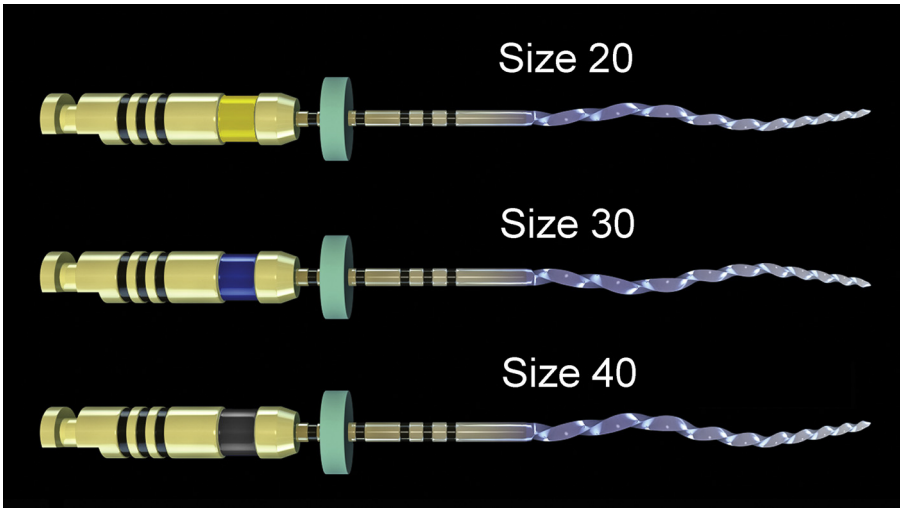

Fig. 1 – Complete set of three TRUShape® 3D Conforming Files.