# Microscopic computerized tomographic evaluation of root canal transportation prepared with twisted or ground nickel-titanium rotary instruments

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***Objective.*** The aim of this study was to evaluate, ex vivo, canal transportation and the centering ability of nickel-titanium rotary instruments manufactured by twisting and by traditional grinding, with the use of microscopic computerized tomography (μCT).
***Study design.*** Fifteen mandibular molars were embedded in a rubber-based impression material and submitted to μCT before and after instrumentation. Images were reconstructed, and cross-sections corresponding to distances 1, 2, 3, 4, 5, 6, and 7 mm from the anatomic apex were selected for analysis. Statistical analysis was performed with Mann-Whitney test.
***Results.*** Canal transportation and centering ability results were similar for both instruments. Statistically significant differences ($P < .05$) were observed only at the 3 and 4 mm cross-sections, with lower levels of apical transportation and a better centering ratio associated with twisted instruments than with ground instruments.
***Conclusions.*** Our findings showed that twisted and ground instruments behaved similarly, allowing the preparation of curved canals with little transportation, which occurred in both mesial and distal directions. **(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:e143-e148)**

Despite ongoing research aimed at consolidating a safe instrumentation technique, one that promotes effective cleaning and shaping and does not cause root canal transportation, the need to enlarge curved canals and at the same time preserve dental anatomy will always involve the challenge of selecting appropriate endodontic instruments. After the introduction of instruments manufactured from nickel-titanium alloys (NiTi)[1] there was a significant improvement of the quality of root canal shaping, with predictable results and less iatrogenic damage, even in severely curved root canals.[2] Moreover, in the past few years, important modifications to the design and manufacturing process of rotary instruments have been proposed with the aim of increasing their reliability, effectiveness, and safety.[2,3]

Instruments manufactured by twisting are based on a concept that differs completely from all other endodontic instruments currently available. By using a heating and cooling process (R-phase), the instruments are twisted and cutting flutes created.[4] According to the manufacturer, the heat treatment used, the twisting manufacturing process, and the advanced surface conditioning/deoxidation treatment to which the instruments are submitted significantly increase their flexibility and resistance to cyclic fatigue, allowing them to remain in a central position even in severely curved canals.[5]

Different methodologies have been used to assess the effects of different endodontic instruments on canal transportation. Classical in vitro methods of studying the morphologic characteristics of root canal systems either produce an irreversible change in the specimen or provide only a 2-dimensional projected image.[6,7]

Computerized tomography (CT) has been shown to be useful in endodontic evaluations, because it nondestructively measures the amount of dentin removed from root canal walls.[8-10] The major disadvantages of CT are low resolution and difficulties when assessing the effects of root canal instrumentation techniques in the apical third.[11]

In this scenario, special attention has been paid to microscopic CT (μCT), which allows both quantitative

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and qualitative assessments of the canal in 3 dimensions.[12-14] Although earlier studies have assessed twisted and ground instruments regarding cyclic fatigue and fracture,[5,15-17] there are no reports available in the literature describing canal transportation associated with these 2 types of instruments, assessed with the use of μCT.

Therefore, the aim of the present ex vivo study was to examine the effect of the different manufacturing methods (ground vs. twisted) on the amount and direction of root canal transportation and on the instruments' centering ability.

## MATERIALS AND METHODS

The study protocol was approved by the Research Ethics Committee at the School of Dentistry, University of São Paulo (USP; protocol no. 161/2008), São Paulo, Brazil.

Fifteen mandibular molars with intact pulp chambers, fully formed roots, 2 mesial canals with independent foramina, severe curvature (25-35°),[18] and a curvature radius <10 mm[19] were selected from the human permanent tooth bank of the School of Dentistry at USP.

Tooth size was standardized at 18 mm by grinding the occlusal surfaces with a diamond disk (Buehler, IL, USA). After surgical access, the mesial canals were instrumented using K file sizes 10 and 15 (Maillefer, Ballaigues, Switzerland) until the tip of the file became visible at the apical foramen with the help of an operating microscope (Alliance, São Paulo, Brazil), at ×8 magnification. Working length was established 1.0 mm short of the distance measured on the K file.

Teeth were embedded in high-precision rubber-based (vinyl polysiloxane) impression material (Vigodent, Rio de Janeiro, Brazil), with the access cavities facing down, and were mounted on a holder with an internal diameter of 15 mm.[20] The negative replicas of the coronal structure and of the access cavity allowed for precise repositioning of the tooth on the holder for the acquisition of pre- and postoperative μCT scans.

Specimens were scanned with the use of an x-ray microtomograph (SkyScan 1172; Aartselaar, Belgium) at a voltage of 89 kV and a current of 112 μA, with a 0.5-mm aluminum filter. Cross-section radiographs were produced at a resolution of 11.84 μm, from multiple angle projections along 180 degree rotation, at every 0.4 degrees. Each specimen was scanned for a total of 45 minutes.

Pre- and postoperative distances were measured using the CTan software (SkyScan 1172). Axial sections corresponding to distances 1, 2, 3, 4, 5, 6, and 7 mm from the anatomic apex were selected (Fig. 1), and distances between the edges of uninstrumented canals and the root edges were measured in mesial and distal directions. After instrumentation, the same reference points were adopted for the acquisition of postoperative measurements (Fig. 2).

### Root canal instrumentation

Before the use of the rotary systems, cervical interferences were removed with Gates-Glidden burs size 2 and 3 (Maillefer) in a crown-down movement, with a penetration depth of 3 mm, which corresponds to the head size of the Gates-Glidden bur size 3. Mesiobuccal canals were instrumented with the Twisted File system (TF group; SybronEndo, Orange, CA, USA), and mesiolingual canals were instrumented with the EndoSequence system (ES group; Brasseler, Savannah, GA, USA), using the crown-down technique according to the manufacturers' instructions. Instruments were used following a predetermined size/taper sequence (30/0.06, 25/0.06, and 25/0.04), coupled to an electric motor (X-Smart; Maillefer) at a constant speed of 500 rpm and no torque control.

Instruments were used 5 times and then discarded. At each instrument change, root canals were irrigated with 3 mL 1% sodium hypochlorite (Fórmula e Ação, São Paulo, Brazil). Final irrigation was conducted with 5 mL 17% EDTA (Fórmula e Ação), followed by 5 mL 1% sodium hypochlorite.

### Canal transportation

Canal transportation was calculated in millimeters with the formula $[(X1 - X2) - (Y1 - Y2)]$, as described by Gambill et al.,[21] where X1 is the distance between the mesial portions of the root and the uninstrumented canal, X2 is the distance between the mesial portions of the root and the instrumented canal, Y1 is the distance between the distal portions of the root and the uninstrumented canal, and Y2 is the distance between the distal portions of the root and the instrumented canal (Fig. 2). Pre- and postoperative measurements were compared to reveal the presence or absence of deviations in canal anatomy and to identify the most affected region.

### Centering ability

The centering ratio, which measures the ability of the instrument to remain in a central position within the canal, was calculated for each cross-section using the values obtained in the assessment of root canal transportation, using the ratio of $(X1 - X2)$ to $(Y1 - Y2)$.[21]

Whenever these numbers were not equal, the lower figure was considered to be the numerator of the ratio. According to this formula, a result of 1 indicates optimal centering ability.