Vertical Load Induced with Twisted File Adaptive System during Canal Shaping

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Abstract

Introduction: To evaluate the vertical load induced with the Twisted File Adaptive (TFA; SybronEndo, Orange, CA) system during canal shaping of extracted teeth by comparing it with the Twisted File (TF, SybronEndo), ProTaper Next (PTN; Dentsply Maillefer, Ballaigues, Switzerland), and ProTaper Universal (PTU, Dentsply Maillefer) systems. **Methods:** Fifty-two root canals were shaped using the TFA, TF, PTN, or PTU systems (n = 13 for each system). They were shaped gently according to the manufacturers' instructions. During canal shaping, vertical loads were recorded and shown in 2 directions, apically and coronally directed loads. The vertical peak loads of 3 instrumentation stages were used for comparison. The effects of rotary systems on the mean positive and negative peak loads were analyzed statistically using the Kruskal-Wallis and Mann-Whitney tests at a confidence level of 95%. **Results:** The overall pattern of the instantaneous loads appeared to increase with the use of successive instruments within the system. During canal shaping in all groups, the apically and coronally directed peak loads ranged from 0.84–7.55 N and 2.16–2.79 N, respectively. There were significant differences in both peak loads among the tested systems at each instrumentation stage. TFA had the lowest apically directed peak loads. In terms of coronally directed peak loads, the TFA and TF had a significantly lower amount of loads developed with their instruments than PTN and PTU. **Conclusions:** The choice of instrument system had an influence on the loads developed during canal shaping. TFA instruments were associated favorably with the lowest values of peak loads followed by TF, PTN, and PTU. *(J Endod 2016;42:1811–1814)*

Key Words

ProTaper next, ProTaper Universal, Twisted File, Twisted File Adaptive, vertical load

Significance

Clinically, TFA instruments might be safely used to shape canals because they were associated favorably with the lowest values of peak loads followed by TF, PTN, and PTU.

Canal shaping is considered a crucial step of root canal treatment when instrumentation should be achieved to provide a space for irrigation, medication, and obturating materials. It can be achieved by the use of nickel-titanium (NiTi) rotary instruments, which are widely attractive among dentists because of greater flexibility, improved cutting ability, lesser amount of canal transportation, and more rapid and centered root canal shaping compared with stainless steel instruments (1, 2). However, they tend to unexpectedly fracture because of flexural fatigue and/or torsional failure (1, 3).

In an attempt to improve the clinical performance and safety of instruments during canal shaping, significant enhancements in the design, control of the raw materials, and motion kinematics for file instruments have been made (4–8). Changes in instrument performance have been shown to reduce the amount of vertical loads, which, in turn, could decrease the torque and extend the fatigue life (9). Several variations in the design and raw materials were used in the fabrication of endodontic file instruments, which have great influence on file properties (6, 7, 10). Furthermore, compared with continuous motion, instruments' alternating motion in clockwise and counterclockwise directions was reported to produce different stress points along the instrument and canal wall during canal shaping, which may show superior resistance to instrument fracture and fewer dentinal crack formations, respectively (8, 11).

The Twisted File (TF; SybronEndo, Orange, CA) system is manufactured by transforming an austenitic NiTi wire to R-phase through a thermal process. In the R-phase, the wire is twisted along with repeated heat treatment. Recently, a new version of this system, the Twisted File Adaptive (TFA) system, has been launched; this system uses a special motion that automatically adapts the motion to a continuous rotary or reciprocating motion based on the imposed intracanal stress over the instrument during canal shaping. The manufacturer claimed that the adaptive technology and twisted file design improve flexibility and debris removal and selectively use the reciprocal motion when the instrument engages dentin (7, 12).

ProTaper Universal (PTU; Dentsply Maillefer, Ballaigues, Switzerland) instruments are manufactured from the conventional NiTi alloy with a progressive taper over the length of the cutting blades. Recently, ProTaper Next (PTN; Dentsply Maillefer, Ballaigues, Switzerland) was introduced; its instruments are made from martensitic NiTi wire in an offset design with progressive and regressive tapers (13).

To better minimize the incidence of instrument fractures, biomechanical studies investigated the load and torque parameters that are induced during canal shaping (14–19). These parameters were shown to be affected by a variety of factors such as

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the contact area between the instrument and the canal walls, instrument geometry and design, preoperative canal volume, and instrument motion kinematics (8, 15, 17, 18). Based on these, determining the load needed by different rotary instruments to shape a root canal is clinically substantial. Several experiments and protocols have been proposed to study the loads developed during canal shaping on extracted teeth or synthetic canals with different rotary systems (13, 15–23). However, the vertical shaping load developed with the TFA system has not been adequately addressed. Therefore, the aim of this study was to evaluate the amount of vertical load induced with TFA instruments during canal shaping compared with the TF, PTN and PTU instruments. The null hypothesis tested was that there was no difference among the experimental rotary systems in terms of the vertical loads.

Materials and Methods

Teeth Selection

Fully erupted, defect-free human premolar teeth were obtained from a pool of extracted human teeth. The reasons for extraction and the age of the patients at the time of extraction were deidentified. The teeth were stored immediately in distilled water and used in the current study. Periapical radiographs were taken in the proximal view to verify the teeth as having small canals with a curvature no more than 10°. After access cavity preparation, the root canal was defined as a narrow canal by inserting a size 15 K-file that would bind no less than 3 mm from the canal length. Otherwise, the tooth was excluded. According to these criteria, 52 root canals were selected.

Mounting of Roots

The apical tip of the tooth was covered with utility wax, and the tooth was embedded in a mixed autopolymerizing resin (DuraLay; Reliance Dental Mfg Co, Worth, IL), covering the tooth root surface and surrounding the wax. After the resin was set, the utility wax was removed.

Root Canal Shaping

The working length (WL) was determined by placing a size 10 K-file down in the canal until the file was just flush with the apical foramen. The distance from the reference plane in the occlusal direction to this flush level minus 0.5 mm was defined as the WL of the root canal. According to the canal curvature, the root canals were randomly distributed into 4 experimental groups with 13 canals each, and no significant differences among the groups were found as confirmed by 1-way analysis of variance ($P = .73$).

In the beginning, the mechanical glide path was performed with size 08, 10, and 15 stainless steel K-files (SybronEndo, Orange, CA) at the WL. All canals were shaped to the full WL with 3 instruments in 3 stages. Canals in the TFA group were shaped with the TFA program using the Elements Motor (SybronEndo) in the sequence of SM1, SM2, and SM3 instruments. In the TF, PTN, and PTU groups, the canals were shaped using a digital torque control motor (DTC, SybronEndo) under continuous motion. In the TF group, SM1, SM2, and SM3 instruments were sequentially inserted to the WL at a speed of 500 rpm and a torque of 2 Ncm. In the PTN group, canal shaping was completed with the sequence of X1, X2, and X3 instruments to the WL at a speed of 300 rpm and a torque of 2 Ncm. Canals in the PTU groups were shaped initially with S1 and S2 until the WL − 1 mm at a speed of 300 rpm and a torque of 2 and 1.5 Ncm, respectively. Then, F1, F2, and F3 were used sequentially to prepare the canals to the WL at a speed of 300 rpm and a torque of 2 Ncm.

Shaping of the canals was performed by an experienced operator with the tested systems. Each canal was shaped gently with a slight in-and-out instrument movement of 2 mm until the WL was reached. After each instrument use, the canal was irrigated with 1% sodium hypochlorite solution, and canal patency was controlled with a size 10 K-file. Each rotary instrument was used in 4 canals or until there was evidence of deformation or fracture.

Vertical Load Measurements

A force gauge (M5-20 Advanced Digital Force Gauge; Mark-10 Corporation, Long Island, NY) with a load capacity for 100 N was used for recording real-time shaping loads and showing them using MESUR Lite software (Mark-10 Corporation). The vertical loads were shown in 2 directions, apically and coronally directed loads. The former represented the positive load needed to introduce the instrument into the canal, and the latter represented the negative load developed when the instrument was withdrawn from the canal against frictional resistance. The force gauge accuracy was ensured by loading it with a calibrated weight. The tooth was set on a fixed stage, and the force gauge was zeroed before each use. The vertical peak loads of the 3 shaping stages were used for comparison. The total active instrumentation time was recorded.

Data Analysis

The effects of rotary systems on instrumentation time and mean positive and negative peak loads were analyzed using the Kruskal-Wallis and Mann-Whitney tests. All statistical analyses were performed using SPSS software version 22 (SPSS Inc, Chicago, IL) at a confidence level of 95%.

Results

Vertical load profiles were drawn to show the instantaneous loads induced during canal shaping (Fig. 1*A* and *B*). The overall pattern of the instantaneous load appeared to increase with the use of successive instruments within the system (Fig. 1). All the canals were shaped with 3 sequential instruments to the full WL. Their mean and standard deviation values of positive and negative peak loads (N) for each instrument are shown in Figure 2.

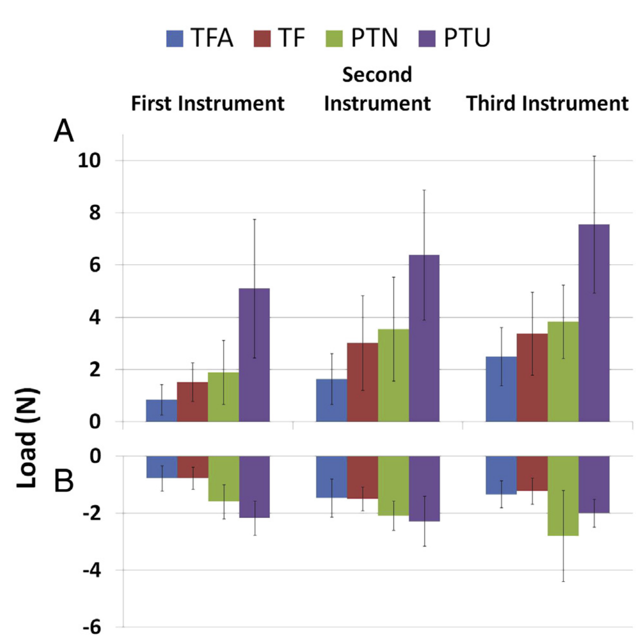

Figure 1. The mean and standard deviation of peak values of (*A*) apically and (*B*) coronally directed loads for each instrument in the tested systems. The first, second, and third instruments represent the instrument sequence that reached the full WL.