Suboptimal Debridement Quality Produced by the Single-file F2 Protaper Technique in Oval-shaped Canals

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Abstract

Introduction: The aim of this study was to determine whether the debridement quality of the single-file F2 ProTaper instrumentation technique is comparable to a full conventional ProTaper sequence in both round and oval-shaped root canals. **Methods:** Fifty-four recently extracted vital lower incisors were instrumented with either a full range of ProTaper Universal instruments in rotary motion (group 1) or with the single-file F2 ProTaper technique in reciprocating motion (group 2). Teeth were previously classified as round or oval-shaped by means of bidirectional radiographs, resulting in 24 round canals, 24 oval canals, and 12 controls. After instrumentation, the roots were demineralized, and the apical 3 mm was multi-sliced and processed for histologic examination. The percentage of residual pulp tissue (PRPT) was calculated with the aid of image analysis software. Univariate analysis of variance was used to verify the variables influencing PRPT. **Results:** Both canal shape and technique significantly influenced PRPT ($P < .05$). Oval-shaped canals displayed much more PRPT than round canals in both techniques ($P < .05$). The difference in PRPT between the techniques depended on the root canal shape, since a significant interaction between canal shape and technique was observed ($P < .05$). Group 1 displayed considerably less PRPT in oval canals than group 2 ($P < .05$), whereas in round canals no significant difference was found between the 2 techniques ($P > .05$). **Conclusions:** The single-file F2 ProTaper technique displayed similar PRPT to the full range of ProTaper instruments in round canals. However, the debridement quality of the single-file F2 ProTaper technique was suboptimal in oval canals. *(J Endod 2010;36:1897–1900)*

Key Words

Instrumentation, ProTaper, reciprocate movement, root canal preparation, single file technique

Proper cleaning and shaping of the whole root canal space have been recognized as a real challenge, particularly in curved, narrow, or oval-shaped canals (1–6). By using the reliable micro-tomography method, Peters et al (6) reported that nickel-titanium (NiTi) instruments left about 35% of untouched root dentin surfaces. This deficient mechanical preparation could offer an opportunity for remaining microorganisms to recolonize the filled canal space, resulting in endodontic failure.

In 2008, a new preparation technique using only the F2 ProTaper instrument in a reciprocating movement was published (7). The concept of using a single NiTi instrument to prepare the entire root canal is interesting, because the learning curve is considerably reduced as a result of technique simplification. Moreover, the use of a single NiTi instrument is more cost-effective than the conventional multi-file NiTi rotary systems.

Although the first clinical impressions of the single-file F2 ProTaper technique appear promising (7), other important parameters still need to be properly assessed by both laboratory and clinical studies. Root canal debridement, for instance, is considered an important goal to be achieved after mechanical instrumentation of the root canal and is frequently measured in terms of cleaning efficacy (2–5, 8). In fact, the technique proposed by Yared (7) has never been assessed in terms of debridement quality. In the present study, we sought to evaluate the amount of residual pulp tissue after the use of either the full range of ProTaper instruments or the single-file F2 ProTaper technique in both round and oval canals. Two null hypotheses were tested: (1) there is no significant difference in debridement quality promoted by conventional full sequence of the ProTaper Universal NiTi files and the single-file F2 ProTaper technique in circular-shaped canals; (2) there is no significant difference in debridement quality promoted by conventional full sequence of the ProTaper Universal NiTi files and the single-file F2 ProTaper technique in oval-shaped canals.

Materials and Methods

In Vivo Prospective Selection Process of Vital Teeth

One hundred twenty-two adult subjects voluntarily participated in the present study, which was revised and approved by the Ethics Committee. Teeth were scheduled for extraction because of advanced periodontal disease or non-restorability.

With the purpose of collecting just vital mandibular incisor teeth, an analysis of tooth pulpal vitality was initially performed by using Green Endo-Ice refrigerant spray (Hygenic, Akron, OH). After a positive response to the vitality test, teeth were then isolated and accessed, and if the bleeding pulp was also confirmed, the tooth was included

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for the study. In the absence of pulp hemorrhage, the tooth was excluded. After each extraction, teeth were immediately placed into a vial containing 10 mL of buffered 10% formalin labelled with a random 4-digit alphanumeric code corresponding to 1 of the 4 experimental groups.

For 6 months (August 2009–January 2010) following the above-mentioned selection process, 98 mandibular incisor teeth were collected. Radiographs were taken in buccolingual and mesiodistal directions to select only teeth with a single root canal as well as to categorize them as oval or circular-shaped canals. The space corresponding to the root canal lumen was measured 5 mm from the apex; when the mesiodistal diameter was 2.5 times larger than the buccolingual diameter, the canals were classified as oval-shaped; for round-shaped canals, the mesiodistal diameter had to be similar to the buccolingual diameter. All teeth presenting isthmus, lateral, or 2 canals had been eliminated. Furthermore, only root canals with an initial apical size equivalent to size 10 K-file were selected. As a result, just 54 incisor teeth fit the selection criteria. From the selected sample, 24 teeth were classified as circular-shaped and 24 as oval-shaped root canals. The 6 remaining teeth were used as histologic controls.

Root Canal Preparation

A common silicone impression material was used to simulate the bony socket site. Tooth length was standardized to 18 mm, and the root canal patency was confirmed by inserting a size 10 instrument. The working length was established at the apical foramen.

The use of different instrumentation techniques in both oval-shaped and circular-shaped root canals resulted in 4 experimental groups with 12 specimens each. Teeth for both experimental and control groups were randomly assigned with the aid of a computer algorithm (http://www.random.org).

For both groups, 1 mL of 5.25% NaOCl solution was used between each instrument. To standardize the final irrigation volume used in the experimental groups, the volume of NaOCl was changed according to the number of instruments used in each technique. Thus, a total volume of 18 mL of NaOCl per treatment was used. The smear layer was removed with 3 mL of 17% ethylenediaminetetraacetic acid for 3 minutes. Three milliliters of bi-distilled water was used for 3 minutes as a final flush.

Twenty-four teeth (12 circular-shaped and 12 oval-shaped canals) were prepared with the ProTaper Universal instruments (Dentsply Maillefer, Ballaigues, Switzerland) driven at 300 rpm and 2 N/cm of torque (XSmart; Dentsply-Maillefer) under rotary motion (group 1). The sequence was the following: (1) S1 file (1/3 of the working length [WL]); (2) SX file (1/2 of the WL); (3) S2 file (2/3 of the WL); and (4) F1 and (5) F2 files (full WL). Therefore, all the canals in this group were instrumented with 5 NiTi instruments.

The other 24 teeth (12 circular-shaped and 12 oval-shaped canals) were prepared by the single-file F2 ProTaper technique (7); rotational speed was set at 400 rpm, and the F2 instrument was driven with ATR Teknica electric micromotor (Pistoia, Tuscany, Italy) under reciprocating movement (group 2).

Histologic Assessment

Specimens were immediately immersed in 10% buffered formalin for 48 hours and then demineralized in 22.5% (vol/vol) formic acid solution and 10% (wt/vol) sodium citrate solution for a period of 2–3 weeks. The end point was monitored radiographically. After rinsing for 24 hours in tap water, the specimens were dehydrated and processed for histologic examination. Teeth were embedded in paraffin wax, and 0.6-μm–thick serial cross sections were obtained, taking every 0.3 mm from the 1–5 mm apical levels. As a result, a total of 12 slides were prepared per tooth. Sections were mounted on glass slabs and stained with hematoxylin-eosin.

Morphometric Evaluation

The specimens were visualized in Axioplan 2 Imaging fully motorized light microscope (Carl Zeiss Vision, Hallbergmoos, Germany). Image analysis and processing were completed by using the Axion Vision image 4.5 Zeiss system (Zeiss) to trace the outline of the area of interest. In this way, the cross-sectional areas of each root canal and remaining pulp tissue were measured (μm^2). Furthermore, the percentages of remaining pulp tissue area (PRPT) were calculated for each root canal section.

Statistical Analysis

Univariate analysis of variance (GLM; SPSS 17.0, Inc, Chicago, IL) was used to verify whether either the instrumentation technique or the root canal shape at different levels of evaluation influenced PRPT. Technique and root canal shape were fixed factors, whereas the level of cross section was the random factor.

Results

All microscopic images for the positive control group displayed substantial amount of residual pulp tissue. Thus, the results from the positive control group confirmed the experimental histologic model as well as the efficiency of the prospective *in vivo* collection of the specimens.

Univariate analysis of variance demonstrated that both root canal shape and instrumentation technique significantly influenced the PRPT ($P < .05$). Much more tissue was removed in round canals than in oval ones in both techniques ($P < .05$). The shape of the canal significantly influenced the result of the technique, which can be seen by the significance in the interaction between canal shape and technique ($P < .05$). Group 1 removed significantly more pulp tissue than group 2 in oval canals ($P < .05$), whereas there was no difference between techniques in round canals ($P > .05$). The level of cross section did not influence the PRPT ($P = .325$). The descriptive data are displayed in Table 1.

Discussion

The present results show no differences in the debridement quality of circular-shaped canals prepared by the conventional full sequence of ProTaper Universal NiTi files and the single-file F2 ProTaper technique. Therefore, the first null hypothesis was accepted. On the other hand, the oval-shaped canals prepared by conventional ProTaper full sequence displayed significant improvement in debridement quality than those prepared with the single-file F2 ProTaper technique. Thus, the second null hypothesis tested was rejected.

Recently, Taha et al (1) reported that the wide variation among different teeth prepared by the same technique appears to result

TABLE 1. Mean and Standard Deviation (±SD) of PRPT Left by Each Technique on Roots of Different Canal Shapes

Root canal shape	Technique	Mean, % (±SD)
Oval*	ProTaper	0.097 (±0.09)†
	F2	0.179 (±0.12)†
Round*	ProTaper	0.01 (±0.04)
	F2	0.01 (±0.03)

*Significant differences between canal shapes.

†Significant differences between techniques.