

Original Research Article

Histological evaluation of refinement influence in the cleaning efficacy of rotary nickel-titanium ProTaper® instruments in oval-shaped root canals

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Abstract

Objective: The aim of this *in vitro* study was to evaluate the cleaning and shaping efficacy of rotary nickel-titanium ProTaper® instrumentation in oval canals and the influence of ultrasonic irrigation on the final refinement. **Material and methods:** Twenty mandibular molars were accessed and divided in two groups. Only distal roots with oval canals were used. Group I was instrumented using only rotary nickel-titanium ProTaper® instruments. Group II received the same preparation followed by refinement with 3 minutes of ultrasonic passive irrigation. After preparation, the distal roots were sectioned for histological processing. Coronal, middle and apical thirds were analyzed. Uninstrumented perimeter in each third was measured by the software *Image tool 3.0*. **Results:** The percentage of uninstrumented perimeter was calculated for each third of each root and average percentage was calculated for each third in both groups. Statistical analysis was performed with t-test through the software SPSS 11.0.1 for Windows. The level of significance was set at 1%. Group I showed higher percentage of uninstrumented perimeter in all thirds. Group II, which received ultrasonic irrigation showed better results in all thirds ($p < 0.01$). Comparing the three

thirds in the same group, no statistically significant differences were found ($p > 0.05$). **Conclusion:** Under the conditions of this *ex vivo* study, the three minutes use of ultrasonic irrigation after rotary instrumentation resulted in significantly more instrumented walls in the distal roots of mandibular molars.

Introduction

The mechanical preparation of root canals plays a significant role in endodontic therapy [12]. One of the objectives of the root canal preparation is to clean and shape the root canal system while maintaining the original configuration. It provides a progressive conical shape toward the apex, which offers a shape conducive to the placement of three dimensional filling of the root canals and all accessory canals [20].

One of the most important steps in any root canal treatment is canal preparation [17] but many methods of preparing root canals mechanically still fail to cleanse root canal systems effectively [20]. Variations in the internal root canal anatomy might be present, making the current instrumentation techniques inefficient at cleaning all surfaces and irregularities within the root canal space [21] and large portions of the canal walls can remain uninstrumented, leaving organic and inorganic debris in the root canal [5]. Therefore, irrigation is an essential part of a root canal treatment as it allows for cleaning beyond the root canal instruments [22].

Stainless steel files probably are still the instruments of choice by most of dentists for cleaning and shaping canals, but rotary-driven nickel-titanium files are gaining rapidly in popularity [6]. A number of studies have shown that rotary nickel-titanium (Ni-Ti) instruments allow more rapid, more centered, rounder and more conservative shaping of canals than stainless steel instruments [11, 19, 24]. However, rotary instrumentation with Ni-Ti files has limited area of action. Due to their super elasticity, it is known that they cannot be pressed against the root canal walls [5]. It may result in a larger flare on one side of the canal wall due to the tendency of creating round preparations, even in oval shaped canals and a few areas may remain uninstrumented [24, 25].

One approach to overcome this limitation is the use of ultrasonic irrigation of the root canal. The use of an ultrasonic irrigating file allowed for the continual deposition and renewal of irrigating solution within the canal [13]. Passive ultrasonic

irrigation relies on the transmission of acoustic energy from an oscillating file to an irrigant in the root canal [22]. The energy is transmitted by means of ultrasonic waves and can induce acoustic streaming and cavitation of the irrigant [1, 2]. As the root canal has already been shaped, the file can move freely and the irrigant can penetrate more easily into the apical part of the root canal system [14, 15] and the cleaning effect will be more powerful [1, 2]. The cleaning efficacy of passive ultrasonic irrigation implies the effective removal of dentine debris, microorganisms (planktonic or in biofilm) and organic tissues from the root canal. Because of the active streaming of the irrigant, its potential to contact a greater surface area of the canal wall will be enhanced [22]. Therefore, it improves the removal of bacteria, pulpal remaining, debris and smear layer from the root canal [7, 23].

The aim of this *ex vivo* study was to evaluate the cleaning efficacy of rotary nickel-titanium ProTaper® instrumentation in oval-shaped canals and the influence of ultrasonic irrigation on the final refinement.

Material and methods

A set of twenty permanent human mandibular molars, except for the third molars, with oval-shaped distal root canals, freshly extracted from patients, were used in this study and approval was obtained from the Ethics Committee of UERJ (University of Rio de Janeiro State). After extraction, teeth were immersed into 5.25% sodium hypochlorite (NaOCl) for 30 minutes and stored into 0.1% thymol solution. Coronal access was made and the patency of each canal was confirmed by inserting a size 10 K-file (Dentsply Maillefer Balaigues, Switzerland) through the apical foramen. The working length was defined by observing under a clinical optical microscope the tip of the file protruding through the apical foramen and subtracting 1mm from the recorded length.

Next, teeth were subdivided into two groups of 10 teeth each. The teeth were prepared by crown-down technique, using rotary instrumentation with

ProTaper® NiTi files (Dentsply/Maillefer, Balaigues, Switzerland) according to the recommended sequence of the manufacturers until the working length achieved a size of #30 (F3).

All teeth were instrumented using an electric endodontic engine (Endo Pro Torque, VK Driller Equipamentos Elétricos, São Paulo, Brazil). The device was adjusted to a 300-rpm constant clockwise speed and to a torque of 2 N.cm. For both groups, canals were flushed with 2 mL of 5.25% sodium hypochlorite (Mil formulas- Farmácia de manipulação, Rio de Janeiro, Brazil) at each change of file and patency was verified with a size #10 K-File (Dentsply/Maillefer, Balaigues, Switzerland).

Group I was cleaned and shaped only by ProTaper® NiTi files. Group II received the same preparation of Group I, followed by ultrasonic irrigation used for final refinement. Final refinement of Group II was conducted with size #20 ultrasonic file at the ENAC ultrasonic unit (Osada Enac, Tokyo, Japan), introduced up to the working length. This file was used for 3 minutes for each tooth, comprising: 1 minute of continuous flush of ultrasonic irrigation and aspiration of distilled water; then the root canal was filled by 5.25% NaOCl and this solution was agitated with the ultrasonic file for another 1 minute; and finally, continuous flush of ultrasonic irrigation and aspiration with distilled water was carried out for more 1 minute.

After preparation, the distal roots were cross-sectioned and only these were used for histological processing. After decalcification, the roots were sectioned with a surgical blade on their coronal, middle and apical thirds. Serial 5- μ m-thick cross-sections of each third of each root were stained with hematoxylin and eosin, and examined with an optical microscope at x40 magnification (Nikon Eclipse E200, Nikon Tokyo, Japan) and images were taken with a digital camera (Nikon Coolpix 5000, Nikon, Japan).

Image analysis and processing were completed using the software *Image tool 3.0* (UTHSCSA, San Antonio, Texas, USA). Through this software, total perimeter of each third of each root canal could be measured, the uninstrumented perimeter in each sample of groups I and II were also analyzed. The percentage of uninstrumented perimeter was calculated for each third of each root and average percentage was calculated for each third in the two groups. Statistical analysis was performed with t-test through the software SPSS 11.0.1 for Windows. The level of significance was set at $p < 0.01$.

Results

Group I showed higher average percentage of uninstrumented perimeter in all thirds. Group II, which received ultrasonic irrigation, showed better results in all thirds ($p < 0.01$) (table I). Comparing three thirds in the same group, no statistically significant difference were found ($p > 0.05$). Figure 1 shows that some canal walls were not touched by the rotary files.

Table I - Comparison of average percentage of uninstrumented perimeter of root canals on each group

	Cervical third	Middle third	Apical third
Group I	51,65%	69,45%	57,73%
Group II	27,99%	30,15%	35,24%



Figure 1 - Apical third cross-section of root canals prepared by ProTaper® rotary files. Some canal walls were not touched by the files

Discussion

Chemo-mechanical preparation is the key to successful endodontic treatment. Its objective is to clean the root canal and its ramifications as thoroughly as possible, creating ideal conditions for tissue regeneration and health [5]. Cleaning and shaping oval-shaped canals represent a real challenge because in most preparation techniques, the final preparation is usually round in one side of the root canal, leaving uninstrumented areas.

This *ex vivo* study investigated the ultrasonic refinement influence in the cleaning efficacy of rotary nickel-titanium ProTaper® instruments in oval root canals.

Cleaning and shaping of root canals is the single most important phase of endodontic treatment [20]. It is very important to remove vital and necrotic pulp tissue, infected dentine and micro-organisms from the root canal system. The ability to achieve some of these objectives was examined in this *ex vivo* investigation on oval shaped root canals using NiTi rotary ProTaper® instruments. Our study, used natural human teeth because their root canal anatomy is remarkably flattened and irregular [12] and may provide conditions that are close to the clinical situation [10]. This aspect of human root canals may increase the difficulty of instrumentation and make it difficult to completely remove debris from isthmus areas [12].

This study showed statistically significant difference between the uninstrumented perimeters when two groups were compared. Group II, which was ultrasonically irrigated for 3 minutes showed better results. Group I, which was instrumented only by ProTaper® files, showed higher average percentage of uninstrumented perimeter in all thirds, leaving uninstrumented extensions and tending to produce round preparations on one side of the oval-shaped root canal. This is in agreement with several previous studies and showed that the rotary instrumentation had limited working area, and was not capable of reaching all root canal walls [5, 7, 8, 18, 25].

In the present study, the cleaning efficiency was histologically examined by measuring the total perimeter and the uninstrumented perimeter on the coronal, middle and apical thirds of each sample. In all samples, uninstrumented areas with remaining debris were found. This finding has also been described by other authors [4, 5, 7, 12]. However, by comparing the three thirds in the same group, no statistically significant differences were found. Foschi *et al.* [9] found presence of several areas of dentine that were not cut and/or shaped only in the apical third when compared with coronal and middle third and suggest the use of a larger master file to remove greater portion of debris from apical third. In their study they use maxillary single canal incisors, mandibular premolars and mandibular canines, and all teeth that presented round canals.

Peters *et al.* [16] evaluated the performance of ProTaper® nickel-titanium instruments shaping root canal classified as “wide” and “constricted” using micro CT. In that study, “wide” canals had a significantly higher proportion of unprepared surfaces than “constricted” canals. The results

suggested that these instruments may be more effective in shaping narrow canals than in wider ones. This may explain the higher average percentage of uninstrumented perimeter in all thirds in the group instrumented only by ProTaper® instruments in our study. The distal canal of mandibular molars is usually wide and oval-shaped and instruments are not able to contact all canal walls. A similar result were obtained by Grande *et al.* [11] that evaluated morphologic differences of two different preparation techniques in shaping oval canals. This study suggested that NiTi rotary instruments do not come in close contact with all the dentinal walls, especially at the middle third.

Although we observed high average percentages of non-instrumented perimeter, the best result was obtained with final ultrasonic irrigation. Activation of the irrigants seems to be advisable to improve chemical dissolution of residual debris and disinfection of the root canal system [3, 8]. Van der Sluis *et al.* [22], in a review of the literature article, says that passive ultrasonic irrigation relies on the transmission of acoustic energy from an oscillating file to an irrigant in the root canal. The energy is transmitted by means of ultrasonic waves and can induce acoustic streaming and cavitation of the irrigant [1, 2]. After the root canal has been shaped the file can move freely and the irrigant can penetrate more easily into the apical part of the root canal system [14] and the cleaning effect will be more powerful [1]. In the present study the apical diameter obtained by ProTaper rotary instrumentation was size #30 and the oscillating file used with ultrasonic irrigation was size #20, consequently we can suppose that acoustic streaming phenomenon was responsible for the best results achieved in the group submitted to the ultrasound action.

Conclusion

In conclusion, under the conditions of this *ex vivo* study, the three minutes use of ultrasonic irrigation after rotary instrumentation resulted in significantly more instrumented walls in the distal roots of mandibular molars.

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