Influence of Hero Apical instruments on cleaning ovoid-shaped root canals

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Abstract: The cleaning capacity of Hero 642 nickel-titanium files, complemented by the Hero Apical instruments in flattened roots, was determined by histological analysis, considering the area of action of the instruments on the coronal walls and the presence of remaining debris. Twenty-four single-canal, human mandibular incisors were divided into three groups and prepared as follows: GI, instrumented with Hero 642 NiTi files 30/.06, 25/.06, 20/.06, 25/.06, and 30/.06; GII, instrumented as GI followed by Hero Apical size 30/.06; GIII, instrumented as GI followed by Hero Apical sizes 30/.06 and 30/.08, then returning to 30/.06 with pendulum movements. The apical thirds were prepared for histological processing, analyzed at 40× magnification and the images were examined morphometrically. Statistical analysis showed that GIII presented the best results for removing debris (5.22% ± 4.13), with more contact between the instruments and the root canal walls (19.31% ± 0.15). This differed statistically from GI (14.04% ± 4.96 debris removal, with 42.96% ± 7.11 instrument contact) and GII (12.62% ± 5.76 debris removal, with 35.01% ± 0.15 instrument contact). Root canal preparation with Hero 642, complemented by Hero Apical instruments (30/.06 and 30/.08, then re-instrumented with Hero Apical 30/.06 using pendulum movements), was more efficient for debris removal and allowed more contact of the instruments with the root canal walls. GII presented the worst results.

Descriptors: Dental Instruments; Root Canal Therapy; Dental pulp; Endodontics.

Introduction

The use of rotary nickel-titanium instruments in endodontics has brought significant contributions to clinical practice in terms of safety, speed, cleanliness and the shaping of root canals.[1-3] These instruments do not follow the ANSI/ADA or ISO/FDI standards, and they present different cross-section designs when compared to conventional manual files.[4] Such innovations aim to produce an ideal preparation, respecting biological and mechanical principles.

Rotary nickel-titanium instruments should be used preferably with the crown-down technique, in which the cervical and middle thirds of the canal are prepared with more tapered instruments, with the taper size decreasing as it reaches the working length.[5-7] This technique reduces the occurrence of aberrations, ledges, zips and instrument fracture; it also

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provides correct initial instrument determination.

Currently, it is well established in the literature that the use of NiTi rotary instruments during preparation of the middle and coronal cross-sections of ovoid-shaped root canals frequently shows circular bulges; yet, the buccal and lingual extensions of the ovoid root canals often remained unprepared.[8-12]

Regardless of the type of instrument or technique applied during root canal preparation, the literature shows that the anatomical variability of teeth is often a complicating factor in root canal treatment. In their study, Plotino *et al*.[13] question whether flexible NiTi instruments allow controlled and complete preparation of such extensions. They state that, to obtain circumferential cleaning and shaping of these recesses, specific instrumentation motions such as "brushing" are recommended for use.

Hero Apical instruments were designed to be used after the Hero 642 instrument sequence in order to improve preparation of the apical third, and to allow the instrument to act circumferentially on root canal walls without altering the shape at the middle and cervical thirds. These instruments are available in two different sizes (30/.06 and 30/.08), with an active working part of only 4 mm, and are to be used after the root canal is prepared to help enlarge the apical region.[14]

Therefore, the aim of this study was to determine, by histological and morphometric analyses, the area of action of the instruments on the canal walls (perimeter) and the presence of remaining debris after instrumentation with Hero 642 nickel-titanium instruments, whether complemented or not by Hero Apical instruments in ovoid canals of mesiodistally flat roots.

Methodology

Twenty-four human mandibular incisors, kept in 0.1% thymol at 9 °C, were used in this experiment. The teeth were washed in running water for 24 h to eliminate remnants of thymol. The study protocol was reviewed and approved by the local Ethics Committee (075/05).

Following conventional access preparation, the cervical and middle thirds were enlarged using NiTi rotary instruments, sizes 25, 0.12 taper, 25, 0.10 taper, and 25, 0.08 taper (Micro-Mega, Besançon, France). They were used serially with a crown-down technique, towards the apex.

Samples were divided into three groups. GI was instrumented with the Hero 642 system (Micro-Mega, Besançon, France), according to the following sequence: 30/.06, 25/.06, 20/.06, 25/.06 and 30/.06. GII received the same instrumentation as GI, followed by the Hero Apical 30/.06 instrument (Micro-Mega, Besançon, France). GIII followed the protocol established for GI, complemented with the Hero Apical instruments 30/.06, 30/.08 and again 30/.06. The use of the 30/.06 Hero Apical instrument for the second time aimed to prepare areas on the buccal and lingual sides of the canal that were not reached previously, since this instrument could be moved more freely, thus allowing a pendulum movement.

Two milliliters of distilled and deionized water were used between instruments, for irrigation during instrumentation.

After root canal preparation, the roots were measured with a digital caliper (Digimess Instrumentos de Precisão Ltda., São Paulo, Brazil) and sectioned at 4 mm distance from the apex (Figure 1).

The apical third of each root was removed for

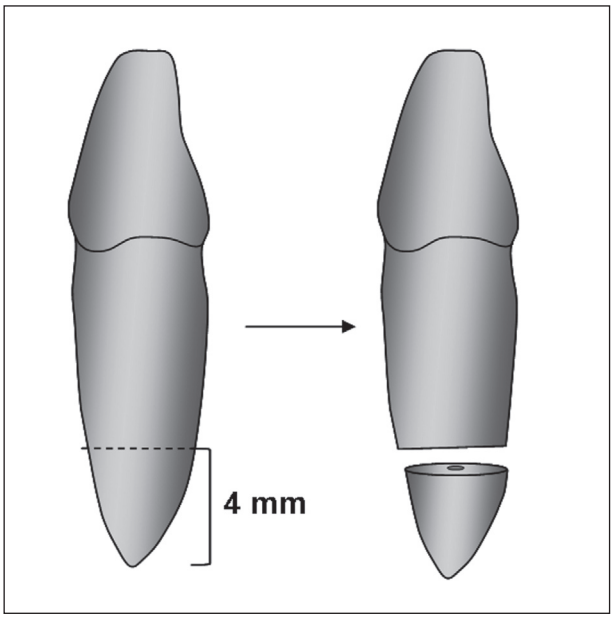

Figure 1 - Diagram showing sectioning of the root at 4 mm from the apex.

histological preparation and stained with hematoxylin and eosin. The images were recorded in tagged image file format (Adobe Premiere 5.1, Adobe Systems Incorporated, San Jose, USA) and evaluated for the percentage of debris and uninstrumented root canal walls. The percentage of debris was calculated by placing an integration grid (Corel Photo Paint 12, Corel Corp., Ottawa, Canada) over the cross-section images, to allow counting of the points in the root canal that coincided with either clean areas or areas containing debris. The action of the instruments on the root canal walls was assessed based on surface regularity, abrupt change in the continuity of the root canal wall, and partial or total predentine removal. The percentage of uninstrumented root canal walls was determined by calculating the length of the canal outline that was not touched by the instruments in relation to the total length of the canal outline, using Scion Image software (Scion Corporation, Frederick, USA) (Figures 2A and 2B).

The mean percentages of remaining debris and uninstrumented root canal perimeter at the apical third, considering different apical enlargement, were statistically compared using the one-way ANOVA with post hoc Tukey tests. Statistical analysis was performed at the 0.05 level of significance using SPSS software version 17.0 (SPSS Inc., Chicago, USA).

Results

Area with debris

Data regarding the area with debris are shown in Table 1. ANOVA showed statistically significant differences between the techniques ($p < 0.01$). The Tukey post-test showed similar results between GI (Hero 642) and GII (Hero 642 plus Hero Apical 30/.06); and, both groups were different from GIII (Hero 642 plus Hero Apical 30/.06, 30/.08 and 30/.06), which presented the lowest amounts of debris in the root canal.

Perimeter of action of the instruments

Table 1 also shows the values, in percentage, found for the perimeter of action of the instruments. ANOVA showed statistically significant differences between the tested techniques ($p < 0.01$). The Tukey post-test showed similar results between GI (Hero 642) and GII (Hero 642 plus Hero Apical 30/.06), which showed the lowest perimeter of action on the root canal walls; and they were different from GIII (Hero 642 plus Hero Apical 30/.06, 30/.08 and 30/.06), which presented greater area of action of the instruments in the root canals.

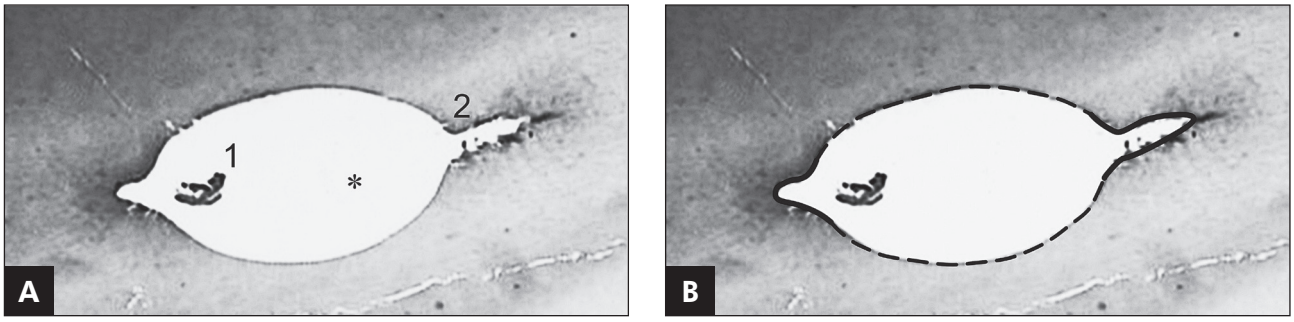

Figure 2 - (A) Apical section of the roots at 40× magnification showing **(*)** clean areas, **(1)** areas with debris, and **(2)** area not touched during instrumentation. **(B)** Determination of the perimeter of action of the instruments (continuous line indicates no-action and non-continuous line shows area with instrument action).

Table 1 - Percentage of the area of the transversal section of the root canal containing debris, and percentage values of the perimeter of the areas unaffected by the instruments.

	GI	GII	GIII
Debris	14.04 ± 4.96 (A)	12.62 ± 5.76 (A)	5.22 ± 4.13 (B)
Perimeter	42.96 ± 7.11 (a)	35.01 ± 0.15 (a)	19.31 ± 0.15 (b)

Equal letters indicate statistically similar results. Small letters indicate 1st row, Capital letters stand for 2nd row.

Discussion

Cleaning of the root canal system is directly related to the action of the instruments and irrigating solutions on their walls during preparation.[8-9] Siqueira[15] emphasized the need for instrumentation to touch all root canal walls and remove substantial amounts of pulp tissue and bacteria, and suggests that the size of the preparation ideally should incorporate anatomic irregularities which can be difficult, and sometimes impossible, to carry out in canals that are not round in their cross-sections. To obtain circumferential cleaning and shaping of these recesses, specific instrumentation motions such as brushing have been recommended for use.[15,16] However, as reported by Plotino *et al.*[13], little information on the preparation of ovoid root canals using NiTi rotary instruments with this specific motion is available in the literature.

These same authors also evaluated cyclic fatigue resistance of Mtwo NiTi rotary instruments, after simulated clinical use, in brushing and non-brushing actions in ovoid root canals. They concluded that fatigue in larger instruments could be reduced by using them with lateral brushing or pressing movements. However, each file was successfully used up to 10 times without intracanal failure.

Although there are contradictory findings in the literature regarding the effects of apical enlargement on the outcome of treatment,[17-21] instrumentation to larger file sizes can also result in increased penetration of the irrigating needle and facilitate better irrigant exchange in the apical third of the root canal.[22-24]

Previous studies report that the Hero 642 instruments are not able to clean the root canals completely, when used alone.[25-27] However, these instruments have been shown to be more effective than others in cleaning ovoid root canals[3]. This is probably due to their lower flexibility, when compared to other instruments that do not have the triple-helix cross-section which allows directing the Hero 642 instruments against the buccal and lingual walls of the root canal during instrumentation.

According to Plotino *et al.*[13], rotary instruments can be used safely in clinical practice with lateral brushing movements; and, only the larger instruments showed slightly more potential for breakage, due to cyclic fatigue stress, than instruments used with non-brushing action.

In this study, 2 mL of distilled water were used between each instrument since the purpose was to evaluate the mechanical action of the instrument and not the chemical action of the irrigant solution.

The best results, obtained for GIII (Hero 642 plus Hero Apical 30/.06, 30/.08 and 30/.06), probably occurred because Hero Apical instruments have a triple-helix cross section, different from a triple-U one.[28] The shank narrows as it approaches the handle, which provides greater flexibility and allows the pendulum movements that were used for GIII. The second use of the Hero Apical 30/.06 instrument allowed the application of these movements directly onto areas left untouched previously. Thus, only 19.2% of the apical region was left unaffected by the instrument.

The same result was observed for the percentage of debris remaining in the root canal after instrumentation, where GIII (Hero 642 plus Hero apical 30/.06, 30/.08 and 30/.06) also presented the best results when compared to the other groups ($p < 0.01$). This was probably due to the increased contact of the instruments in the polar areas of the canal, causing displacement of the pulp tissue adhering to the pre-dentine and facilitating its removal by the physical actions of irrigation-aspiration. Distilled and deionized water were used for irrigation to avoid any kind of chemical action, such as tissue dissolution. Thus, there seems to be a strong relationship between the contact of the instruments with the root canal walls and debris removal.

Knowledge of the mechanical action of nickel-titanium instruments on the root canal walls is necessary to determine protocols that will allow increased contact, and to obtain complete cleaning with the aid of irrigating solutions.

Conclusion

It can be concluded that root canal preparation with Hero 642, complemented by Hero Apical instruments (30/.06 and 30/.08, re-instrumented with Hero Apical 30/.06 in pendulum movements), was more efficient for debris removal and allowed more contact of the instruments with the root canal walls.

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