

Influence of Apical Foramen Lateral Opening and File Size on Cemental Canal Instrumentation

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Since instrumentation of the apical foramen has been suggested for cleaning and disinfection of the cemental canal, selection of the file size and position of the apical foramen have challenging steps. This study analyzed the influence of apical foramen lateral opening and file size can exert on cemental canal instrumentation. Thirty-four human maxillary central incisors were divided in two groups: Group 1 (n=17), without flaring, and Group 2 (n=17), with flaring with LA Axxess burs. K-files of increasing diameters were progressively inserted into the canal until binding at the apical foramen was achieved and tips were visible and bonded with ethyl cyanoacrylate adhesive. Roots/files set were cross-sectioned 5 mm from the apex. Apices were examined by scanning electron microscopy at $\times 140$ and digital images were captured. Data were analyzed statistically by Student's t test and Fisher's exact test at 5% significance level. SEM micrographs showed that 19 (56%) apical foramina emerged laterally to the root apex, whereas 15 (44%) coincided with it. Significantly more difficulty to reach the apical foramen was noted in Group 2. Results suggest that the larger the foraminal file size, the more difficult the apical foramen instrumentation may be in laterally emerged cemental canals.

Key Words: Apical foramen, coronal preflaring, endodontic files, maxillary central incisor.

INTRODUCTION

Loss of 1 mm of the working length increases the failure rate by 14% in teeth with periapical lesions (1). Furthermore, a working length more than 2 mm short of the apex represents a 20% reduction in the success rates when periapical lesions are present (2). This may be explained by the presence of microorganisms at the apical portions of the canal and their participation in the development of periapical lesions (3,4).

The success of endodontic treatment depends on the eradication of microorganisms from the root canal system and prevention of reinfection (5). For such purpose, it seems reasonable to suppose that instrumentation should be carried out in the entire length

of the canal, including the cementum portion, beyond the apical constriction (6-8).

Cleaning of the cemental canal with a small-diameter K-file passively inserted through the apical constriction (9) has been questioned by Souza (8) and Hülsmann and Schäfer (10). Apical foramen widening has been demonstrated to be more favorable to the healing of chronic periapical lesions (11) and it should be performed with a file which fits closely the constriction of the canal and be followed by the next two of its type in series and size (12).

Maxillary central incisors usually have wide canals, requiring the use of large files. On the other hand, analysis of the apical anatomy of these teeth show that the apical foramen frequently emerges laterally to

the apex (13-16).

Considering that files of large diameter present limited flexibility, it is possible that both aspects, instruments with large diameters and lateral opening of the apical foramen, pose some challenges on apical foramen widening.

The aim of the present work was to evaluate the influence of apical foramen lateral opening and file size can exert on cemental canal instrumentation in maxillary central incisors.

MATERIAL AND METHODS

Thirty-four human maxillary central incisors with fully developed roots from the tooth bank of the Dental School of the Bahiana School of Medicine and Public Health were used for this study. The criteria adopted for selection of the teeth were absence of complex external anatomy, accentuated curvature, incomplete root formation and apical resorption, as determined by direct examination and periapical radiographs. One operator performed all experimental procedures.

Access and preparation of the pulp chamber were carried out with a #3 carbide round bur (KG Sorensen, Cotia, SP, Brazil) and Endo-Z bur (Maillefer, Ballaigues, Switzerland).

After irrigation with 1 mL 2.5% NaOCl, root canals were explored with a size 15 K-file (FKG Dentaire, La-Chaux-de-Fonds, Switzerland), manually inserted until the apical foramen was reached and the tip of the file was visible. Thus, canal length was determined for all teeth.

Teeth were randomly divided into two groups. In Group 1 (n=17), canals were irrigated with 1 mL 2.5% NaOCl and K-files (FKG Dentaire) of progressively increasing diameters were gently inserted into the canal with reciprocating motion until binding at the apical foramen and its tip was visible. The diameter of this instrument was recorded and it was bonded with ethyl cyanoacrylate adhesive. Roots/files set were cross-sectioned 5 mm from the apex.

Table 1. Mean (S.D.), minimum and maximum values and median of file size in both groups (mm).

Group	Mean (S.D.)	Mini value	Max value	Median	p
1 (non-flared)	33.82 (4.85)	30	45	30	0
2 (flared)	42.06 (7.72)	30	55	40	

In Group 2 (n=17), coronal flaring was carried out with 20/0.06 and 35/0.06 LA Axxess burs (SybronEndo, Glendora, CA, USA), attached to an Endo-Pro torque endodontic motor (Driller, Jaguaré, ES, Brazil) at 3.5 N-cm torque and 6,000 rpm. Burs were inserted up to 4 mm short of the apex and canals were irrigated with 1 mL 2.5% NaOCl at each change of instrument. A 5 mL impression syringe and capillary tip (Ultradent Products Inc., South Jordan, UT, USA) were used for the irrigation in both groups.

After coronal flaring, a size 15 K-file as reintroduced up to the apical foramen to reestablish patency and K-files of progressively increasing diameters were gently inserted into the canal with reciprocating motion until binding at the apical foramen and its tip was visible. The diameter of this instrument was recorded and it was bonded with ethyl cyanoacrylate adhesive. Roots/files set were cross-sectioned 5 mm from the apex.

The roots of both groups were fixed on stubs and gold sputtered as previously reported (17) and a scanning electron microscope Philips XL-30 (Philips, Eindhoven, Netherland) was used to examine the apices at $\times 140$ magnification. Images were captured digitally and data were analyzed statistically by Student's t-test and Fisher's exact test. A significance level of 5% was set for all analyses.

RESULTS

The mean size of the files in each group, as well as the standard deviations, minimum and maximum values, and the medians are shown in Table 1.

The mean values of the file sizes were subjected to the Student's t-test and statistically significant differences were observed between the groups ($p=0$). The mean size of the foraminal files (i.e., those that bound at the cemental canal) was larger in Group 2 (with flaring), as shown in Table 2. The rate differences for each file size was tested by Fisher's exact test. Statistically significant difference ($p=0.047$) was observed between sizes 30 and 35 files in Group 1, when compared with Group 2. For

Table 2. Distribution of the foraminal files in the two groups, according to their sizes.

Group	#30	#35	#40	#45	#50	#55
1 (non-flared)	9	4	3	1	-	-
2 (flared)	1	5	4	2	3	2

the remaining file sizes, no significant difference was observed between the groups.

Analysis of the SEM micrographs showed that 19 (56%) apical foramina emerged laterally to the root apex (Fig. 1A), whereas 15 (44%) coincided with it (Fig. 1B). In Group 2 there was more difficulty when trying to insert files up to the apical foramen of some canals, especially in those with slightly curved roots (Figs. 2A and 2B).

DISCUSSION

In addition to contributing to more precise determination of the actual apical diameter (18,19), another goal of access flaring is to facilitate file penetration and instrumentation of the apical third of the canal. Thus, coronal flaring should also facilitate

penetration of the file up to the apical foramen.

By reducing the interferences at the cervical and middle thirds, flaring allowed larger files to bind at the apical foramen in Group 2, as shown in Tables 1 and 2. However, in this group we encountered more difficulties to insert files up to the apical foramen of some canals, particularly in those with slightly curved roots (Figs. 2A and 2B). In straight roots, these difficulties were less significant.

The need for enlargement of the root canal is not justified only for mechanical (shaping) reason. There is also a biological (cleaning) reason (20,21). Success of endodontic treatment depends on the eradication of microbes from the root-canal system (5) and debridement of the root canal by instrumentation and irrigation is considered the most important single factor in the prevention and treatment of endodontic diseases (22).

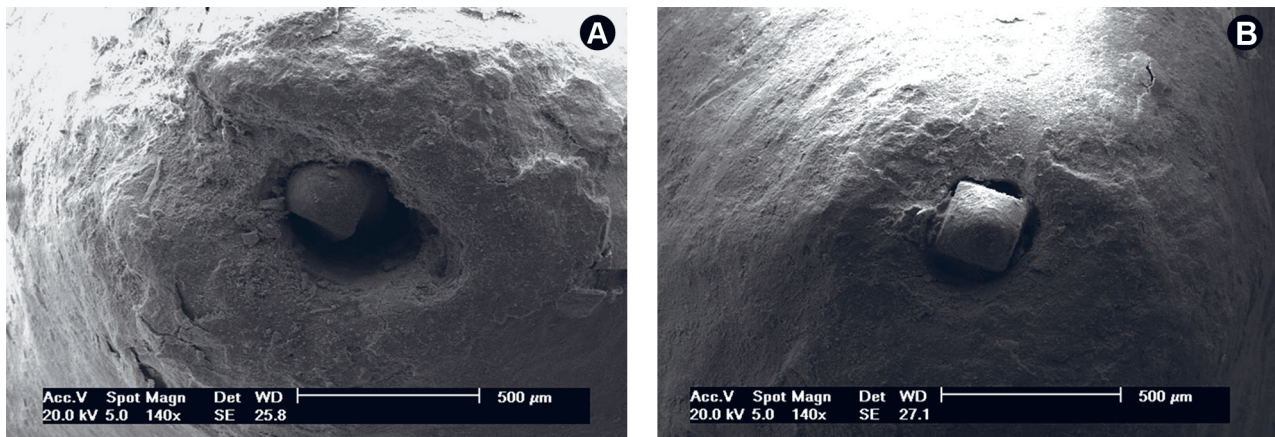


Figure 1. Location of the apical foramen in relation to the root apex. A: Apical foramen emerging laterally. B: Apical foramen coinciding with the root apex.

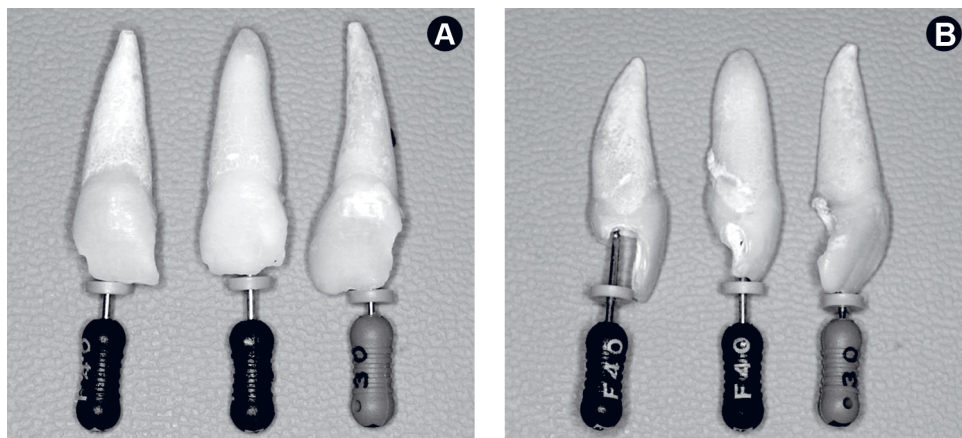


Figure 2. Shape of the maxillary central incisor roots. Observe the slightly curved roots. A: Frontal (mesiodistal) view. B: Proximal view.

Thus, as in dentinal portion of the canal, instrumentation of the cemental canal should be considered.

Apical foramen widening is more favorable to the healing of chronic periapical lesions (11) because there are more chances to eradicate microorganisms from the root canal, particularly those in cemental canal, and promote infection control.

Butler (12) established that the apical foramen should be instrumented with a file which fits closely the constriction of the canal and be followed by the next two of its type in series and size, whereas Souza et al. (23) observed that for adequate relationship it would require 4 instruments beyond the foraminal file. However, this is not only a microbiological matter, but also an anatomic issue. In view of the foraminal file sizes (Tables 1 and 2) and the high frequency of lateral opening of the apical foramen, corroborated by other authors (13-16), widening of the apical foramen in some teeth, such as maxillary central incisors, can be difficult.

Large-diameter instruments are less flexible and therefore more difficult to bend prior to insertion in apical foramens which open laterally. It is possible that in these situations the pressure applied during insertion of the files into the apical foramen induces changes in its anatomical configuration. Despite the need of enlargement for better infection control, instrumentation with larger files may represent a challenge in laterally-emerging foramen.

In view of this, one can recommend initial penetration up to the foramen to be carried out with smaller files, which are able to reach the foramen without applying excessive pressure. In a subsequent step, larger file sizes could be used. Yet, other alternatives would be the use of more flexible instruments, such as nickel-titanium (NiTi) files, safe-adjusted file (SAF) (23), or the development of appropriate instruments for this purpose.

The present results demonstrate that the larger the foraminal file size the more difficult the apical foramen instrumentation may be in laterally emerged root canals. Further studies focusing on this topic should be conducted, including other groups of teeth.

RESUMO

Tendo em vista que a instrumentação do forame apical tem sido sugerida para a limpeza e desinfecção do canal cementário, a seleção do calibre do instrumento e a posição do forame apical representam passos desafiantes. Este estudo analisou a influência que a saída lateral do forame apical e o calibre do instrumento podem exercer na instrumentação do canal cementário. Trinta

e quatro incisivos centrais superiores foram divididos em dois grupos: Grupo 1 (n=17), sem preparo cervical, e Grupo 2 (n=17), com preparo cervical com brocas LA Axxess. Limas K com aumentos de diâmetro foram progressivamente inseridas no canal até ajustar no forame apical e as pontas ficarem visíveis e foram fixadas com adesivo de etil cianoacrilato. Os conjuntos raízes/limas foram seccionados transversalmente a 5 mm aquém do ápice. Os ápices foram examinados por microscopia eletrônica de varredura com aumento de 140x e imagens digitais foram capturadas. Os dados foram examinados estatisticamente pelo teste t de Student e teste exato de Fischer com nível de significância de 5%. A microscopia eletrônica de varredura mostrou que 19 (56%) dos forames apicais saíram lateralmente em relação ao ápice radicular, enquanto que 15 (44%) coincidiram com ele. Dificuldade significativamente maior para chegar ao forame apical foi observada no Grupo 2. Os resultados sugerem que quanto mais calibroso for o instrumento foraminal, mais difícil poderá ser a instrumentação do forame apical em canais cementários que apresentam saída lateral.

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