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Root canal length changes during mechanical preparation due to different cervical enlargement patterns

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Abstract: This study aimed to evaluate the root canal real length (RL) changes due to the mechanical instrumentation use with different flaring magnitudes. After access cavity, 60 mesial root canals of mandibular molars were randomly separated in three groups: Hyflex EDM (HF; #25/.12, #10/.05 e #25/~), Reciproc Blue (RB; R25), and MTwo (M2; #10/.04, #15/.05, #20/.06 e #25/.06). The RL was defined as the apical limit, and 2.5% sodium hypochlorite irrigating solution was chosen. After the access cavity (RL 1), cervical flaring (RL 2), and complete chemical-mechanical preparation (RL 3), the RL was evaluated. The RL was evaluated by a blind examiner with the aid of a microscope (16x) placing the endodontic file stop at the coronary reference. When comparing length measurements, the RL was shorter before instrumentation than that after instrumentation. A reduction of 0.65 mm (HF), 0.61 mm (RB), and 0.48 mm (M2) was observed. However, among groups, no statistical differences were found ($p > 0.05$). Under the conditions tested, it can be inferred that all mechanical systems provoked RL variations, which emphasizes the need for constant verification of the odontometry, mainly before root canal obturation.

Keywords: Endodontics; Odontometry; Dental Pulp Cavity.

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Introduction

During endodontic therapy, from the access cavity to the root canal filling, several anatomical alterations are induced in the teeth by the disinfection and modeling process of the chemical-mechanical instrumentation.[1] One such alteration is the reduction change of the root canal real length (RL) after instrumentation.[2]

The reduction has been associated with dentin interferences' removal, mainly after the cervical preparation or flaring.[3] The cervical flaring has been pointed as an important chemical-mechanical preparation step of the root canal once it reduces cervical interferences, such as dentin projection.[4] Flaring the cervical third of the root also improves its medium and apical third cleaning[5,6] and reduces the amount of debris that could be extruded from the apical foramina[7,8] and also a flare-up incidence.[4,9] Cervical pre-flaring may also reduce the instrument fracture incidence[10,11] and allow a more precise electronic odontometry performance,[12-14] given that the endodontic file could be better adjusted to the apical third of the root.[15-17]

Considering the exposed, it is known that electronic odontometry is to be performed after cervical flaring.[3,18] However, even when performing cervical flaring, RL variations have still been found during the root canal preparation.[2,19] Such variations change the obturation apical limit, which might compromise the treatment prognosis, increasing chances of overfilling.[20.]

The root canal instrumentation systems present variable shapes, surface treatments, and taper according to the modeling of the medium and cervical thirds of the root. The Hyflex EDM (HF) system, for instance, presents 0.12 taper.[14,21,22] Other systems, such as the MTwo (M2), do not present specific instruments to the root cervical third preparation, once they only produce instruments of 0.06 taper.[23] For the Reciproc Blue (RB) system, only one instrument can be employed. At the cervical third, it presents a reduced taper, allowing instrumentation with less aplitude.[9]

Given the importance of a correct RL determination during the different root canal preparation phases to reduce the overfilling risk and knowing that there are different instrumentation systems, this study aimed to investigate the possible RL alteration during the mechanical instrumentation performed with HF, RB, and M2 systems. Such systems were chosen once they present different root canal flaring magnitudes.

Methodology

The sample size calculation was performed considering the protocol as described by Vasconcelos et al.[2] An alpha error of 0.05, beta power of 0.8, and a relation N2/N1 of 1. To detect differences among groups, a total of 18 samples per group was selected as the ideal sample size. Considering the instrument fracture risk, the sample was increased by 10%.

After the local Ethics Committee (nº 2.655.470) approval, 30 mandibular molars with Vertucci class IV mesial roots (two root canals and two independent apical foramina), without dilacerations (< 25°), and with apical foramen measuring less than 200 µm were chosen. A total of 60 root canals were used.

The access cavity was performed with #1013 e #3082 (KG Sorensen, Cotia, SP, Brazil). After this step, the root canal was explored with the C-pilot #10 file (VDW GmbH, Munich, Germany), confirming the apical foramen patency. Those root canals without patency were replaced. To measure RL, a manual file was inserted into the root canal until it could be seen through the apical foramen when the root was observed with a microscope (16× magnification) (Alliance, São Carlos, Brazil). The roots that present a foramen diameter over the #20 instrument were replaced. RL was determined in triplicate using a digital pachymeter (Mitutoyo, Suzano, Brazil). The final RL was defined as the three repetitions' mean. Root canals with a length of over 20 ± 2 mm were also replaced. The RL was evaluated two more times: after the access cavity (RL1), cervical third preparation (RL2), and apical third preparation (RL3).

The teeth were randomly separated into three experimental groups according to the system to be used: HF, RB, and M2. All groups were actioned by an electrical motor (VDW Silver; VDW GmbH). After each instrument change, a 2.5% sodium hypochlorite irrigation solution was used (Biodinâmica, Ibiporã, Brasil). The instrument use sequence followed the steps described below.

HF

In the HF group, root canals were prepared using #25/.12 instruments in the cervical third; in other words, these instruments were inserted until 2/3 of RL1. Following this step, #10/.05 instruments were employed as a glide path, and finally, for apical preparation, a #25/~ instrument was used, both with apical limit till RL1. The instruments were actioned and used at 500 RPM and 500 g.cm as rotation parameters.

RB

In the RB group, root canals were prepared with only one instrument, R25 (#25/.08). Thus, after reaching two-thirds of RL1, the cervical flaring was considered finished. When RL2 was reached, the apical third preparation, in turn, was concluded. For this experimental protocol, the program was set to "Reciproc All" with forward-backward movements.

M2

In group M2, root canals were prepared by #10/.04 and #15/.05 instruments inserted until RL1 as a reference to the beginning of the preparation, regarded as the finished cervical flaring step. Further, to prepare the apical third, #20/.06 and #25/.06 instruments were employed, and RL2 was considered the instrumentation limit.

Only one experienced examiner blinded to the employed system, as well as the previously measured RL, performed all measurements in triplicate, being considered as the final length of these three measures' mean. Regarding the RL variation during root canal preparation, the differences between the lengths' mean values were calculated considering each preparation stage (RL1 - RL2; RL2 - RL3) and the final and initial RL (RL1 - RL3).

Statistical analyses

Normality is assessed by the Shapiro–Wilk test. As the obtained data did not show a normal distribution, the data were analyzed by Kruskal–Wallis and Dunn's tests, both considered $p < 0.05$.

Results

RLs' variations due to different NiTi instrumentation systems employed are shown in Figure. Medians and minimal and maximal values of RL values were depicted in Table. All systems tested caused RL variation with median values between 0.48 mm (M2) and 0.65 mm (RB). The reduction values were at a minimum of 0.05 mm (M2) to maximal values of 1.69 mm (M2). Significant differences were observed between intermediate instrumentations stages and these stages' sum in the RB and M2 systems ($p < 0.05$). In the HF group, the difference was restricted to comparisons between stage 1 and their sum. Further, between the systems under study, the statistical analyses did not find significant differences, independent of the preparation stage or after the preparation was finished ($p > 0.05$).

Discussion

The present study evaluated RL changes of the root canals provided by the employment of mechanical instrumentation systems with different cervical flaring strategies. Up to now, few studies have been dedicated to evaluate the root canal preparation influence on RL reduction during or after root canal preparation.[2,19] Moreover, none of them observed whether this variation depended or not on different cervical flaring protocols employed, as available in NiTi systems. Thus, the comparison made here is unprecedented and points out the constant need for RL determination. This observation is regardless of the employed system or cervical flaring protocols, once the three systems under evaluation reduced the root canal real length.

In this study, mesial roots of mandibular roots were used because they are less often indicated to endodontic intervention, as well as present dentinal projections close to the root canal opening.[14,24] These dentinal projections are the reason for anti-curve and compensatory wear as strategies to achieve more precise odontometry and safer instrumentation.[20,21]

Regarding root canal preparation, the instrumentation systems employed were selected in function of the conicity indicated by manufacturers to anticipate the odontometry, and thus, it would be responsible for the canals' medium and cervical thirds. Between the chosen systems, the apical diameter of the each sequence final instruments was the point of convergence; however, it is worth noting that frequently, the apical preparation has to be larger than the instrument #25; greater enlargements may generate results different from those found in this study.

Given the purpose of performing different cervical flaring patterns, the following systems were employed: the HF system, which employs a specific instrument to cervical preparation (#25/.12),[21] RB, which consists of a single instrument system with a regressive conicity to reduce cervical dentine removal,[9] and M2, which does not promote cervical third flaring.[23]

Regardless of the cervical flaring protocol, the three systems caused root canal variation, but among them, no significant difference was found. At the end of instrumentation, the minimal variation observed was 0.05 mm (RB); however, the maximal variation reached 1.69 mm (M2). Considering the total variation during the treatment, the three groups' medians were close to 0.05 mm. Such changes corroborate with previous findings[2,20] that

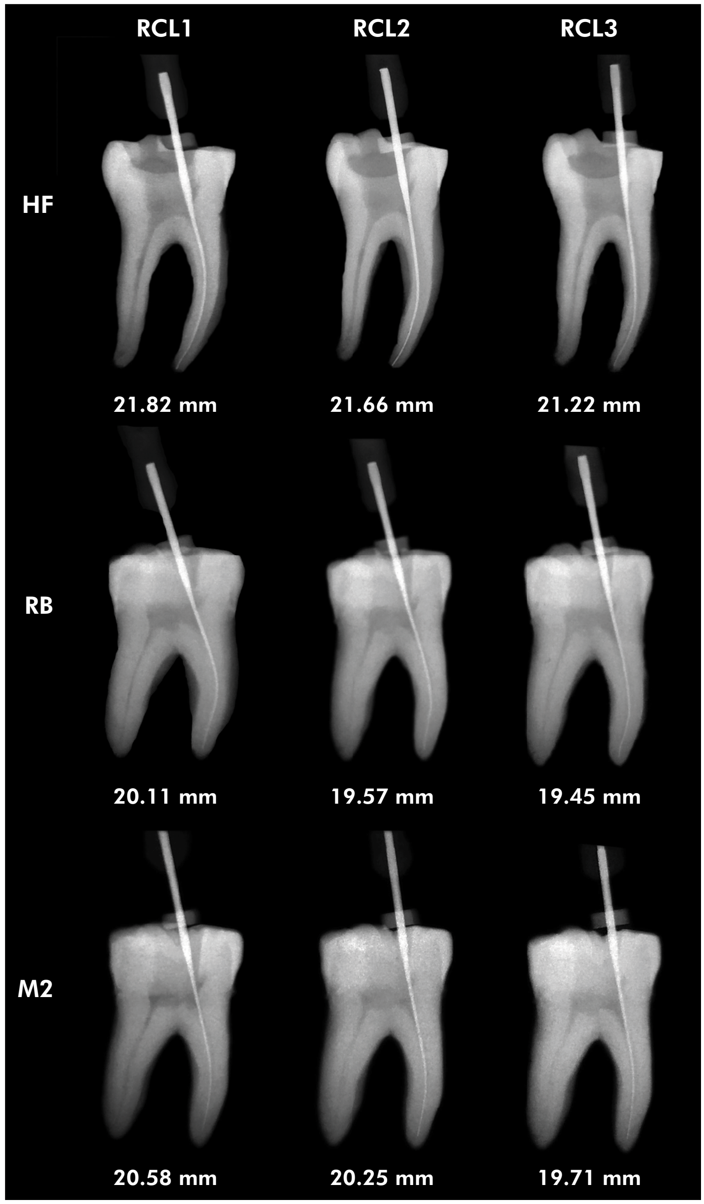

Figure. Radiographic alteration and RLs variations due to different NiTi instrumentation systems employed.

Table. Reduction of the root canal real length (RL) (mm) between each phase of the endodontic treatment considering the systems underuse.

M2			RB			HF	
Median	Limit		Median	Limit		Median	Limit
	Min.	Max.		Min.	Max.		Min.
0,27[a,A]	0,04	0,81	0,40[a,A]	0,05	0,63	0,30[a,A]	0,03
0,20[a,A]	0	0,88	0,20[a,A]	0,03	0,79	0,30[a,A]	0,04
0,48[a,B]	0,05	1,69	0,65[a,B]	0,18	0,93	0,61[a,B]	0,15

[a,b]Different lowercase letters indicate significant differences between the systems according to Kruskal–Wallis and Dunn's tests ($p < 0.05$), in each phase; [A,B]Different uppercase letters indicate significant differences between the phases of the chemical-mechanical preparation according to Kruskal–Wallis and Dunn's test ($p < 0.05$), considering each system.

pointed out a reduction in RL during the endodontic treatment with WaveOne and Profile GT, suggesting the importance of confirming odontometry.

Additionally, different from the common sense that cervical preparation would be responsible for RL reduction, the present study does not observe significant differences when these two root canal preparation stages were compared; it is true for the three systems evaluated. In addition to having contributed in a similar way to the cervical preparation ($p < 0.05$), the completion of the chemical-mechanical preparation produced reductions in RCL, in the specimens that showed the greatest variation, that reached 0.88 mm (M2), 0.79 mm (RB) and 1.16 mm (HF), values that could certainly compromise the treatment prognosis.

This observation reinforces that both cervical and apical preparation similarly contribute to the root canal length reduction. These findings highlight the importance of assessing odontometry during the endodontic treatment, but not to be limited to the access cavity phase or to the cervical flaring step.[2,13,19]

Given the exposed, this study's findings suggest that all instrumentation systems led to root canal length reduction, which was seen markedly after finishing the canal preparation. Therefore, between the phases of the root canal system preparation, it is indispensable to perform odontometry: a first one to assess the working length, and a second measurement to define the apical limit of root canal filling. This should be independent of the used instrumentation system in to prevent overfilling and reduction of the success index of the endodontic treatment.

Conclusion

Given this study's conditions of, it can be concluded that regardless of the mechanical preparation system, HF, RB, and M2 systems reduced the root canal length during the chemical-mechanical preparation.

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