Influence of working length on apical extrusion of debris and sodium hypochlorite

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ABSTRACT

Objective: The aim of this study was to evaluate the amount of debris and sodium hypochlorite extruded apically when three different working lengths were used for root canal preparation. **Methods:** Thirty single-rooted teeth were used. ProTaper Universal rotary system was used for root canal preparation. Teeth were randomly divided into three experimental groups (n = 10). G1: instrumentation 1-mm short the major foramen; G2: instrumentation at the limit of the apical foramen; and G3: instrumentation 1-mm beyond the foramen. All groups were irrigated with 20 ml of 1% sodium hypochlorite. The irrigant extruded through the apical foramen during canal preparation was collected in pre-weighed Eppendorf tubes. **Results:** Data were analyzed by Kruskal-Wallis and Dunn tests. G1 had the lowest amount of extruded sodium hypochlorite, which was significantly different from the other groups (p-value < 0.05). **Conclusion:** The working length for root canal instrumentation has direct influence on the amount of sodium hypochlorite extruded apically.

Keywords: Endodontics. Root canal therapy. Sodium hypochlorite. Root canal irrigants.

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Introduction

Root canal irrigation plays a key role in cleaning, debris removal, solvent action, lubrication, and disinfection of the root canal.[1] Different endodontic treatment protocols demonstrate cleaning and shaping of the root canal system; however, extrusion of irrigants via apex seems to be a problem inherent in the procedure.[2,3]

Sodium hypochlorite (NaOCl) is the most widely used endodontic irrigant due to its excellent antimicrobial, organic tissue dissolving, and lubricating properties. Nevertheless, it is highly cytotoxic to periapical tissues.[4]

Chemical injury to periapical tissue through extrusion of irrigating solutions is one of the most frequent causes of post-treatment pain, being reported in 25% to 40% of all patients undergoing endodontic treatment, regardless of the pathological condition of pulp tissue.[5,6] This discomfort is caused by induction of an acute inflammatory response following tissue contact with an irritant.[7]

Thus, the action of NaOCl should be restricted to the root canal, preventing overflow that can injure periapical tissues, act negatively in healing, and cause postoperative flare-ups in which there is bacterial contamination.[2]

A correlation between apical extrusion of NaOCl and a series of variables has already been established, including the depth to which the irrigation needle is introduced into the canal,[1] movement kinematics,[8] and the establishment of apical patency.[9]

According to a literature review on apical extrusion of debris, in most studies about extrusion, the influence of working length (WL) has not been the main target of investigation; however, it has been further evaluated to provide additional complementary information.[10] Some studies concluded that filing to the foramen resulted in more debris extrusion compared with filing 1-mm shorter the foramen.[11,12]

Nevertheless, the influence of WL from which the solution may extrude to periapical tissues has not been enough investigated. Therefore, the aim of this study was to evaluate in vitro the extrusion volume of NaOCl irrigant through apical foramina of root canals under three experimental conditions: instrumentation 1-mm short the major foramen, instrumentation at the limit of the apical foramen, and instrumentation 1-mm beyond the foramen.

Material and methods

The present research was approved by local Research Ethics Committee, protocol #080/2009. Thirty incisors with straight and conical root canals stored in saline solution and kept in an incubator at 37 °C with 100% humidity until the beginning of the experiment were used. For better standardization of samples, teeth with lengths ranging from 20 to 22 mm were selected.

Inclusion criteria were as follows: teeth with complete apex formation; single, straight, and conical roots; no root carious lesions, fractures, cracks, or signs of internal or external resorption; and checked with the aid of a 10X stereomicroscope and buccolingual and mesiodistal radiography.

Tubes used to collect the overflown material were weighed, even when empty, in an analytical scale (Ohaus, Pine Brook, New Jersey, United States). Three consecutive weighings were performed and the average weight of each tube was considered for registration.

Coronal access to the pulp chamber was performed with diamond burs in 1012 or 1013 (KG Sorensen, São Paulo, Brazil) and Endo-Z (Dentsply Maillefer Ind. & Com. Ltda, Petrópolis, Rio de Janeiro, Brazil) with a high-speed air turbine. Then, the root canal was exploited with #15 endodontic K-files (Dentsply Maillefer Ind. & Com. Ltda, Petrópolis, Brazil) until the end of the file was visible at the apical foramen with the aid of a 10X stereomicroscope. The length between the tip of the instrument and the silicone stop was measured,and this measure was considered the WL of the tooth.

Subsequently, preparation was carried out using an apparatus made from Eppendorf polypropylene centrifuge tubes (Axygen, Union City, California, USA) with capacity of 2 mL. Each tooth was fixed with Teflon sealing tape (Tiger, Camaçari, Bahia, Brazil) within the Eppendorf tube, then this was backed into a clear glass container and wrapped with another layer of thread sealing tape to prevent any external leakage. A 27G needle was inserted through the apparatus to balance internal and external pressures (Fig 1).

Chemical-surgical preparation was performed with ProTaper Universal rotary system (Dentsply, Maillefer, Ballaigues, Switzerland) driven by X-Smart electric motor (Dentsply, Maillefer, Ballaigues, Switzerland) at a speed of 300 rpm and torque of 2 N. This was followed by the crown-down technique, according to the manufacturer's recommendations, ending with Shaping File 2 (S2) instrument.

Figure 1. Apparatus mounted to collect debris and irrigation during endodontic treatment: **a**) tooth; **b**) thread seal tape; **c**) 2-ml Eppendorf tube; **d**) 7-ml glass vial; **e**) hypodermic needle.

At this stage, teeth were randomly divided into three groups (n = 10) according to the WL, and the technique of chemical-surgical preparation used:

G1: teeth in group 1 were prepared with WL established at 1-mm short the root apex. Subsequently, modeling was performed with Finishing File 3 (F3) instrument. Patency was performed passively using one #15 K-file (Dentsply Maillefer Ind. & Com. Ltda, Petrópolis, RJ) at the limit of the major apical foramen.

G2: In group 2, debridement and shaping of teeth were performed similarly to group 1. The apical limit of work was the variable factor for instrumentation in this group up to the limit of the root apex.

G3: In the third group, foraminal enlargement was performed. Chemical-surgical preparation was performed with rotary instruments used in WL established by adding 1 mm beyond the root apex, with enlargement of the foramen up to F3 instrument.

For the control group, two empty Eppendorf tubes were used. They were weighed before and after drying the samples in an oven to ensure there had been no significant change in weight.

During preparation, root canals were kept flooded with 1% NaOCl; and at each change of instrument, the canals were irrigated with 4 mL of 1% NaOCl with an Endo-Eze irrigation cannula (Ultradent, São Paulo, SP) inserted passively into the canal 3-mm short the apical foramen. Final root canal irrigations were performed with 4 mL of 1% NaOCl injected passively for 2 min with constant pumping motion and then aspirated with an aspiration cannula type Capillary Tip 0.019 (Ultradent, São Paulo, Brazil). All procedures were performed by a single operator.

After root canal preparation, teeth were carefully removed from the apparatus. Eppendorf tubes containing the extruded material after instrumentation (NaOCl + debris) were weighed to determine weight-1 of each sample. Then, all tubes were incubated at 37 °C for 15 hours for all the collected liquid to evaporate until only the apically extruded debris remained. After evaporation of NaOCl, the Eppendorf tubes containing only dry debris were weighed a final time; this weight was assigned weight-2.

All weighings were performed in triplicate, the final average values being adopted for subtraction. Weight-2 of each sample was subtracted from weight-1 of the respective samples in order to determine the unique weight of NaOCl that overflowed and was collected in each tube. The mass in grams (g) was converted to volume (mL) by the formula: $d = m/v$, in which d was density of sodium hypochlorite, approximately equal to 1 g/ml, m was mass, and v was volume.

Data were recorded in a database and later transferred to te BioEstat Program 5.0 in which analyses were performed. Shapiro-Wilk test was used to check for normality of distribution. The sample exhibited abnormal distribution. Nonparametric Kruskal-Wallis analysis of variance and Dunn tests were used to determine if significant differences existed between groups ($p < 0.05$). Friedman test was used to determine if significant differences existed within each group ($p < 0.05$).

Results

When we analyzed the amount of NaOCl and debris extruded through the apical foramen during instrumentation, all groups showed leakage of both.

Group 1 showed lower average leakage of NaOCl and debris than the other groups, as shown in Table 1 and Figure 2. Statistically significant difference was only present when G1 was compared with G2 and G3 ($p < 0.05$). However, between G2 and G3, no statistically significant differences were found (Fig 2B). Values of debris and extruded NaOCl within the same group showed no statistically significant differences ($p > 0.05$).

Table 1. Mean and standard deviation of sodium hypochlorite and debris extruded apically during chemical-surgical preparation in groups.

Group	n	NaOCl + Debris $\bar{x} \pm SD$	NaOCl $\bar{x} \pm SD$	Debris $\bar{x} \pm SD$
GI	10	1,4406 ± 0,0310^A	0,0412 ± 0,0316^A	0,0019 ± 0,0012^A
GII	10	1,9137 ± 0,2691^B	0,5311 ± 0,2416^B	0,0196 ± 0,0105^B
GIII	10	2,4271 ± 0,4671^B	1,0291 ± 0,5022^B	0,0397 ± 0,0226^B

n: sample size. $\bar{x}$: mean. SD: standard deviation. H Statistic = 21.83; $p < 0.01$ (Kruskal-Wallis test). Means followed by different letters are significantly different (Dunn test).

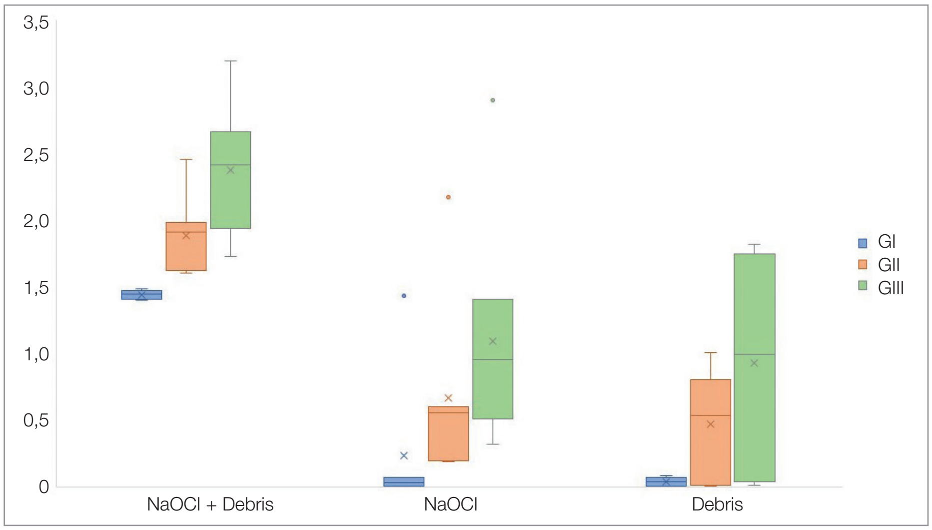

Figure 2. Graphical representation of NaOCl and debris overflowed apically in different groups.

Discussion

Those who oppose patency argue that the apical dentin barrier aids maintaining irrigation inside the root canal and that an instrument introduced to maintain the WL and unclog the area acts as a piston on the debris, favoring accidental apical extrusion.[13]

The most apical extrusion and the diameter of the instrument used to perform patency are directly related.[14] In this research, #15 K-file was standardized as the instrument of patency, and results showed that higher extrusion in G2 was directly related to the WL.

A limitation to the technique of foraminal enlargement is the possibility of postoperative pain caused by aggression of over-instrumentation on periapical tissue.[6] However, in cases of necrotic pulp with periapical lesion, with high foraminal contamination, only the action of instruments in this area is satisfactory to reduce the remaining bacteria and debris-infected dentin, providing a more effective action of irrigating solutions and biological decontamination.[15]

The use of rotating nickel-titanium instruments provides the most assistance in determining apical preparation and expansion, leading to a better reach and irrigating action in this region,[16] as well as less extrusion of debris and irrigation solution at the apex.[17,18] However, the WL can also affect apical extrusion, even when the rotary system is used.[14]

ProTaper rotary system promotes better removal of dentin debris than the manual step-back technique,[17] as the special design of the system, combined use of crow-down technique and rotational movements may reduce apical extrusion.[19] Furthermore, creating a glide path before instrumentation can reduce the amount of apically extruded debris.[20]

These benefits associated with abundant irrigation can reduce the risk of postoperative pain.[21]

The irrigant in chemical-surgical root canal preparation is also key for disinfection and removal of debris.[22,23] In the present study, the volume of irrigant was the same in all groups injected with a passively pumping movement, associated with the constant movement of the irrigating tube, which is important to enable flow of solution and subsequent aspiration. The needle locked in the root canal is not conducive to simultaneous flow and can increase the amount of extruded irrigant.[24]

The depth of needle penetration is dependent on the morphology of each root canal, as the needles used for irrigation are always in size 30G or 27G (3). Placing the tip of the needle 2 mm below the WL is recommended, for the solution gently injected by the syringe has a range of 1 mm beyond the tip of the needle.[25]

The positioning of the needle away from the apex is associated with decreased pressure and reduced leakage of irrigating apex.[26,27] In this study, insertion of the irrigation needle was 3 mm from the apical foramen, as root canal preparation was carried out with an F3 file. This resistance does not allow further deepening of the needle.[28,29]

With regard to pressure applied to the irrigant, if low positive pressure is used, the irrigator cannot reach across the apical region. However, if too high a positive pressure is employed, using conventional irrigation and positive

pressure,[30], there is a risk of the root canal being forced apart during irrigation.[30,31]

Research suggests irrigation with EndoVac system (Discus Dental, Culver City, CA, USA) for cases of instrumentation with WL at the root apex, working with negative pressure, performing reliable cleaning of the entire apical area by controlling force during irrigant application, and decreasing extrusion of irrigant and the risk of post-operative periapical chemical injury[32,33].

No differences were found between initial weights (NaOCl + debris) and the sums of weights of debris and extruded solutions, which confirmed the reliability of using an analytical scale, supporting the methodology adopted by Parirokh et al.

A systematic review demonstrated that extrusion occurs regardless of the instrumentation techniques used.[34] It is the common opinion of most authors that extrusion of some debris is inevitable during root canal instrumentation and a methodology that completely avoids this phenomenon has not been developed.[10]

In conclusion, under the conditions of this study, the WL established at 1-mm short of the root apex was associated with less debris and irrigant extrusion. No differences were observed when the WL was established at the limit or 1-mm beyond the root apex.

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