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ORIGINAL ARTICLE

Impact of different flow rate on apically extruded debris and irrigants

ABSTRACT

Aim: *Root canal instrumentation might lead to extrusion of debris and irrigants, leading to postoperative pain and compromised outcomes. Several factors might impact extrusion during root canal instrumentation, including the flow rate in which the irrigant solution is applied inside the root canal. The aim of this study was to assess the extrusion of irrigants and debris with different flow rates of 0.9% saline solution.*
Materials and Methods: *Thirty mandibular premolars presenting single roots and straight root canals were used in this study. The roots were standardized in 17 mm and inserted in Eppendorf tubes. A 1.5% agar gel was placed inside the tube that involved the roots, while the coronal part of the roots was kept visible. The combination of tube and agar gel was weighted. Then, the specimens were randomly distributed to 3 different groups (n=10) according to the flow rate of the irrigation: Control Group (CG) 5 mL/min, High Flow rate Group (HG) 10 mL/min, and Ultra-High flow rate (UG) 60 mL/min. The canals were instrumented with a Reciproc Blue instrument size 25.08 up to the length of the root, following the manufacturer guidelines. After the instrumentation, the roots were removed and the tube and agar were weighted again. The difference between the final weight and the initial weight represented the total amount extruded beyond the apex. For statistical analysis, the ANOVA test (post-hoc Bonferroni) was used at P>0.05.*
Results: *The mean weight of the extruded debris and irrigants for CG, HG, and UG was respectively 0.0079 ± 0.0087, 0.0110 ± 0.0093, and 0.0083 ± 0.0091. There were no statistically significant differences among the groups.*
Conclusions: *Within the limitations of this study, it can be concluded that the flow rate of irrigants does not impact the extrusion of debris and irrigants.*

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Introduction

Root canal therapy involves the removal of vital or necrotic pulp tissue, bacteria, and its by-products. Root canal instrumentation using different instruments and irrigants is the most common method for the removal of such contents. While irrigation is of major importance in the reduction of bacterial load and removal of pulp tissue coronally, there is a risk of extrusion of debris and/or irrigants into periapical area.

Sodium hypochlorite has been largely applied for root canal irrigation for several years (1). The main benefits of NaOCl are the disinfection and tissue dissolution inside the root canal. However, NaOCl might impose severe damage in case of extrusion beyond the apex; for many years, there have been reports of accidents due to NaOCl extrusion (2-4). Therefore, different irrigants have been proposed for replacement of or in combination with NaOCL (5). Chlorhexidine (CHX) has been demonstrated to be comparable to NaOCl in regards to root disinfection. The use of 2% CHX gel proved more efficient than 5% NaOCl in a previous study (6). However, CHX gel alone is not able to properly remove the contents from the root canal system. Therefore, it is used in combination with saline solution or distilled water, with adequate flow rate is necessary for a better cleaning of the root canal system (7).

Several factors might contribute to the extrusion of irrigants: volume used, type and position of the needle, and flow rate of the irrigation (8-10). While different studies have assessed the impact of such variables on the extrusion of debris, the effects of different flow rates have scarcely been assessed in recent literature (8). Therefore, the aim of this study is to assess the extrusion of debris and irrigants with different flow rates of saline solution.

Materials and Methods

This study was reviewed and approved by the Ethical Committee of the Faculdade de Odontologia São Leopoldo Mandic (# 2.973.441). This *ex vivo* study comprised 30 first or second mandibular premolars extracted for reasons not related to this study. Only single rooted teeth presenting a single canal as well as fully formed apices were included. The teeth were radiographed in both bucco-lingual and mesio-distal direction in order to select only teeth presenting curvatures smaller than 5°, following Schneider´s method (11). The teeth with cracks or fractures, caries, calcification, resorption, or any sign of previous root canal therapy were excluded from the experiment.

Sample Size Calculation

The sample size calculation was based on a previous study by Lu et al. (12) that compared three different systems in regards to apically extruded debris. For achieving an alpha-type error of 0.5 and study power of 95% were input to test using a G*Power 3.0 for Mac statistical package. The results indicated a total of 10 teeth per group in order to observe differences in apically extruded debris and irrigants.

Preparation of the Specimens

After the selection, the teeth were decoronated with a diamond bur and the length of the roots was standardized in 17 mm. The content of the canals was gently removed with a size 10 k-file under 5% NaOCl irrigation. Then, a size 15 k-file was inserted up to the major foramen (MF) in order to assure the selection of specimens with MFs of 0.15 mm in diameter.

The roots were covered with a teflon tape, allowing only 1 mm of the apical third to be exposed. The lids of the Eppendorf tubes (Eppendorf do Brasil, São Paulo, SP, Brazil) were perforated with a diamond bur, the roots were inserted in these lids, and the margins were sealed with cyanoacrylate glue and a layer of gingival dam. Each set of root and lid was weighted 3 times on a scale with 10^{-4} precision (Nowak, São José do Rio Preto, Brasil), and the mean weight was registered in a spreadsheet. Then, 1.5% agar gel (Kasvi, São José dos Pinhais-PR, Brasil) was placed inside the Eppendorf tubes, and each set of root and lid was inserted in the flasks in order to have the roots completely involved in the agar gel. After 24 hours of setting, the whole set was weighted 3 times and the mean weight was calculated. The initial considered weight of the tooth-free flask with agar was the difference between the 2 means.

Root Canal Preparation
The root canals were prepared using a Reciproc Blue (VDW, Munich, Germany) reciprocating instrument (25.08) in the VDW Silver motor (VDW) in the "Reciproc ALL" setting. The instrument moved to the WL in an in-and-out fashion of three movements with an amplitude of 3-4 mm. After each set of movements, the instrument was removed and cleaned with an alcohol-soaked gauze. The canal was again irrigated and the apical patency checked with a size 10 k-file. These movements were repeated until the instrument reached the WL that was previously determined (at the MF), assuring the instrumentation of the whole length of the root.

Irrigation Protocols
The specimens were randomly assigned to three different groups, according to the irrigation protocol. The canals were irrigated with 0.9% saline solution at different flow rates, controlled by a peristaltic pump (LPD 101-3, MS Tecnopon, Piracicaba, Brazil). In the CG, the irrigation was done at 5 mL/min, in the HG at 10 mL/min, and in the UG at 60 mL/min. The same volume (8 mL) of saline solution was used for each specimen. The gauge 31 endo-eze (Ultradent, South Jordan, UT) side-vented needle, placed as close as possible to the WL, was used in all samples. All procedures were carried out by a single operator.

Post-Instrumentation Analysis
After the root canal instrumentation, the lids with the roots were removed and the set of Eppendorf tubes with the agar gel was weighted three times. Then, the mean weight was calculated. The final weight that included both irrigants and debris extruded was the difference between this final weight and the previously calculated weight of the whole content. All weighting measures were conducted by a operator blinded to the group of the specimen.

Statistical Analysis
The data was submitted to the Kolmogorov-Smirnov test that assumed the normality of the results. Therefore, the ANOVA, post-hoc Bonferroni, was used for statistical analysis for differences among the groups. The Statistical Package for Social Sciences (SPSS 20.0 for Windows) was chosen and the $P<0.05$ was considered for statistical differences.

Results

The mean weight of the extruded debris and irrigants for CG, HG, and UG was respectively 0.0079 ± 0.0087, 0.0110 ± 0.0093, and 0.0083 ± 0.0091. There were no statistically significant differences among the groups $P>0.05$.

Table 1

Mean and standard deviation of the amount of extruded debris in each group

Group	n	Mean (g)	SD
Control	10	0.0110	0.0093
High Flow Rate	10	0.0083	0.0091
Ultra-High Flow Rate	10	0.0079	0.0087
P value		.719	

Discussion

The traditional methodology for assessment of apically extruded debris is based on the collection of extruded material in an empty flask (13). Then, the flask is dried, the irrigant evaporates, and the remaining debris can be properly weighted. The major drawback in this methodology is that the amount of extruded irrigants cannot be assessed. The methodology herein adopted uses a 1.5% agar gel for collecting the apically extruded material (12). The advantage of this methodology is the possibility of collecting not only debris, but also irrigants pushed beyond the apex. Moreover, the agar gel promotes a better simulation of the counter pressure promoted by the periapical tissues (5, 12). The characteristics of the gel also prevent the observation of the extruded debris, diminishing the risk of bias.

Different technologies were proposed and demonstrated to diminish the risk of apically extruded debris, including negative apical pressure (NAP) irrigation, and lasers (14). Contrary to suggested, there are studies and meta-analysis that shows the lasers have the potential for extrusion of fluid from the apex (5), and there has been no evidence yet if NAP prevents the extrusion of debris (15). It was also observed that all the irrigant activation devices, including sonics and ultrasonics, extruded debris and irrigants from the apex (16). Due to all of these contradictory results, in this study investigating the effect of different flow rates on debris and irrigant extrusion, any irrigant activation devices were not used and only the side-vented needle was used to deliver the solution into the canal.

The WL adopted in the present study allows preparation in the whole extension of the canal, rather than only up to the apical constriction. By doing so, a larger preparation of the apical third is achieved, aiming the reduction of the bacterial load (17, 18). The use of 2% CHX gel in association with 0.9% saline was proposed to avoid the harmful effects of extruded NaOCl. However, a gel does not possess the proper surface tension to effectively flush the entire root canal system; therefore, saline solution is used for the removal of the entire contents of the root canal. In this study, the needle was positioned at the WL, aiming to ensure a better disinfection (19); the increase in flow rate theoretically could improve the cleaning effects. One might infer that the combination of foraminal enlargement and active irrigation leads to painful postoperative results; however, the effects on postoperative pain are controversial (20, 21). A previous study showed fewer irrigant extrusions when a side-vented needle was used (5); the results of the present study suggest that preparation at the MF associate with high flow rate irrigation does not increase apical extrusion. Boutsioukis et al. (22) demonstrated that a higher flow rate of 0.26 mL/s (15.6 mL/min) increased the amount of extruded irrigants when compared to 0.14 mL/s (8.4 mL/min) in both open-vented and side-vented needles. A recent study also demonstrated that a flow rate of 6 mL/min is related to higher amounts of irrigant extrusion than 3 mL/min (23). In that study, both open- and side-vented needles were used. In both aforementioned studies, only the extrusion of irrigants was assessed, while in the present study the combination of irrigants and debris extrusion could be evaluated. In disagreement with those findings, the present study showed no difference in apical extrusion when 5 mL/min, 10 mL/min, or 60 mL/min were used. It seems clear that the extrusion of irrigants increases when a higher flow rate is applied. The findings of the present study suggest that the total combination of irrigants and debris extruded seems to be unaltered when a high flow rate (60 mL/min) is used with side-vented needles.

In the present study, the instrumentation was performed at the MF, promoting the disruption of the constriction. While this maneuver presents controversial results, our findings need further investigation (20, 21). Further studies should investigate the impact of high flow rate with different needle types in addition to the effects of the variation in flow rate in the cleaning effects.

Conclusions

Within the limitations of the present study, it can be concluded that a higher irrigant flow rate did not impact apical extrusion of debris and irrigants.

Clinical Relevance

Extrusion of debris and irrigants might increase inflammation and promote postoperative pain, especially in necrotic teeth. The different flow rates applied during irrigation might impact the extrusion, therefore resulting in increased postoperative pain. This study aimed to evaluate the impact of different flow rates on the extrusion of irrigants and debris.

Conflict of Interest

The authors deny any conflict of interest related to this study.

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None.

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