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The influence of different working lengths on apically extruded debris

La influencia de diferentes longitudes de trabajo en los desechos extruidos apicalmente

A influência de diferentes comprimentos de preparo na extrusão de debris

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Karla Garcia
ORCID: https://orcid.org/0000-0001-7442-3936
São Leopoldo Mandic, Brasil
E-mail: karlagarfer@gmail.com
Ana Grasiela da Silva Limoeiro
ORCID: https://orcid.org/0000-0003-4633-720X
Faculdade de Ilhéus, Brasil
E-mail: grasielalimoeiro@gmail.com
Wayne Martins Nascimento
ORCID: https://orcid.org/0000-0003-4201-4710
São Leopoldo Mandic, Brasil
E-mail: waynemartins@gmail.com
Eduardo Mansur Kadi
ORCID: https://orcid.org/0000-0002-6316-6740
São Leopoldo Mandic, Brasil
E-mail: duhmansur@hotmail.com
Sandra Radaic
ORCID: https://orcid.org/0000-0003-3088-1390
São Leopoldo Mandic, Brasil
E-mail: sanradaic@ig.com.br
Lívia Neri
ORCID: https://orcid.org/0000-0002-8073-7082
São Leopoldo Mandic, Brasil
E-mail: livia.nm@hotmail.com
Adriana de Jesus Soares
ORCID: https://orcid.org/0000-0002-8078-1606
Universidade Estadual de Campinas, Brasil
E-mail: ajsoares.endo@uol.com.br
Marcos Frozoni
ORCID: https://orcid.org/0000-0001-8001-4063
São Leopoldo Mandic, Brasil
E-mail: marcosfrozoni@gmail.com.br

Abstract
Aim: To evaluate the influence of three different working lengths on the amount of apically extruded debris. Methodology: Thirty lower premolars with single roots and straight root canals were standardized at 17 mm. Then, they were inserted into Eppendorf tubes, and the 1.5% agar gel was introduced into the tubes surrounding the roots. The coronal section of the roots was kept visible. The set of tubes and agar gel was weighed 3 times and the average value was recorded. Then, the specimens were randomly distributed in 3 different groups according to the working length (CT) used for the instrumentation: Group (CT -1) - the working length 1 mm below the major foramen (MF); Group (CT 00) - the length was determined at the MF, and Group (CT +1) - the CT was determined 1 mm beyond the MF. Instrumentation was performed with Reciproc Blue R25 (VDW, Munich, Germany) under irrigation with 0.9% saline. After preparation, samples were removed from Eppendorf tubes and weighed 3 times again. The difference between the mean values of the initial and final weight was recorded. The one-way ANOVA test (post-hoc Bonferroni) was used with P> 0.05. Results: The average weight of the extruded waste was 0.0134 ± 0.0157 for CT -1, 0.0075 ± 0.0062 for CT 00 and 0.0075 ± 0.0068 for CT +1, with no statistically significant differences between groups. Conclusion: There was no impact of the different CTs on the amount of extruded debris beyond the apex.
Keywords: Root canal therapy; Working length; Debris extrusion.

Resumen
Objetivo: Evaluar la influencia de tres longitudes de trabajo diferentes sobre la cantidad de detritos extruidos apicalmente. Metodología: Treinta premolares inferiores con raíz única y conductos radiculares rectos se estandarizaron a 17 mm. Luego, se insertaron en tubos Eppendorf y se introdujo el gel de agar al 1,5% en los tubos que rodean las raíces. La sección coronal de las raíces se mantuvo visible. El conjunto de tubos y gel de agar se pesó 3 veces y se registró el valor medio. Luego, las muestras se distribuyeron aleatoriamente en 3 grupos diferentes según la longitud de trabajo (CT) utilizada para la instrumentación: Grupo (CT -1) - la longitud de trabajo 1 mm por debajo del foramen

mayor (FM); Grupo (CT 00): la longitud se determinó en el FM y Grupo (CT +1): la CT se determinó 1 mm más allá del FM. La instrumentación se realizó con Reciproc Blue R25 (VDW, Munich, Alemania) bajo irrigación con solución salina al 0,9%. Después de la preparación, las muestras se retiraron de los tubos Eppendorf y se pesaron nuevamente 3 veces. Se registró la diferencia entre los valores medios del peso inicial y final. Se utilizó la prueba ANOVA de una vía (post-hoc Bonferroni) con P> 0,05. Resultados: El peso promedio de los residuos extruidos fue 0.0134 ± 0.0157 para CT -1, 0.0075 ± 0.0062 para CT 00 y 0.0075 ± 0.0068 para CT +1, sin diferencias estadísticamente significativas entre grupos. Conclusión: No hubo impacto de los diferentes CT en la cantidad de escombros extruidos más allá de la cumbre.
Palabras clave: Terapia de conducto radicular; Longitud de trabajo; Extrusión de escombros.

Resumo
Objetivo: Avaliar a influência de três diferentes comprimentos de trabalho na quantidade de detritos extrusionados apicalmente. Metodologia: Trinta pré-molares inferiores com raízes únicas e canais radiculares retos foram padronizadas em 17 mm. Em seguida, foram inseridas em tubos Eppendorf, e o gel de ágar 1,5% foi introduzido no interior dos tubos envolvendo as raízes. A seção coronal das raízes foi mantida visível. O conjunto de tubos e gel de ágar foi pesado 3 vezes e o valor médio foi registrado. Em seguida, os espécimes foram distribuídos aleatoriamente em 3 grupos diferentes de acordo com o comprimento de trabalho (CT) utilizado para a instrumentação: Grupo (CT -1) - o comprimento de trabalho 1 mm aquém do forame maior (FM); Grupo (CT 00) - o comprimento foi determinado no FM, e Grupo (CT +1) - o CT foi determinado 1 mm além do FM. A instrumentação foi realizada com Reciproc Blue R25 (VDW, Munich, Germany) sob irrigação com solução salina 0,9%. Após o preparo, as amostras foram removidas dos tubos Eppendorf e pesadas novamente 3 vezes. Foi registrada a diferença entre os valores médios do peso inicial e final. O teste ANOVA one-way (post-hoc Bonferroni) foi usado com P> 0,05. Resultados: O peso médio dos resíduos extrusionados foi de 0,0134 ± 0,0157 para CT -1, 0,0075 ± 0,0062 para CT 00 e 0,0075 ± 0,0068 para CT +1, sem diferenças estatisticamente significativas entre os grupos. Conclusão: Não houve impacto dos diferentes CT na quantidade de detritos extrusionados além do ápice.
Palavras-chave: Terapia do canal radicular; Comprimento de trabalho; Extrusão de debris.

1. Introduction

The working length (WL) determines where the root canal should be instrumented and obturated. Traditionally, this determination is set 1 mm short of the radiographic apex, aiming the instrumentation solely at the dentinal canal rather than its full extension (Ricucci et al., 2016). Other studies, however, suggest that the WL should be set at the limit of the major foramen (MF), thus allowing the cleaning of the canal, encompassing both dentinal and cemental canals (De Souza Filho, et al., 1987).

By instrumenting the canal beyond the traditional 1 mm short of the apex, there is a cleaning of the MF and an enlargement of the preparation in the apical third. A more significant enlargement demonstrated decreased bacterial load, increasing the odds of a proper outcome (Card et al., 2002). One possible drawback of the foraminal cleaning is the risk of increasing postoperative pain, mainly when sodium hypochlorite is used as irrigant (Cruz Junior et al., 2016). Saline has been proposed as irrigant to prevent the possible disadvantage of NaOCl beyond the apex, associated with 2% chlorhexidine in a gel formulation (Ferraz et al., 2007). Therefore, the risk of the cytotoxic effects of NaOCl beyond the apex is minimized.

It has been suggested that instrumentation beyond the apical constriction might increase the risk of debris extrusion beyond the apex (Beeson et al., 1998). Another study, however, demonstrated that a different working length did not impact the extrusion of debris (Silva et al., 2016). The majority of these previous studies used a methodology that is not able to assess the extrusion of irrigants, underestimating the role of these in the total amount of material extruded beyond the apex.

Recently, a different methodology was adopted to assess extrusion beyond the apex, allowing the data collection of solid debris and liquid beyond the apex (Lu et al., 2013). This methodology better replicates the clinical condition that the clinician faces daily. Therefore, this study aimed to assess the debris and irrigants extrusion with different WL determinations.

2. Methodology

The Ethical Committee approved this research protocol of our Institution under the number 3.141.750. This research encompassed 30 mandibular premolars obtained from patients requiring either periodontal or orthodontic treatments. After radiographic images were obtained from buccolingual and mesio-distal directions, teeth presenting single roots and single root

canals were initially selected. Further, an examination was done to ensure that the MF was smaller than 0.20 mm and that the roots presented straight root canals (curvature < 5°) according to a method established in a previous study (Schneider, 1971). The exclusion criteria ruled out teeth presenting any signs of cracks, fractures, caries, pulp canal obliteration, internal or external resorption, or previous endodontic therapy.

Sample Size Calculation

The number of specimens required for this study was based on a previous study by Lu et al. (2013). The sample size was calculated for achieving an alpha-type error of 0.5, and a study power of 95% was input to test using a G*Power 3.0 for Mac statistical package. The results indicated a total of 30 specimens equally distributed in 3 different groups in order to observe statistically significant differences in the total of apically extruded debris.

Preparation of the Specimens

The teeth were decoronated using a diamond disk, and the roots were standardized in the same length of 17 mm. Under copious irrigation of 5% NaOCl, a size #10 k-file was gently used to remove the canal's content. All of the major foramen (MF) were standardized to a size of 0.15 mm using a size 15 k-file. The roots presenting with MF smaller than 0.15 mm were gently instrumented until this size was reached. The roots with an initial diameter of the MF larger than 0.15 mm were discarded.

The roots were covered with a teflon tape throughout the full extension, except the 1 mm of the apical third that was kept exposed. The tubes' lids (Eppendorf of Brasil, São Paulo, SP, Brazil) were pierced, the roots were inserted through these lids, and the gap between the roots and the lids were sealed using cyanoacrylate and gingival dam. The root and lid set were weighed on a scale with 10^{-4} precision (Nowak, São José do Rio Preto, Brasil). Each set was weighted 3 times 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 the set of root and lid were inserted in the tubes to have the roots completely involved in the agar gel. After 24 hours of sitting at room temperature, the whole set was again weighted 3 times and the mean weight was calculated. The difference between the 2 means was considered the initial weight.

Root Canal Shaping

The root canals were shaped using a reciprocating instrument, Reciproc Blue (VDW, Munich, Germany), size 25, taper 8 in the first 3 mm. The file was used in a dedicated endodontic motor (VDW Silver, VDW, Munich, Germany) in the specific "Reciproc ALL" configuration. The instrument slowly moved to the determined WL in small increments from 3-4 mm of amplitude. After 3 movements, the instrument was removed, cleaned with gauze, and the canal was again irrigated and flooded with 0.9% saline. After each removal of the reciprocating instrument, the foraminal patency was re-checked with a size 10 k-file.

The specimens were assigned to 3 different groups according to the groups previously determined. The randomization of the specimens was achieved using a computerized algorithm – random.org. The canals were instrumented in 3 different groups according to the WL of choice: Group (WL -1) – instrumentation was done 1 mm short of the MF; Group (WL 00) – instrumentation at the MF; and Group (WL +1) – instrumentation performed 1 mm beyond the MF. The MF position was considered the point at which the tip of a size 10 k-file was visible under 10x magnification of a dental operating microscope. All of the canals were irrigated with 0.9% saline solution at the same flow rate of 2 mL/min., controlled by a peristaltic pump (LPD 101-3, MS Tecnopon, Piracicaba, Brazil). Likewise, the same volume of solution (8 mL) was used for irrigation. All of the instrumentation was performed by the same experienced operator.

Post-Instrumentation Analysis

After the root canal shaping procedures, the lids with the roots were removed. The set of Eppendorf tubes with the agar gel, at this moment impregnated with debris and irrigants, was weighted 3 times. Once more, the mean weight was calculated and registered. The final weight included both irrigants and debris extruded was the difference between this final weight and the previously calculated initial weight of the whole content.

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.

3. Results

Table 1 shows the mean weight, in grams, of the extruded debris and irrigants was 0.0134 ± 0.0157 for WL -1, 0.0075 ± 0.0062 for WL 00, and 0.0075 ± 0.0068 for WL +1. There was no statistically significant difference among the groups $P > 0.05$.

Table 1. Mean and standard deviations (SD) of apically extruded debris by different working length (WL).

Groups	Mean	SD	P – value*
WL -1	0.0134 a	0.0157	
WL 00	0.0075 a	0.0062	
WL +1	0.0075 a	0.0068	
			0,363

p*: Same lowercase letters indicate that there was no statistical difference between the groups ($p < 0.05$). Source: Authors.

4. Discussion

The most common methodology for assessing apically extruded debris is based on a study by Myers and Montgomery (Myers & Montgomery, 1991). In this methodology, the collected material extruded beyond the apex is dried to evaporate the liquid content so the amount of debris extruded can be measured. The findings of that methodology are limited to the solid content and do not permit the assessing the irrigant solution used during root canal shaping. The methodology used in this study included a 1.5% agar gel for collecting the apically extruded material (Lu et al., 2013). Therefore, the solid and the liquid material extruded beyond the apex could be assessed. Instead of an empty flask, the agar gel also simulates in vitro the counter-pressure promoted in vivo by the periapical tissues (Lu et al, 2013; George & Walsh, 2008). Therefore, it is our understanding that this in vitro methodology can better mimic the clinical situation.

The instrumentation protocol adopted in this study is based on a single-file reciprocating system. This system demonstrated to promote less extrusion than a full sequence of rotary instruments (De-Deus et al., 2010); likewise, it is well established that hand instrumentation is more prone to promote extrusion than rotary instrumentation (Ferraz et al., 2001, Toyoglu & Altunbas, 2017). Interestingly, a previous study showed that patency beyond the apex promoted more debris extrusion when hand instrumentation is adopted. That study also showed that when using rotary instrumentation, files beyond the apex did

not increase the amount of extruded debris (Tinaz et al, 2005). A classical study using hand instrumentation also demonstrated that, using hand files, instrumentation beyond the apex with or without ultrasonic activation increases apically extruded debris (Martin & Cunningham, 1982). The present study results showed that, under reciprocating instrumentation, the determination at or beyond, the MF did not increase the amount of apically extruded debris. Therefore, these findings suggest that the instrumentation technique plays a more critical role in apically extruded debris than the WL determination.

A recent study showed that instrumentation at the apex produced the same amount of extruded debris as instrumentation 1 mm short of the apex (Silva et al., 2016). Also, further instrumentation up to the size 40.06 was not related to an increase of apically extruded debris. The present study's findings follow with that previous research; similarly, the present study also applied a reciprocating size 25.08 instrument. Based on the present study's findings, one may infer that instrumentation 1 mm beyond the MF is also safe in regard to apically extruded debris and irrigants.

Previous studies presented controversial results regarding postoperative pain after root canal preparation at the apex or 1 mm short of the apex. While Cruz-Jr et al. (2016) found that instrumentation at the apex resulted in higher postoperative pain levels, Silva et al. found no difference in postoperative pain assessing the same WL as a variable (Silva et al., 2013). It is essential to mention that both studies used NaOCl as irrigants. It is our understanding that, when instrumentation at or beyond the MF applies an irrigant other than NaOCL, such as saline, then either distilled water or chlorhexidine (CHX) should be considered. The results of the present study showed the same amount of apically extruded debris and irrigants beyond the apex, the same amount of postoperative pain should be expected. Therefore, further clinical studies using instrumentation at or beyond the MF should consider using fewer cytotoxic irrigants.

5. Conclusion

The results of the present study conclude that instrumentation at the MF, 1 mm short or 1 mm beyond the MF, leads to the same amount of apically extruded debris and irrigants.

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