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Radiographic evaluation of root canal cleaning, main and laterals, using different methods of final irrigation

Avaliação radiográfica da limpeza de canais radiculares, principal e laterais, utilizando diferentes métodos de irrigação final

Gisselle Moraima CHÁVEZ-ANDRADE[a], Juliane Maria GUERREIRO-TANOMARU[a], Lucas Martinati MIANO[a], Renato de Toledo LEONARDO[a], Mario TANOMARU-FILHO[a*]

[a]Faculdade de Odontologia, UNESP – Univ Estadual Paulista, Araraquara, SP, Brasil

Resumo

Objetivo: O objetivo deste estudo foi avaliar a eficácia da irrigação ultrassônica passiva (IUP), utilizando os fluxos intermitente ou contínuo, e da irrigação manual convencional (IMC) na limpeza de canais radiculares, principal e laterais simulados. **Material e método:** Os canais radiculares de 24 dentes artificiais foram preparados e os canais laterais foram confeccionados nos terços médio e apical. Os espécimes foram divididos em três grupos: G1- IMC, G2- IUP 1 (fluxo intermitente) e G3- IUP 2 (fluxo contínuo). Os canais radiculares foram preenchidos com uma solução de contraste e as raízes foram radiografadas antes e após a irrigação. As imagens digitais foram importadas para o programa Image Tool 3.0 e as áreas do canal totalmente preenchidas com o contraste, e após a irrigação, com remanescente do contraste, foram mensuradas para obtenção de dados percentuais. A análise estatística entre os grupos foi realizada por meio dos testes ANOVA e Tuckey. **Resultado:** No terço apical, os grupos G2 e G3 (IUP) mostraram melhor limpeza do que o grupo G1 (IMC) ($p<0.05$). Não houve diferenças estatisticamente significantes entre os grupos G2 e G3 ($p>0.05$). **Conclusão:** Irrigação ultrassônica passiva com fluxo intermitente promoveu melhor limpeza dos canais laterais simulados do que a irrigação manual convencional no terço apical do canal radicular. Não houve diferenças entre os grupos no canal principal e no terço médio. **Descritores:** Endodontia; irrigantes do canal radicular; ultrassom.

Abstract

Objective: To evaluate the efficacy of passive ultrasonic irrigation (PUI) using intermittent or continuous flushing and conventional manual irrigation (CMI) on the cleaning of main and simulated lateral root canals. **Material and method:** The root canals of 24 artificial teeth were prepared and simulated lateral canals were made in the medium and apical thirds of the root. The specimens were divided into three groups: G1- CMI, G2- PUI 1 (intermittent flushing) and G3- PUI 2 (continuous flushing). Root canals were filled with contrast solution and the roots were radiographed pre- and post-irrigation. The digital images were transferred to Image Tool 3.0 software and the areas of root canal completely filled with contrast, and after irrigation with contrast remnant, were measured to obtain percentage data. Statistical analysis between groups was performed by ANOVA and Tukey tests. **Result:** In the apical third, G2 and G3 (PUI) groups showed higher percentage of cleaning than G1 (CMI) ($p<0.05$). **Conclusion:** Passive ultrasonic irrigation using intermittent flushing promoted a higher cleaning of simulated lateral canals than conventional manual irrigation in the apical third. There were no differences between groups in the main root canal and the middle third.

Descriptors: Endodontics; root canal irrigants; ultrasonics.

INTRODUCTION

The persistence of microorganisms and their products within the root canal system is the main etiologic factor of periradicular pathology[1-3]. The endodontic irrigation aims to promote cleaning and disinfection of the root canal system[2,4,5]. The efficacy of root canal irrigation depends on the method employed[4], enabling cleaning of the main and lateral canals as well as the isthmus area[4,6-8].

Passive Ultrasonic Irrigation (PUI), used as a final irrigation protocol, has demonstrated efficacy on the removal of debris and microorganisms when compared to conventional manual irrigation (CMI) using syringe and needle[4,8-12].

Different methodologies have been used for evaluation of root canal irrigation efficacy. Abou-Rass, Piccinino[13] employed radiopaque contrast mixed with dentin chips in root canals

from extracted molars. De Gregorio et al.[6] evaluated the effects of PUI within main and simulated lateral root canals in single-rooted cleared human teeth. Rödig et al.[14] assessed PUI efficacy on removing dentin debris from simulated irregularities in root canals, and showed greater debris removal for PUI comparing with CMI.

The aim of this study was to evaluate the efficacy of passive ultrasonic irrigation by using two methods of irrigation solution flushing (continuous or intermittent) on the cleaning of main and simulated lateral root canals in the medium and apical thirds. The null hypothesis is that the action of cleaning by both methods of passive irrigation shows similarity in relation to conventional manual irrigation.

MATERIAL AND METHOD

Twenty-four single-rooted artificial resin teeth (Fábrica de Sorrisos, Dental Rossetto Ltda., Arujá, SP, Brazil) were used in this study. Teeth had the crowns removed by using a cutting machine (Isomet 1000, Buelher Ltda., Lake Bluff, Il, USA). The roots were standardized in 14 mm of length.

The working length (WL) was established 1 mm short from the apex and the root canal instrumentation was realized by using a rotary system (MTwo, VDW, Munich, Germany). The basic sequence of the system was used (10/.04, 15/.05, 20/.06, 25/.06), followed by size 25/.07 instrument and apical preparation with size 30/.05, 35/.04 and 40/.04 instrument. All instruments were used to the working length. After each file change, the root canals were irrigated with 2 mL of distilled water using syringe (Ultradent Products, USA) and a 30G needle (NaviTip Tips, Ultradent Products, USA).

After root canal preparation, four lateral canals were made in each root, in the labial and lingual surfaces, at 2 mm and 7 mm short from the apex, according to the methodology reported by Almeida et al.[15]. A cylinder-shaped bur with 0.20 mm diameter (Brocas Undercut, Union Tool Co., Pluritec, SP, Brazil) was used.

The root canals were filled using a radiographic contrast solution (Meglumine/sodium diatrizoate – 76%, Pielograf, BerliMed SA, Madrid, Spain) thickened with propylene glycol and bismuth oxide at the following proportion: 1 g of bismuth oxide, 1 mL of contrast solution and 1 mL of propylene glycol, according with modified methodology of Guerreiro-Tanomaru et al.[16]. Digital periapical radiographs were performed (Kodak RVG 6100 Digital Radiography System, France) with teeth placed in a standardization device. A radiograph was used to confirm the complete filling of main and lateral canals by the contrast solution. The specimens were put in a glass flask filled with a silicon-based impression material (Zetaplus, Zhermack, Italy), immersed 1 mm short of the cervical surface, and stored until the experiment. The specimens were divided according to the irrigation protocols (Table 1).

1. Irrigation Protocols

It was used 5 mL of 1% NaOCl for each specimen and the total period of irrigation was 2 minutes for each root canal. In G1, conventional manual irrigation (CMI) was used with syringe and 30G needle (NaviTip Tips, Ultradent Products, USA) at 1 mm short from the working length, followed by the simultaneous aspiration.

In G2, the passive ultrasonic irrigation (PUI 1) was carried out through using the irrigating solution activated by an ultrasonic tip IRRI S (smooth wire) size 25/.00 (VDW, Endo Ultrasonic Files, Endodontic Synergy, Germany), at 1 mm short from the working length. PUI was performed using a piezoelectric device with 30 kHz frequency (CVDent 1000, CVD Vale, São José dos Campos, SP, Brazil) according to Al-Jadaa et al.[17] and van der Sluis et al.[18]. The irrigation period was divided as follow: 2 mL of solution in the first 30 seconds using CMI followed by 20 seconds using PUI; 1 mL of the solution for 20 seconds using CMI followed by 20 seconds using PUI; 2 mL of the irrigating solution using CMI for 30 seconds, according to Bhuva et al.[1]. The root canals were filled with the irrigating solution by using a 31G needle (NaviTip – Double Sideport Irrigator Tip, Ultradent Products, USA).

In G3, PUI 2 was used similarly to G2, except for a simultaneous irrigation performed during the ultrasonic activation (continuous flushing). The continuous flushing was carried out with an irrigating syringe and 31G needle (NaviTip – Double Sideport Irrigator Tip, Ultradent Products, USA) at 2 mm short from the working length and simultaneous aspiration, following the method used by Bhuva et al.[1] and modified by Cameron[19].

After the irrigation protocols, new digital radiographs were transferred to Image Tool 3.0 software. The areas of root canal filled with contrast and after the irrigation (contrast remnant) were delimited as shown in Figure 1. The evaluation was performed by an examiner trained to properly use the software and blind to experimental groups. The images were imported into the Image Tool 3.0 software and analyzed using the tools of the software. This procedure allows an automatic delineation after calibration of parameters. The measurements were obtained in mm^2 for both the main and lateral canals, and the percentage of cleaning was

Table 1. Protocols of final irrigation used for the experimental groups

Groups	Protocol of final irrigation	Total time of irrigation	Total volume	n
G1 - CMI	Syringe and 30G needle	2 minutes	5mL	8
G2 - PUI 1	PUI - intermittent flushing	2 minutes	5mL	8
G3 - PUI 2	PUI - continuous flushing	2 minutes	5mL	8

G, group; CMI, conventional manual irrigation; PUI, passive ultrasonic irrigation.

calculated for each group. Data were submitted to the normality test and comparison among groups by using ANOVA and Tukey tests ($p < 0.05$).

RESULT

The results demonstrated that there was no statistically significant difference among groups regarding to the efficacy of contrast solution removal from the main root canal (p>0.05). For the simulated lateral canals, there was no difference among groups in the medium third (p>0.05). In the apical third, PUI using intermittent flushing showed the highest cleaning when compared to CMI group (p<0.05), however there was no difference among G2 and G3 (p>0.05) (Table 2).

DISCUSSION

The radiographic analysis has been used for the assessment of the irrigation efficacy in root canals from extracted teeth[13,20]. In this present study, the digital radiographic system and the evaluation using image software analysis were used. The use of image software enables the assessment of the evolution or regression of periapical lesions[21], the cleaning and penetration capacity of irrigating solutions into root canal system[6,19]. Bronnec et al.[22] evaluated the penetration of the irrigant in curved root canals of lower molars during the root canal preparation, by using a radiographic contrast solution (sodium diatrizoate), 3% NaOCl, syringe and 27G needle. The specimens were radiographed in a standardization device and analyzed by using Image J software.

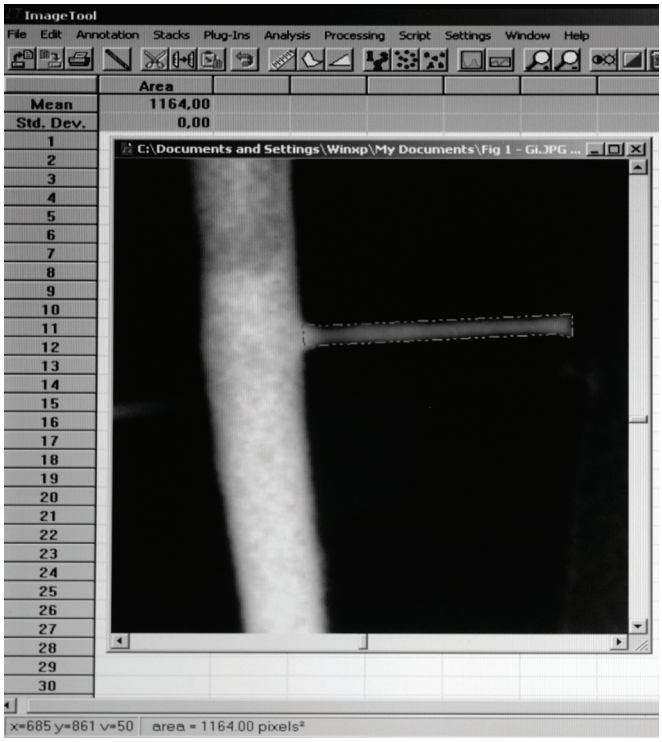

Figure 1. Image representative of measurements in simulated lateral canals (mm^2) in the Image Tool 3.0 software.

Simulated lateral canals can be made in either resin teeth or blocks[23-27] or natural teeth[15,28] followed by radiographic analysis[29]. In the present study, simulated lateral canals were created in artificial resin teeth, as already described by Tanomaru-Filho et al.[26]. A 0.20 mm diameter bur was used as conducted by Al-Jadaa et al.[11] in resin blocks and Almeida et al.[15] in natural teeth. The radiographic contrast solution was thickened with propylene glycol and bismuth oxide to provide consistency and radiopacity[16].

Either in vitro or ex vivo studies evaluated the penetration capacity of contrast solutions or dyes in simulated lateral canals using human teeth or resin blocks[6,22,30]. Kahn et al.[30] using a video camera, evaluated the presence or absence of a dye within root canals after irrigation methods. De Gregorio et al.[6] observed the dye penetration in lateral canals in cleared specimens. Saber Sel, Hashem[31], using single-rooted human mandibular premolars, compared PUI, CMI, and other irrigation systems, regarding to smear layer removal in the cervical, medium, and apical thirds of root canals, using SEM and score systems. The results did not show difference between PUI and CMI, which was in agreement with other studies[32] demonstrating that PUI was not able to completely remove the smear layer from the apical third of root canal.

PUI (intermittent flushing) was also assessed regarding to the effect of dissolution of bovine pulp tissue of simulated lateral canals (0.20 mm diameter) in the apical third of root canal in epoxy resin models[11]. The results showed a higher effect of PUI on the pulp dissolution when compared to other irrigation systems (including the non-activation of the irrigant), suggesting a greater apical third cleaning, corroborating the results of the present study.

Few studies compared the two methods of PUI application: intermittent and continuous flushing. Van der Sluis et al.[18] determined the influence of irrigation period on dentinal debris removal in simulated irregularities in the apical third during PUI by using the two methods. The authors concluded that PUI associated with the intermittent flushing for 1 minute was more

Table 2. Comparison among groups for the main and lateral root canals (mean and standard deviation of the cleaning percentage)

Groups	Main Canal	Lateral Canals (medium third)	Lateral Canals (apical third)
G1- CMI	94.54 (± 1.92)^{A}	53.87 (± 13.28)^{A}	51.95 (± 24.23)^{B}
G2- PUI 1	97.52 (± 1.67)^{A}	73.47 (± 18.32)^{A}	77.56 (± 18.68)^{A}
G3- PUI 2	96.08 (± 2.95)^{A}	69.50 (± 24.91)^{A}	73.29 (± 13.15)^{A,B}

Different letters indicate statistically significant differences ($P < 0.05$) in the same column; PUI, passive ultrasonic irrigation; CMI, conventional manual irrigation; G, group.

effective on dentinal debris removal than PUI associated with continuous flushing for 3 minutes. Using a similar methodology, van der Sluis et al.[33] compared the two methods of PUI application showing that there was no difference between PUI (continuous flushing) with 50 mL of NaOCl and PUI (intermittent flushing) with 12 mL of the irrigant, in the dentinal debris removal from apical third. In the present study, both PUI methods promoted root canal cleaning.

The effective apical irrigation is one of the most important procedures during root canal treatment[34]. Notwithstanding, the use of intermittent flushing was the most effective method on cleaning of apical lateral canal. This result suggests the use of this method because the apical root area presents the greatest amount of accessory canals and apical ramifications, resulting in greater difficulty for cleaning and disinfection.

CONCLUSION

According to the methodology employed, passive ultrasonic irrigation (PUI) and conventional manual irrigation (CMI) promotes a similar cleaning of main and lateral root canals in the medium third. However, PUI with intermittent flushing was the most effective method for cleaning simulated lateral canals in the apical third when compared to CMI.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

*CORRESPONDING AUTHOR

Mário Tanomaru Filho, Departamento de Odontologia Restauradora, Faculdade de Odontologia, UNESP - Univ Estadual Paulista, Rua Humaitá, 1680, CP 331, Centro, 14801-903 Araraquara - SP, Brazil, e-mail: tanomaru@uol.com.br

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