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Effect of apical negative irrigation on lateral canals of extracted teeth in endodontic treatment: An original research

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***Abstract*---**Introduction: The aim of this study was to evaluate the efficacy of continuous apical negative ultrasonic irrigation into simulated lateral canals and the apical third in straight and curved root canals. Material and methods: Two simulated lateral canals were created 2, 4 and 6 mm from the working length in 120 single-rooted teeth (6 canals/tooth, n = 360 straight, n = 360 curved). The teeth

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were randomly divided into 3 experimental groups: positive pressure irrigation (PPI) (n = 20); passive ultrasonic irrigation (PUI) (n = 20); continuous apical negative ultrasonic irrigation (CANUI) (n = 20). 20% Chinese ink was added to a 5% sodium hypochlorite solution and delivered into the root canals. Results: The results showed a significantly higher($P < 0.05$) penetration of irrigant into the lateral canals and up to working length in the CANUI group for straight and curved roots. Conclusion: CANUI improves penetration into the lateral canals and up to the working length of the cleared teeth in straight and curved roots.

***Keywords*---**apical negative irrigation, lateral canals, endodontics.

Introduction

Apical periodontitis is a biofilm-related infection, and one of the primary goals of treatment is to kill or remove microbes from the root canal system1. However, complete elimination is difficult in anatomically complex areas of the root canal system, which are often inaccessible to instruments2. Therefore, instrumentation must be combined with adequate irrigation to complete the cleaning process and decrease the microbial load within the root canal system3. The most common irrigation method is the conventional type using an irrigating cannula with the front extremity or side coupled to a syringe.

In this study, we designed a device for continuous apical negative-pressure ultrasonic irrigation (CANUI)3, which combines characteristics of the negative-pressure cleaning systems (to avoid apical extrusion and transport irrigant to the working length) and continuous ultrasonic irrigation systems (to penetrate irrigant into irregularities of the root canal system). The device consists of a body connected to an ultrasonic unit [Suprasson P5 Booster (Satelec, Acteón Group)] through the lower thread. From the top this body emerges a steel cannula (that has a pointed diameter of 0.75 mm) and a micro-cannula (0.3 mm) inserted into a cannula. This micro-cannula is constructed using nickel–titanium and can adapt to the anatomy of curved root canals. The purpose of this study was to compare the effects of three irrigation systems (PPI, PUI, and CANUI) on irrigant delivery into the apical third of the root canal and into simulated lateral canals in cleared extracted teeth in straight and curved root canal

Material and Methods

One hundred twenty extracted human single-root teeth with fully formed apices (maxillary central with straight canal and morphology) that had not undergone prior endodontic treatment were selected of these, 60 teeth were straight, and 60 had root curvatures of 20–30º. After debriding and complete cleaning of the root surface, samples were immersed in a 5.25% NaOCl (Dentaflux, Madrid, Spain) for 30 min and then stored in saline solution until preparation. After completing the shaping procedures, teeth were cleared. Briefly, teeth were submerged in 5% nitric acid for 36 h, and the solution was renewed every 8 h. Once decalcified, samples were cleared with tap water for 3 min, and lateral canals were created by inserting a 06 C+ file (Dentsply Maillefer, Ballaigues, Switzerland) from the buccal to the lingual wall at 2, 4, and 6 mm from the working length perpendicular to the external surface. Samples were dehydrated in ascending grades of ethyl alcohol and submerged in 99.9% methyl salicylate for clearing and rehardening of dental tissues. A contrast solution containing 5% NaOCl (80%) and 20% Chinese ink (Sanford Rotring GmbH, Hamburg, Germany) was prepared and delivered to the prepared root canals.

Group 1 (n = 20): Positive pressure (control). Teeth in group 1 were irrigated with PPI (1 min) using a 30-G ProRinse needle and a syringe to 2 mm from the working length. A total volume of 6 mL of contrast solution was delivered. The solution was not dynamically activated in this group. Group 2 (n = 20): PUI. A total volume of 2 mL of contrast solution was delivered into the teeth in group 2 using a 30-G ProRinse needle, and the solution was left in the root canals. Ultrasonic activation was performed with an ISO15 ESI file (EMS, Nyon, Switzerland) mounted on an ultrasonic unit. The file was passively inserted to 1 mm from the working length and activated using a power setting of 4, as recommended by the manufacturer. The procedure was repeated three times, for a total volume of 6 mL of contrast solution and a total activation time of 1 min for each tooth.

Group 3 (n = 20): CANUI. Continuous apical negative ultrasonic irrigation was performed using prototypes of the device mounted on a Suprasson P5 Booster ultrasonic unit. A 10-mL syringe containing contrast solution was attached to the luer-lock connection on the UI needle and inserted to the working length with the microcannula. Then, the device was activated with the power set to level 6, and the solution was delivered, maintaining a continuous irrigation flow of 6 mL/min. The total activation time was 1 min; a total volume of 6 mL of contrast solution was delivered. The penetration of contrast solution into the simulated lateral canals was scored by counting the number of lateral canals (0–2) penetrated to at least 50% of the total length. The outcome was assessed in each tooth at the three working lengths (2, 4, and 6 mm). One trained evaluator, who was blinded to the group assignment of each sample, scored all samples. *P*-values of 0.05 were considered statistically significant.

Results

Reaching the working length

Straight canals: In the first group (PPI, control), the contrast solution did not reach the working length in any sample (0%). The contrast solution reached the working length in 65% of samples in group 2 (PUI) and 100% of samples in group 3 (CANUI). Penetration of the irrigant to the working length was significantly different among the three groups (Table 1). Curved canals: Penetration was complete in 0% of group 1, 35% of group 2, and 100% of group 3 (CANUI). Penetration of the irrigant to the working length differed significantly among the three groups (Table 2). When we compared curved and straight canals, we found no significant difference, although the penetration was greater in straight canals for PUI.

Penetration into lateral canals

Straight canals: Overall penetration into lateral canals was 0% for group 1 (PPI), 33.33% for group 2 (PUI), and 86.67% for group 3 (CANUI) (Figs. 6, 9). These values differed significantly among the groups ($P < 0.001$). These results were confirmed in separate analyses of the three levels (Table 1). Curved canals: Overall penetration into lateral canals was 0% for group 1 (PPI), 35.83% for group 2 (PUI), and 81.67% for group 3 (CANUI). These values differed significantly among the three groups ($P < 0.001$). These results were confirmed in separate analyses for the three levels (Table 2). There was no significant difference between straight and curved canals in terms of PUI penetration into the lateral canals; similar results were found in the CUI group.

Table 1
Total and percentage of lateral canals penetrated by the irrigation solution in straight root canals

	Group 1: PPI	Group 2: PUI	Group 3: CANUI	P
Reached working length, n (%)	0 (0)	13 (65%)	20 (100%)	< 0.001
Overall	0 (0)	40 (33.33%)	104 (86.67%)	< 0.001
6 mm	0 (0)	15 (37.5%)	38 (95%)	< 0.001
4 mm	0 (0)	10 (25%)	35 (87.5%)	< 0.001
2 mm	0 (0)	15 (37.5%)	31 (77.5%)	< 0.001
No. of canals penetrated, mean	0	0.33	0.87	< 0.001
% total canals penetrated	0	33.33%	86.67%	
Standard deviation	0	0.47	0,34	

Table 2
Total and percentage of lateral canals penetrated by the irrigation solution in curved root canals

	Group 1: PPI	Group 2: PUI	Group 3: CANUI	*P*
Reached working length, n (%)	0 (0)	7 (35%)	20 (100%)	< 0.001
Overall	0 (0)	43 (35.83%)	98 (81.67%)	< 0.001
6 mm	0 (0)	20 (50%)	37 (92.5%)	< 0.001
4 mm	0 (0)	13 (32.5%)	35 (87.5%)	< 0.001
2 mm	0 (0)	10 (25%)	26 (65%)	< 0.001
No. of canals penetrated, mean	0	0.36	0.82	< 0.001
% total canals penetrated	0	35.83%	81.67%	
Standard deviation	0	0.82	0.39	

Discussion

In this in vitro investigation, we compared the ability of two ultrasonic irrigation techniques (PUI and CANUI) and one traditional technique (PPI) to deliver a contrast dye-containing irrigating solution into the apical third of straight and curved root canals and into artificially created lateral canals in cleared extracted teeth. To reproduce the clinical situation, we used an in vitro closed-end canal design that closely replicates in vivo scenarios in which the apical foramen is enclosed in alveolar bone and the periodontal ligament 4-10. Clinically, this design forces the irrigants to exit the canal coronally rather than apically or laterally3. As shown in previous reports, irrigation with PPI did not reach the working length or penetrate lateral canals. This may be due to the presence of an apical vapor lock created by the organic decomposition of NaOCl into a bubble of carbon dioxide and ammoniu 14-16. Furthermore, PPI does not have enough force to penetrate lateral canals in either straight or curved canals.

We also compared two ultrasonic techniques (PUI and CANUI) with each other and with PPI. Both ultrasonic techniques produced adequate irrigant penetration into the apical third of the root canal, but CANUI reached the apical third in all cases, demonstrating significantly greater success than the other groups. This may be due to the apical force of suction of ANP3. This can be explained by the design of the microcannula, which eliminates vapor lock and allows for apical exchange of irrigants. On the other hand, the efficacy of PUI depends on penetration of the ultrasonic file to 1 to 2 mm from the working length, and the volume of activated solution is limited17-18. We found no statistical difference between straight and curved canals. Finally, it was compared the penetration of irrigant into the simulated lateral canals; significant differences were observed among the three groups ($p < 0.05$). Previous studies have observed greater efficacy of PUI when compared syringe and needle (PPI) and other techniques11-15. The effectiveness of this method for activating irrigants may be due to the production of acoustic microwaves and cavitation19. However, some studies have contested its efficacy in curved canals17-19 possibly because the ultrasonic tip should not act freely inside the canal space and may bind to the walls and interfere with acoustic streaming and cavitation, resulting in a poorer debridement19. In our study, there was no significant difference between straight and curved canals in PUI groups, although we observed increased penetration into the apical third of the straight canals. Moreover, complications such as ledge formation, uncontrolled cutting of the root canal walls, and perforations have been reported using PUI19. Limitations of this study include the lack of similar studies for comparison. It can be concluded that under the conditions of this study, CANUI improves penetration into the lateral canals and up to the working length of the cleared teeth in straight and curved roots.

Conclusion

In the present study, we applied ESI instruments made of nickel titanium for increased flexibility, which may improve the quality of the instrument compared to steel, to avoid these problems. In this investigation, we didn´t observe these complications. On the other hand, CANUI groups showed improved penetration into lateral canals compared with PUI in curved and straight canals. This may be due to the continuous exchange of solution and the optimized activation of the solution as it passes through the ultrasonically energized needle, enhanced by the force of the ANP.

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