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Original Article
บทวิทยาการ

Comparison in amount of sodium hypochlorite extrusion during irrigation with needle-syringe and EndoActivator: *in vitro* study

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Abstract

Objective To assess the volume of sodium hypochlorite (NaOCl) that was apically extruded from teeth prepared to different apical sizes during irrigation using an EndoActivator compared with using a needle and a syringe.

Materials and methods One hundred single root canals were instrumented and randomly divided into three experimental groups (n = 30) with final apical sizes of #35, #50, or #80. Each tooth was fixed in an agarose gel model and irrigated with 2.5% NaOCl using a needle and a syringe irrigating technique. The tooth was removed, cleaned, dried and re-fixed in a new agarose gel model prior to irrigating with an EndoActivator. Apical extrusion was assessed by the weight difference before and after each irrigation and confirmed by the color change of a pH-indicator in the gel model. Data were analysed by Kruskal-Wallis test and the Mann-Whiney rank sum test for pairwise comparisons.

Results There was no color or weight change in the size #35 group. Apical extrusion of NaOCl occurred in teeth prepared to apical size #50 or #80. The extrusion volume was increasing when the apical size was larger and was significantly higher in the needle-syringe groups than in the EndoActivator groups ($p < 0.05$).

Conclusion Extrusion occurred in teeth prepared to apical size #50 or #80. Extrusion was significantly reduced when using the EndoActivator compared with the needle and a syringe technique.

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***Key words**: apical preparation size; EndoActivator; extrusion; irrigation; sodium hypochlorite*

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Introduction

Successful endodontic treatment depends on the efficacy of root canal debridement by means of instrumentation procedures, intracanal medication, and copious irrigation.[1] Because of its antibacterial and lubricating properties, and its ability to dissolve pulp remnants, sodium hypochlorite is the most widely accepted endodontic irrigating solution.[2,3] However, the extrusion of sodium hypochlorite through the root canal foramen into periapical tissue can lead to extensive soft tissue or nerve damage, as well as airway compromise.[4] After inadvertent NaOCl extrusion, patients have experienced immediate severe pain, swelling, and ecchymosis, which is referred to as a NaOCl accident.[5] Most patients recover within a week to a month, but emergency medical care and hospitalization can be required in cases of severe swelling.[6] Thus, caution must be used during NaOCl irrigation to prevent a NaOCl accident.

In a study where teeth had been apically prepared to a final size #25-#70 file, debris was seen extruded from the apex during instrumentation and irrigation when the root canal was prepared to size #50.[7] In an *in vivo* study, radiopaque irrigants were observed extruded into the periapical tissue in necrotic pulp tissue cases instrumented to a size #45 file. However, extrusion was not observed when the canals were instrumented to size #30 or #35.[8] This suggests that increasing the apical preparation size results in a higher risk of apical extrusion. In contrast, studies using a computational fluid dynamic (CFD) model indicated an increase in root canal taper and apical preparation size improved irrigant replacement and wall shear stress, thus reducing the risk for irrigant extrusion.[9,10]

The EndoActivator is a sonic irrigation device with flexible polymer tips designed to hydrodynamically activate intracanal irrigants. Hydrodynamically activate intracanal irrigants are an effective method to disinfect the root canal.[11] Many studies have evaluated the effectiveness of the EndoActivator in cleaning the root canal. This system increased the removal of debris and the smear layer from canals.[12,13] The EndoActivator also promoted bacterial removal from the root canal when compared with conventional needle irrigation.[14] To the best of our knowledge, there are only two studies comparing the amount of irrigant extruded from the root canal when using an EndoActivator or other delivery systems. In these studies the use of EndoActivator irrigation resulted in only small amounts of extruded irrigating solution.[15,16]

The purpose of this study was to measure the amount sodium hypochlorite apically extruded from root canals prepared to different apical sizes during final irrigation using the EndoActivator or the conventional irrigation technique.

Materials and methods

The protocol used in this study was approved by the Ethics Committee at the Faculty of Dentistry, Chulalongkorn University (135/2554). One hundred extracted human anterior teeth with single root canals and mature apices were cleaned with a curette and stored in 10% formalin solution until used. Bucco-lingual and mesio-distal radiographs of each tooth were obtained to assess the degree of root canal curvature.[17] Teeth were excluded if the canal curvature was greater than 20 degrees and the initial apical file was larger than a #25 K-file.

Tooth access was prepared with a high-speed diamond #2 round bur and safe-tip diamond bur under copious water spray. A #15 K-file was placed into the root canal until it was visible at the apical foramen. The working length was established 1 mm short of this length. Gates Glidden drills sizes 2-4 were used to flare the coronal one-third of the root canal. The lower two-thirds of the root canal was shaped with ProTaper rotary instruments (Dentsply Maillefer, Ballaigues, Switzerland) and apical preparation to the working length was completed with a F3 file (size 30/.09). The instrumented teeth were randomly divided into three groups (n = 30). The teeth in each group were further instrumented at the working length of each tooth with K-hand files to a different apical size #35, #50, or #80. Apical patency was maintained with a #10 K-file between the instrumentation procedures. After using each file, the root canal was irrigated with 3 ml of 2.5% NaOCl solution using a 5 ml syringe and a monoject 27-gauge needle (Nipro Corp., Osaka, Japan). The final apical preparation size of each tooth was confirmed with a corresponding standardized guttapercha cone. Ten teeth were divided to positive and negative control groups (n = 5). The root canals of both groups were instrumented at their working length to a master apical size #80 file.

The teeth were dried with paper points and air-dried at room temperature for one hour. The root surface of each tooth, except for the negative control group, was double coated with nail varnish excluding its apical foramen. For the negative control group, the entire tooth surface, including the apical foramen, was coated with nail varnish.

To prepare the gel models, each tooth was inserted through a hole cut in the lid of a polystyrene tissue culture dish (CoStar Corp., Tewksbury, USA) and rigidly secured with border wax (Fig. 1A). The lid was placed on top of the culture dish with the root apex 0.5 mm above the base of the dish. Five milliliters of 0.2% agarose gel containing 0.1 ml of 0.2% thymolphthalein blue (Merck, Darmstadt, Germany) was then poured into the culture dish. To prevent the gel from leaking into the root canal, a master apical file was inserted to the working length during model preparation.

Before the final irrigation was performed, each model was weighed to four decimal points using a Precisa XT2200C scale (Precisa Instrument AG, Dietikan, Switzerland), which was calibrated before each use.

The teeth in the experimental groups received a final irrigation using a 5 ml syringe with a monoject 27-gauge needle, which was placed loosely into the root canal 2 mm short of the working length. Three milliliters of NaOCl was constantly delivered at an approximate rate of 0.05 ml/min with an up and down motion of the syringe. The irrigant overflow was suctioned with a high-speed evacuator. After irrigation, the root canal was dried with paper points. The model was weighed with the same scale to determine any weight change.

The tooth was then removed from the model, the root surface cleaned with running water, and left at room temperature for 1 hour to dry. The tooth then was placed in a new gel model, weighed, and received a final irrigation of NaOCl using the EndoActivator (Dentsply Maillefer, Ballaigues, Switzerland). The irrigant was delivered into the root canal until

A B

Fig. 1 A. Agarose gel model; B. Change of agarose gels color from colorless to blue in positive control and experimental group with increased weight.

Table 1 Volume of 2.5% NaOCl extruded from root canals with different apical preparation sizes during final irrigation using the conventional needle-syringe or the EndoActivator technique

Apical preparation size (#)	Extrusion volume (ml, mean ± standard deviation)	
	Needle-syringe technique	**EndoActivator technique**
35 (n = 30)	0.0000 ± 0.00000^{A}	0.0000 ± 0.00000^{A}
50 (n = 30)	0.1903 ± 0.08693^{B}	0.0107 ± 0.01502^{C}
80 (n = 30)	0.8381 ± 0.17378^{D}	0.0877 ± 0.06786^{B}
Negative control	0.0000 ± 0.00000	
Positive control	2.8637 ± 0.04572	

Mean values sharing the same superscript letter were not significantly different at $p = 0.05$

overflow from the access cavity was observed. The EndoActivator with a 35/.04 size tip was then placed into the root canal 2 mm short of the working length and was used with an up and down motion for 1 minute using the vibration mode 3 setting (166 Hz). After irrigation, the root canal was dried with paper points. The model was weighed with the same scale to determine any weight change.

For the control groups, the teeth were placed in gel models, weighed, and then 3 ml of NaOCl was delivered into the root canal using a 5 ml syringe with a monoject 27-gauge needle at the working length for 1 minute. After irrigation, the root canal was dried with paper points. The model was weighed with the same scale.

Extruded irrigant was visually detected when the pH indicator changed from colorless to blue. The difference in model weight before and after each irrigation technique was determined. The weight difference was divided by the density of NaOCl (1.06g/ml)[18] to generate the volume of extruded irrigant.

The resulting data were analyzed for normality using one-sample Kolmogorov-Smirnov test. Because the data was found to be non-parametric, the Kruskal-Wallis and Mann-Whitney test were used with statistical significance set at $p < 0.05$.

Results

The results demonstrated that when root canals were instrumented to a master apical size #35 file, neither irrigation technique resulted in extruded NaOCl. However, regardless of the irrigation technique used, apical extrusion occurred when the apical preparation size was increased (Table 1). In teeth prepared to a size #50, the needle-syringe group had a mean extrusion of 0.1903 ml, which was significantly higher than that for the EndoActivator group at 0.0107 ml. Preparing teeth to a size #80 resulted in a mean extrusion of 0.8381 ml; this was significantly different than that of the EndoActivator group, where a mean of 0.0877 ml was found.

No color change was observed in either the negative control group or from teeth apically prepared to size #35, corresponding to the result of no weight change. In contrast, the color of the agarose gel changed to blue in the positive control group and the experimental groups with increased weight subsequent to irrigation (Fig. 1B).

Discussion

In the present study, the amount of apically extruded NaOCl was assessed by weighing the tooth gel models pre and post irrigation. The weight change in the tooth gel models was determined. The volume of the extruded NaOCl irrigant was calculated by dividing the density of NaOCl (1.06 g/ml) by the weight change. The collection and weighing of extruded debris and/or irrigating solution has been performed in many previous studies because of its simplicity.[15,19,20] However in these studies, teeth were fixed in empty bottles, therefore they did not simulate the periapical tissue anatomy. Using teeth embedded in agarose gel created a closed system. This system simulated the periapical tissues, which may restrict apical extrusion.

Thymolpthalein blue is a pH indicator with a transition range at approximately pH 9-10.5. When NaOCl (pH = 11) is extruded through the apical foramen, the color of the pH indicator in the gel will change from colorless to blue. Thus, the observed color change in the gel model confirmed that the measured weight change of the tooth model was the result of NaOCl extrusion from the apical foramen. In our study, all the models with unchanged weight also showed no change in the color of the agarose gel.

We found that, regardless of irrigation technique, teeth prepared to apical size #35 showed no apical extrusion of NaOCl. This result differed from a previous study which found apical extrusion from teeth instrumented to this size.[16] In the present study, teeth were instrumented using an F3 ProTaper with a .09 taper, while in the previous study teeth were prepared with less tapered files (.06 taper). ACFD study showed that when canal tapering increased, the apical pressure gradually decreased.[10] Therefore, the differing results may be caused by the difference in the taper of the prepared canals. Irrespective of which irrigating technique was used, apical extrusion was visually observed in experimental groups of teeth prepared to apical size #50. This finding corresponded to a previous study where debris was seen extruded from the apex when the apical root canal was prepared up to file size #50.[7] Greater apical extrusion occurred when the apical preparation size was increased from size #50 to #80. Enlarging the apical preparation size results in a marked increase in surface area (by a power of two) and circumference. This could increase the potential for apical extrusion when instrumenting the root canal to large apical preparation sizes.

Each technique produces a different pattern of fluid movement inside the root canal. The EndoActivator is a sonic device with a vibrating polymer tip that produces a powerful hydrodynamic force. The rate of vibration can be adjusted from 33 Hz (mode 1) to 166 Hz (mode 3). Used during the final irrigation, the EndoActivator tip vibrates back and forth, producing a wave of energy along the entire length of the tip.[11] Irrigant is not replenished while the tip is in motion, thus irrigant tends to circulate inside the root canal with less apical pressure. In the needle and syringe technique, the use of an up and down while replenishing the irrigant generates pressure at the apical foramen.[9] Irrigant replacement occurred when flow rates in the range of 0.53-0.79 ml/sec were used.[21] However, the higher initial velocities will increase possibilities of irrigating solution or air extrusion toward the periapical tissue.[22] The EndoActivator technique generated less apical extrusion compared with the needle and syringe irrigation technique. In our study, the amount of NaOCl extruded from apices prepared to a size #50 or #80 in the EndoActivator group was significantly less than that of the needle group. These findings correspond with previous studies where the EndoActivator generated a minimal amount of extruded irrigating solution when compared with other techniques.[15,16] However use of side-vented needles with no canal binding could reduce apical pressure.[23,24] Using small sized needles should be positioned in 2 or 3 mm short of the WL in order to ensure adequate irrigant exchange and to prevent the apical extrusion.[25]

The aims of root canal irrigation are to disinfect and clean the root canal system. Irrigation using the EndoActivator increased debris, smear layer, and bacteria removal from the root canal.[12-14] Thus, the EndoActivat or can be used during a final rinse before medication and obturation procedures. However, when using the EndoActivator, irrigant is not replenished, which may affect the cleaning of the root canal. Therefore in clinical situations, EndoActivator use should be in conjunction with the conventional technique. The present study evaluated the amount of irrigant apically extruded during the final flush. This is one of the most important complications of the chemomechanical procedure. Further studies should be done to assess other aspects of root canal debridement outcome such as cleanliness and canal penetration and relate them to the apical extrusion of irrigant.

Currently, the exact amount of extruded irrigant that results in damage to the periapical tissue is still unknown. However, when instrumenting teeth to a large apical preparation size, caution should be taken because the apical extrusion of irrigant is likely to occur regardless of irrigation technique used.

Conclusion

Regardless of irrigation technique, the apical extrusion of NaOCl was not observed in teeth prepared to an apical size #35. However, NaOCl extrusion from the apex did occur when the apical canal portion was prepared up to file size #50 and this extrusion increased in teeth prepared to apical size #80. The use of the EndoActivator resulted in significantly less apical extrusion than with needle and syringe irrigation.

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

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References

1. Siqueira JF, Jr., Rocas IN. Clinical implications and microbiology of bacterial persistence after treatment procedures. J Endod. 2008;34:1291-301 e3.
2. Zehnder M. Root canal irrigants. J Endod. 2006;32:389-98.
3. Dutner J, Mines P, Anderson A. Irrigation trends among American Association of Endodontists members: a web-based survey. J Endod. 2012;38:37-40.
4. Spencer HR, Ike V, Brennan PA. Review: the use of sodium hypochlorite in endodontics-potential complications and their management. Br Dent J. 2007;202:555-9.
5. Hulsmann M, Hahn W. Complications during root canal irrigation-literature review and case reports. Int Endod J. 2000;33:186-93.
6. Kleier DJ, Averbach RE, Mehdipour O. The sodium hypochlorite accident: experience of diplomates of the American Board of Endodontics. J Endod. 2008;34:1346-50.
7. Vande Visse JE, Brilliant JD. Effect of irrigation on the production of extruded material at the root apex during instrumentation. J Endod. 1975;1:243-6.
8. Salzgeber RM, Brilliant JD. An in vivo evaluation of the penetration of an irrigating solution in root canals. J Endod. 1977;3:394-8.
9. Boutsioukis C, Gogos C, Verhaagen B, Versluis M, Kastrinakis E, Van der Sluis LW. The effect of apical preparation size on irrigant flow in root canals evaluated using an unsteady computational fluid dynamics model. Int Endod J. 2010;43:874-81.
10. Boutsioukis C, Gogos C, Verhaagen B, Versluis M, Kastrinakis E, Van der Sluis LW. The effect of

root canal taper on the irrigant flow: evaluation using an unsteady computational fluid dynamics model. Int Endod J. 2010;43:909-16.

11. Ruddle CJ. Hydrodynamic disinfection: tsunami endodontics. Dent Today. 2007;26:110-7.
12. Jiang LM, Verhaagen B, Versluis M, van der Sluis LW. Evaluation of a sonic device designed to activate irrigant in the root canal. J Endod. 2010;36:143-6.
13. Caron G, Nham K, Bronnec F, Machtou P. Effectiveness of different final irrigant activation protocols on smear layer removal in curved canals. J Endod. 2010;36:1361-6.
14. Pasqualini D, Cuffini AM, Scotti N, Mandras N, Scalas D, Pera F, et al. Comparative evaluation of the antimicrobial efficacy of a 5% sodium hypochlorite subsonic-activated solution. J Endod. 2010;36:1358-60.
15. Desai P, Himel V. Comparative safety of various intracanal irrigation systems. J Endod. 2009;35:545-9.
16. Mitchell RP, Baumgartner JC, Sedgley CM. Apical extrusion of sodium hypochlorite using different root canal irrigation systems. J Endod. 2011;37:1677-81.
17. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol. 1971;32:271-5.
18. Guerisoli DM, Silva RG, Pecora JD. Evaluation of some physico-chemical properties of different concentrations of sodium hypochlorite solutions. Braz Endod J. 1998;3:21-3.
19. Martin H, Cunningham WT. The effect of endosonic and hand manipulation on the amount of root canal material extruded. Oral Surg Oral Med Oral Pathol. 1982;53:611-3.
20. Lambrianidis T, Tosounidou E, Tzoanopoulou M. The effect of maintaining apical patency on periapical extrusion. J Endod. 2001;27:696-8.
21. Boutsioukis C, Lambrianidis T, Kastrinakis E. Irrigant flow within a prepared root canal using various flow rates: a computational fluid dynamics study. Int Endod J. 2009;42:144-55.
22. Gulabivala K, Ng YL, Gilbertson M, Eames I. The fluid mechanics of root canal irrigation. Physiol Meas. 2010;31:R49-84.
23. Boutsioukis C, Verhaagen B, Versluis M, Kastrinakis E, Wesselink PR, van der Sluis LW. Evaluation of irrigant flow in the root canal using different needle types by an unsteady computational fluid dynamics model. J Endod. 2010;36: 875-9.
24. Bradford CE, Eleazer PD, Downs KE, Scheetz JP. Apical pressures developed by needles for canal irrigation. J Endod. 2002;28:333-5.
25. Boutsioukis C, Lambrianidis T, Verhaagen B, Versluis M, Kastrinakis E, Wesselink PR, et al. The effect of needle-insertion depth on the irrigant flow in the root canal: evaluation using an unsteady computational fluid dynamics model. J Endod. 2010;6:1664-8.

การเปรียบเทียบในห้องปฏิบัติการของปริมาณน้ำยาโซเดียมไฮโปคลอไรท์ที่เกินออกนอกปลายรากระหว่างล้างคลองรากฟันด้วยเข็มและหลอดฉีดยากับเอ็นโดแอคติเวเตอร์

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บทคัดย่อ

วัตถุประสงค์ เพื่อประเมินปริมาณโซเดียมไฮโปคลอไรท์ที่เกินปลายราก เมื่อทำการล้างคลองรากฟันด้วยเอ็นโดแอคติเวเตอร์เปรียบเทียบกับการล้างด้วยเข็มและหลอดฉีดยาในฟันที่ขยายขนาดคลองรากฟันส่วนปลายแตกต่างกัน

วัสดุและวิธีการ กลุ่มศึกษา คือ ฟันหน้าแท้รากเดี่ยวจำนวน 100 ซี่ แบ่งเป็น 3 กลุ่ม กลุ่มละ 30 ซี่ ตามขนาดของไฟล์หลักสุดท้าย คือ #35 #50 และ #80 ยึดฟันแต่ละซี่ในอะกาโรสเจลโมเดลและล้างคลองรากฟันด้วยโซเดียมไฮโปคลอไรท์ ร้อยละ 2.5 โดยวิธีเข็มและหลอดฉีดยา ดึงฟันออกจากแบบจำลอง ทำความสะอาดซับคลองรากยึดฟันในแบบจำลองชิ้นใหม่ ล้างคลองรากฟันโดยวิธีเอ็นโดแอคติเวเตอร์ วัดน้ำหนักของแบบจำลองก่อนและหลังการล้างคลองรากแต่ละวิธี นำผลต่างของน้ำหนักมาคำนวนปริมาณน้ำยาล้างคลองราก ฟันที่เกินปลายรากยืนยันการเกินของโซเดียมไฮโปคลอไรท์จากการเปลี่ยนสีของอะกาโรสเจล วิเคราะห์ความแตกต่างของปริมาณโซเดียมไฮโปคลอไรท์ที่เกินปลายรากด้วยสถิติการทดสอบของครัสคัล-วอลลิส และแมน-วิทนีย์ ที่ระดับนัยสำคัญ 0.05

ผลการศึกษา ไม่พบการเปลี่ยนสีของเจลและการเปลี่ยนแปลงน้ำหนักของแบบจำลองในกลุ่มฟันที่มีขนาดคลองรากฟันส่วนปลาย #35 พบโซเดียมไฮโปคลอไรท์เกินปลายรากในกลุ่มฟันที่มีขนาดคลองรากฟันส่วนปลาย #50 และ #80 โดยมีปริมาณเพิ่มขึ้นเมื่อขนาดคลองรากฟันส่วนปลายใหญ่ขึ้นพบความแตกต่างอย่างมีนัยสำคัญของปริมาณโซเดียมไฮโปคลอไรท์ที่เกินปลายราก ในฟัน 2 กลุ่มนี้ เมื่อใช้วิธีล้างคลองรากฟัน แตกต่างกันที่ระดับนัยสำคัญทางสถิติ 0.05

สรุป พบการเกินของโซเดียมไฮโปคลอไรท์ ในกลุ่มฟันที่มีขนาดคลองรากฟันส่วนปลาย #50 และ #80 ปริมาณที่เกินลดลงอย่างมีนัยสำคัญเมื่อล้างด้วยวิธีเอ็นโดแอคติเวเตอร์เปรียบเทียบกับการล้างด้วยเข็มและหลอดฉีดยา

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