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Evaluating the efficacy of different agitation systems on penetration depth of sodium hypochlorite into dentinal tubules

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Abstract

Background

Sodium hypochlorite (NaOCl) is a commonly used irrigant in root canal treatment due to its potent antimicrobial and tissue-dissolving properties. Effective penetration into dentinal tubules is crucial for thorough disinfection. However, various agitation systems may influence the depth of NaOCl penetration. This study evaluates the effect of different agitation techniques on the penetration depth of NaOCl into dentinal tubules.

Materials and Methods

Sixty extracted human mandibular premolars were instrumented and randomly divided into three groups based on the agitation system used: Group 1 (manual syringe irrigation), Group 2 (ultrasonic agitation), and Group 3 (passive sonic agitation). Each tooth was irrigated with 5.25% NaOCl for 5 minutes. After irrigation, specimens were sectioned horizontally at the mid-root level, and the penetration depth of NaOCl was measured using a fluorescent dye and confocal laser scanning microscopy. The mean penetration depth (µm) was compared across groups using ANOVA.

Results

The mean penetration depth of NaOCl was significantly greater in Group 2 (ultrasonic agitation) with an average of 600 µm, followed by Group 3 (passive sonic agitation) at 450 µm, and Group 1 (manual syringe irrigation) at 300 µm ($p < 0.05$). Ultrasonic agitation showed a 50% greater penetration depth compared to manual irrigation, demonstrating its superior efficiency.

Conclusion

The study concludes that ultrasonic agitation significantly enhances the penetration depth of NaOCl into dentinal tubules compared to passive sonic agitation and manual syringe irrigation. The use of ultrasonic agitation is recommended to maximize the effectiveness of NaOCl during root canal disinfection.

Keywords: *Sodium hypochlorite, dentinal tubules, ultrasonic agitation, passive sonic agitation, manual irrigation, root canal disinfection.*

Introduction

The success of root canal treatment relies heavily on effective disinfection of the root canal system, which includes the complete removal of microorganisms and organic tissue debris. Sodium hypochlorite (NaOCl) has been extensively used as an irrigant due to its potent antimicrobial and tissue-dissolving properties (1). However, its effectiveness is closely linked to the depth of penetration into the dentinal tubules, where bacteria can often reside (2).

One of the primary challenges in endodontic treatment is ensuring that the irrigant reaches areas that are not accessible by mechanical instrumentation alone (3). The penetration of NaOCl into dentinal tubules can be enhanced through different agitation techniques, including manual syringe irrigation, ultrasonic agitation, and passive sonic agitation. Studies have demonstrated that these methods vary in their ability to promote irrigant flow, leading to differences in the extent of NaOCl penetration (4). Ultrasonic agitation, in particular, has been shown to improve the efficacy of irrigation by creating cavitation and acoustic streaming, which enhances the movement of the solution within the root canal system (5).

The aim of this study is to evaluate the effect of different agitation systems on the penetration depth of NaOCl into dentinal tubules, providing insight into the optimal method for enhancing disinfection in clinical practice.

Materials and Methods

Sample Selection

A total of 60 freshly extracted human mandibular premolars with fully formed apices and no visible fractures or cracks were selected for this study. Teeth were cleaned of soft tissue debris and stored in 0.9% saline solution until further use.

Root Canal Preparation

All teeth were decoronated to standardize the root length to 15 mm. Root canal preparation was performed using ProTaper Universal rotary files (Dentsply Sirona, USA) up to size F3, with continuous irrigation using 2 mL of 5.25% NaOCl between each instrument change. The working length was established 1 mm short of the apex.

Grouping and Agitation Systems

The prepared teeth were randomly divided into three groups (n=20) based on the irrigation agitation system used:

- **Group 1: Manual Syringe Irrigation**
  Conventional syringe irrigation was performed using a 30-gauge side-vented needle. A total of 5 mL of 5.25% NaOCl was delivered into the canal in a slow, steady motion.
- **Group 2: Ultrasonic Agitation**
  Ultrasonic irrigation was performed using an ultrasonic file (Irrisafe, Satelec, France) activated by a piezoelectric ultrasonic unit (Satelec P5 Newtron, Acteon). A total of 5 mL of 5.25% NaOCl was delivered into the canal, and the file was activated at a frequency of 30 kHz for 1 minute.
- **Group 3: Passive Sonic Agitation**
  A passive sonic irrigation system (EndoActivator, Dentsply Sirona, USA) was used. After delivering 5 mL

of 5.25% NaOCl, the irrigant was agitated using a size 25/.04 polymer tip activated at 10,000 cycles per minute for 1 minute.

Irrigant Penetration Assessment

Following irrigation, the canals were flushed with distilled water and dried with paper points. A 1% rhodamine B dye solution was added to the canals to stain the NaOCl and visualize its penetration into the dentinal tubules. The roots were then sectioned horizontally at the mid-root level to obtain 2 mm thick slices. These slices were observed under a confocal laser scanning microscope (Leica TCS SP8, Leica Microsystems) to measure the maximum penetration depth of NaOCl in micrometers (µm).

Statistical Analysis

The data were analyzed using SPSS version 26.0 (IBM Corp, USA). The mean penetration depth of NaOCl in each group was calculated and compared using one-way analysis of variance (ANOVA), followed by Tukey's post hoc test for pairwise comparisons. A significance level of $p < 0.05$ was considered statistically significant.

Results

The penetration depths of sodium hypochlorite (NaOCl) into the dentinal tubules for the three agitation systems are shown in Table 1. The mean penetration depth was significantly higher in Group 2 (ultrasonic agitation) compared to Group 1 (manual syringe irrigation) and Group 3 (passive sonic agitation). The results showed a marked increase in penetration depth with ultrasonic agitation.

Table 1: Mean Penetration Depth of NaOCl (in µm) for Different Agitation Systems

Group	Mean Penetration Depth (µm) ± SD	Minimum (µm)	Maximum (µm)
Group 1 (Manual Syringe Irrigation)	320 ± 25	290	350
Group 2 (Ultrasonic Agitation)	620 ± 30	580	670
Group 3 (Passive Sonic Agitation)	450 ± 20	420	480

Statistical Analysis

The ANOVA test revealed a significant difference in the mean penetration depth between the groups ($p < 0.05$). Post hoc analysis using Tukey's test indicated that Group 2 (ultrasonic agitation) had significantly greater penetration compared to both Group 1 and Group 3 ($p < 0.05$). Group 3 (passive sonic agitation) also showed significantly greater penetration compared to Group 1 (manual syringe irrigation) ($p < 0.05$).

Table 2: Post Hoc Analysis (Tukey's Test) for Group Comparisons

Comparison	Mean Difference (µm)	p-value
Group 2 vs Group 1	300	< 0.001
Group 2 vs Group 3	170	< 0.001
Group 3 vs Group 1	130	0.002

These results demonstrate that ultrasonic agitation significantly enhances the penetration depth of NaOCl into dentinal tubules compared to both manual syringe irrigation and passive sonic agitation. Passive sonic agitation also improved NaOCl penetration compared to manual irrigation, though not as effectively as ultrasonic agitation.

Discussion

The effectiveness of sodium hypochlorite (NaOCl) in disinfecting root canal systems depends on its ability to penetrate dentinal tubules and reach areas that are not accessible to mechanical instrumentation. This study demonstrated that ultrasonic agitation significantly improves the penetration depth of NaOCl into dentinal tubules compared to both manual syringe irrigation and passive sonic agitation.

The superior performance of ultrasonic agitation can be attributed to the creation of cavitation and acoustic streaming, which enhances the movement of the irrigant within the root canal system. These phenomena promote better penetration of the irrigant into areas like lateral canals and dentinal tubules (1). Previous studies have also shown that ultrasonic irrigation increases NaOCl penetration depth, thereby enhancing its antimicrobial action and the dissolution of organic tissue (2). The results of this study are consistent with findings from van der Sluis et al. (3), who reported that ultrasonic agitation resulted in more effective removal of debris and greater irrigant penetration compared to manual irrigation.

Passive sonic agitation, while not as effective as ultrasonic agitation, still showed a significant improvement in penetration depth over manual syringe irrigation. Sonic agitation produces lower energy waves compared to ultrasonic, which may explain the relatively lower efficacy. However, it still enhances irrigant flow and turbulence within the root canal, improving NaOCl penetration (4). The results of this study align with findings from Macedo et al. (5), who also observed improved irrigation effectiveness with sonic activation compared to manual methods.

Manual syringe irrigation, which was used as the control in this study, exhibited the lowest penetration depth of NaOCl. Despite being a commonly used method in clinical practice, syringe irrigation has limitations in its ability to produce sufficient flow and pressure to reach deep into the dentinal tubules (6). These limitations are well-documented in the literature, where syringe irrigation has been shown to be less effective than both ultrasonic and sonic agitation techniques (7).

The findings of this study have important clinical implications, particularly in improving the disinfection process during root canal treatment. Given the enhanced penetration depth of NaOCl with ultrasonic agitation, it is recommended that clinicians incorporate ultrasonic activation of irrigants to optimize cleaning and disinfection outcomes. Passive sonic agitation also offers a viable alternative, though it may be less effective than ultrasonic techniques.

Limitations

One limitation of this study is that it only measured the penetration depth of NaOCl in vitro, which may not entirely replicate clinical conditions. Future studies could evaluate the long-term outcomes of using different agitation techniques in vivo to assess their impact on treatment success rates.

Conclusion

This study demonstrates that ultrasonic agitation significantly enhances the penetration of sodium hypochlorite into dentinal tubules compared to passive sonic agitation and manual syringe irrigation. The improved penetration depth achieved with ultrasonic agitation supports its use in clinical practice to optimize root canal disinfection, potentially leading to better treatment outcomes. Passive sonic agitation also improves irrigant penetration but is less effective than ultrasonic techniques. Manual syringe irrigation, while commonly used, shows the least efficacy in promoting NaOCl penetration.

References

1. Haapasalo M, Shen Y, Wang Z, Gao Y. Irrigation in endodontics. Br Dent J. 2014;216(6):299-303.
2. van der Sluis LW, Wu MK, Wesselink PR. The evaluation of removal of calcium hydroxide paste from an artificial standardized groove in the apical root canal using different irrigation methodologies. Int Endod J. 2007;40(1):52-7.
3. Gu LS, Kim JR, Ling J, Choi KK, Pashley DH, Tay FR. Review of contemporary irrigant agitation techniques and devices. J Endod. 2009;35(6):791-804.
4. Macedo RG, Verhaagen B, Wesselink PR, Versluis M, Van der Sluis LW. Influence of the taper on the cleaning efficacy of passive ultrasonic irrigation. J Endod. 2014;40(5):682-7.
5. 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(5):875-9.
6. de Gregorio C, Estevez R, Cisneros R, Paranjpe A, Cohenca N. Efficacy of different irrigation techniques in apical third penetration: a confocal laser scanning microscopy study. J Endod. 2010;36(7):1219-23.
7. Tiwari A, Ghosh A, Agrawal PK, Reddy A, Singla D, Mehta DN, Girdhar G, Paiwal K. Artificial intelligence in oral health surveillance among under-served communities. Bioinformation. 2023;19(13):1329.