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Review Article

The importance of surface tension in endodontic irrigation: A review study

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ABSTRACT

The surface tension of irrigants determines their ability to penetrate dentinal tubules and access the apical third of root canals. It is defined as an affinity for a liquid's surface area to decline in the case of surface tension between molecules. Irrigating the canal wall is vital for dissolving organic tissues and disinfecting dentin and its tubules in root canal preparation. Even with super elastic rotary preparation, untouched spaces are a typical issue during root canal instrumentation. As a result, the antimicrobial activity and solvent action in these areas is essential to the disinfection of root canals. The ability to diagnose irrigants quickly and treat them successfully depends on a thorough discernment of their surface tension. In this study, surface tension involved in endodontic solutions was examined for etiological factors, features, and possible consequences. The relevant studies were found by searching online databases. We identified 30 articles using the hand search method and summarized the critical factors of each study. It was found that low surface tension agents would penetrate tubules more acceptable and that surface tensions estimated at various temperatures and concentrations affected canal cleaning.

1. Introduction

Root canal preparation is mainly concerned with cleaning the canal. Treatment failure may be caused by residue pulp tissue, infected dentine, or bacteria within the canal system. It is crucial for endodontic treatment success to use irrigating solutions for root canal space debridement. During the process of enlarging and shaping the root canal system, endodontic irrigants play a pivotal role in cleaning the root canal system. Preparation of the root canal system may be meant to gain radicular access to the un-instrumented root canal system, thereby dispersing irrigants.[1] When a chemical solution is used for endodontic treatment, it must possess substantial wetness, allowing it to expand its solvent capacity and improve its antimicrobial properties.[2,3] Sodium hypochlorite (NaOCl), chlorhexidine (CHX), and Biopure MTAD (a mixture of Doxycycline, citric acid, and detergent) are regarded as promising irrigants for root canal irrigation.[4,5] Endodontic treatments have long used sodium hypochlorite (NaOCl) for this purpose. Aside from being an ideal organic solvent and an effective antimicrobial, it also irritates the periapical tissues, particularly at high concentrations.[6,7] The biocompatibility of CHX as well as its use in allergy-related bleaching solutions makes it useful for treating open apexes, root resorptions, foramen enlargements, and root perforations.[8–10] Aside from contact dermatitis, CHX can produce discoloration of the teeth and tongue, and in rare cases, dysgeusia. The antibacterial properties of MTAD in endodontic irrigants enable them to remove smear layers. As compared to other irrigant solutions, MTAD is more biocompatible and less cytotoxic.[11–13] A common irrigant used in root canal treatment is ethylenediaminetetraacetic acid (EDTA). Due to its heightened dynamic viscosit,

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Ethylenediaminetetraacetic acid (EDTA) is ineffective in dissolving the smear layer in the apical third of root canals. In recent years, silver nanoparticles (AgNPs) have gained attention in dentistry as root canal irrigants or medicaments.[14–17] In addition to being highly effective against bacteria, these particles are compatible with human cells[18–20] Thus, it is vital to investigate the properties of these newly introduced agents in comparison to typical endodontic irrigants.[21] Identifying factors that contribute to the etiology, management methods, and outcomes in endodontic treatment with dental irrigants surface tension was the purpose of this study.

2. Discussion

2.1. NaOCl

Its bactericidal and lubricant properties, as well as its ability to dissolve organic substances, make NaOCl an ideal endodontic irrigant.[22] A 5% NaOCl solution produces a higher surface tension than a 2.5% solution, but it is not superior to the 2.5% solution in terms of cleansing capability; lower concentrations are suggested due to the material's toxicity. A significant difference between exposure times was observed in the depth of NaOCl penetration as the exposure time increased.[23,24] Increases in hypochlorite concentration typically result in a greater penetration of regular solutions. Even so, dissimilarities were not statistically noteworthy in most cases; the only statistically important difference was between 1% and 6% of NaOCl.[25] In the surface tension study,[26] smoother smear layers and less debris were marked when the solution's heat was increased, indicating that heat increased its cleaning capability. The debris particles left on canal walls by 5% NaOCl at 21oC were more intensive than those left by 5% NaOCl at 50oC when used at the same temperature. At 21oC, 2.5% NaOCl produced a similar canal surface appearance to 5% NaOCl, but 2.5% NaOCl at 37oC and 50oC produced smoother smear layers and less debris than 5% NaOCl.[27] In,[28] 5% NaOCl was evaluated at 21°C and 50°C for debridement capabilities, and it was found that 5% NaOCl heated to 50°C produced a finer particle composition smear layer than was achieved at 21°C. There was a statistically significant difference between results obtained from treatments at different temperatures when teeth were treated with 5.25% NaOCl or 6% NaOCl for 20 min.

2.2. CHX

A CHX solution with a 2% concentration had a lower surface tension and more satisfactory cleansing performance than one with a 0.2% concentration. Because of its cleansing properties, CHX solution should be used as a root canal irrigant at a 2% concentration.[29] The surface tension of CHX was lower than that of NaOCI,[30] which asserts the results reported in[31]. At[32] different temperatures, surface tension in CHX solution at 2% concentration was lower than at 0.2% concentration at both concentrations. Added to a solution, CHX decreases the surface tension of the solution by acting as a cationic active agent. CHX solution with higher concentrations has lower surface tension. Compared with 5% NaOCl, specimens irrigated with 2% CHX solution showed smoother smear layers and fewer debris.[33] A 2% CHX solution at 50°C separated smear layers partially in the coronal and middle thirds of some specimens and left some dentinal tubules with open orifices. In addition, debris-free surfaces have been marked throughout the canal. Despite the similar appearance of canal surfaces between specimens irrigated with 0.2% and 2% CHX solution, 2% CHX produced the best results. There seems to be a correlation between the outcomes and solution surface tensions. 2% CHX solution heated to 50oC cannot entirely remove debris from the apical third.[34] This difficulty can be described by the reduction in root canal diameter and subsequent decline in irrigant flow.[35] It can be more worthwhile for apical cleaning to use solutions with low surface tension during canal preparations, particularly in narrow canals. In conclusion, both the temperature and concentration of NaOCl and CHX solutions affected surface tension. The surface tension of solutions decreased as the temperature increased; nevertheless, the concentration impact on surface tension was various. At low concentrations of NaOCI, the surface tension decreased, while at low concentrations of CHX, it increased.

2.3. MTAD

A high detergent effect combined with firm antimicrobial effectiveness was the purpose of launching MTAD on the market.[36] Study results indicate that MTAD has lower antimicrobial and antifungal activity than NaOCl and CHX in comparison with 5% or 6%[37,38] The results.[39] revealed that MTAD was quite more effective at killing Escherichia faecalis than NaOCl when the solutions were diluted.[40] It is presently used more for final irrigation, after using NaOCl as the main irrigant, than for intra-canal irrigation.[41] A satisfactory wettability along with effective antimicrobial activity is unquestionably crucial for an ideal irrigant solution.[42] vouched[43] that Biopure MTAD has a lower surface tension than NaOCl, even though the NaOCl concentration in this study was half that of an earlier study (5,25%). Low surface tension (34.5 mJ/m2) of MTAD is capable of removing the smear layer and opening the dentinal tubule orifices.[44] It may therefore be possible to achieve better antibacterial results with these irrigants (having a low surface tension).[45] Consequently, further research is needed to demonstrate the ability of mentioned fresh irrigants by determining the penetration of antibiotic irrigant solutions into the dentinal tubules, as well as the

decontamination of bacteria with these solutions.[46]

2.4. EDTA

Even though EDTA has been used as an endodontic chelating agent for many years, its antibacterial activities are limited and its surface tension is high.[47] There have been several ways suggested solving these problems, including adding surfactants and antibiotics (tetracycline) to irrigation solutions. EDTA may be more effective against bacteria when cetrimide (CTR) is added.[48] It has been reported in[49] that EDTA compounds with low surface tension alone or in combination with NaOCl can increase root canal dentin's wettability. EDTA solution's surface tension was remarkably reduced after adding surfactant. Root canal dentin had an increase in surface free energy and water contact angle when combined with experimental solutions and NaOCl. When the surfactant is added to the EDTA solution, its surface tension is dramatically declined and its wettability is significantly raised. It is therefore recommended that root canal dentin's adhesion properties may be improved by low-surface tension EDTA solutions. For a prosperous adhesion mechanism, the properties of the adhesive material are also important.[50]

3. Nano-Particles

Despite improving the penetration of NaOCl into the primary canal, surface-active agents do not affect its ability to dissolve pulp tissue. However, there are insufficient data to support a sound conclusion regarding lubrication, antimicrobial, smear layer removal, or debris removal, based on the modification of NaOCl's surface tension. The immediate reaction between the target cells and these particles appears to prevent the organisms from developing resistance[51,52] Despite their high activity against bacteria, they are compatible with human cells.[53] A completely charged imidazolium-based silver nanoparticle (Im AgNPs) showed high antibacterial activity against Enterococcus faecalis and cytocompatibility with fibroblasts in a study reported by.[54] The surface tension of AgNP irrigants is similar to that of distilled water. Compared with the three typical irrigants, the AgNP irrigant has a high surface tension value, which suggests that it might not penetrate dentinal tubules as well. The results of were in agreement with this finding. In this experiment, AgNPs were compared with 2.5% NaOCl and 2% CHX for antimicrobial efficacy against biofilm E. faecalis after 5, 15, and 30 minutes under confocal laser scanning microscope conditions. After 5 minutes of irrigation with AgNPs, more viable bacteria were seen in biofilms than in tubules, but after 30 minutes of irrigation, the number of viable bacteria was more prominent in tubules than in biofilms. The scholars finalized that AgNPs could not penetrate dentinal tubules and eliminate bacteria at any time interval tested.

4. Conclusion

Only a few studies have examined the possibility that surface tension may have a bearing on endodontic therapy success. In studies, low-surface tension irrigants have been shown to eliminate the need to clear considerable amounts of root canal dentin to create a debris-free root canal. It would be possible to reduce surface tension so that irrigants could better contact dentinal walls in root canals. As a result, dental irrigants may be adapted more easily to the dentinal walls. NaOCl is more likely to penetrate the primary canal with the help of surface-active agents, according to the evidence available. Both temperature and concentration influenced surface tensions in NaOCl and CHX solutions. The surface tension of both solutions decreased as the temperatures of solutions increased, but the impact of concentration on surface tension was diverse. Low concentrations of NaOCI solution resulted in decreased surface tension, whereas CHX solution resulted in increased surface tension. The im-AgNP solution decreases the surface wettability of dentin and has an evident effect on its physiochemical properties. This solution has a lower viscosity than other irritants, which allows it to reach root canal apical portions due to its lower viscosity. Because of its higher surface tension, it may not penetrate better inside dentinal tubules. Based on our testing, MTAD appeared to be the best wettability irrigant, followed by 2% CHX and 2.5 percent NaOCl. The wettability of MTAD was the best among the tested irrigants, followed by CHX, 2.5% NaOCl, and two percent of CHX. Surfactants can improve the wetting ability of EDTA and improve root canal dentin adhesion by adding them to EDTA.

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None.

6. Conflict of Interest

None.

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