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Review Article

Advantages and application of ultrasonic irrigation in endodontics

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ABSTRACT

In the current practice, evidence shows that the currently used irrigant solutions (including sodium hypochlorite combined with and without chlorhexidine or ethylenediaminetetraacetic acid) cannot achieve full cleaning outcomes of the root canal. Accordingly, recent approaches were directed to innovate more efficacious modalities that can overcome the limitations of manual instrumentation and irrigation solutions. In this context, ultrasonic irrigation has been described in the literature as a favorable approach with significantly enhanced outcomes. We have provided evidence regarding the use of ultrasonic irrigation in endodontics. Our findings indicate that passive ultrasonic irrigation is more effective than manual instrumentation in eradicating debris and achieving favorable disinfection. Besides, it has been evidenced that the modality significantly reduces the time to achieve favorable treatment outcomes compared with the traditional approaches. It has been furtherly shown that more favorable outcomes were associated with the combined use of passive ultrasonic irrigation with manual instrumentation. Therefore, it has been suggested that manual instrumentation should be used at the initial phase to achieve adequate preparation, and passive ultrasonic irrigation should be used later on to achieve root canal cleaning.

Keywords: Endodontics, Irrigation, Ultrasonic irrigation, Minimally invasive endodontics, Root canal treatment

INTRODUCTION

Performing a successful endodontic treatment has been associated with adequately removing the remnants of necrotic and vital pulp tissues, eradicating bacteria and microorganisms, and eliminating bacterial toxins from the root canal systems.[1] During biomechanical treatment, it has been shown that using irrigation substances has been associated with cleaning and lubrication of the canal to remove microorganisms, inorganic and organic debris, and remnants from tissue degeneration. This maintains the integrity and permeability of the root canal lumen and adequately removes unfavorable dentin structures.[2] However, it should be noted that such favorable events are only achieved when the irrigation solution directly contacts the canal wall, particularly within the most apical portion.

In the current practice, evidence shows that the currently used irrigant solutions (including sodium hypochlorite combined with and without chlorhexidine or ethylenediaminetetraacetic acid) cannot achieve full cleaning outcomes of the root canal.[3,4] Accordingly, recent approaches were directed to innovate more efficacious modalities that can overcome the limitations of manual instrumentation and irrigation solutions. In this context, ultrasonic irrigation has been described in the literature as a favorable approach with significantly enhanced outcomes.[5,6]

Therefore, the present study will review the applications and advantages of ultrasonic irrigation in endodontic treatment.

METHODS

This literature review is based on an extensive literature search in Medline, Cochrane, and EMBASE databases which was performed on 15th November 2021 using the medical subject headings (MeSH) or a combination of all possible related terms, according to the database. To avoid missing potential studies, a further manual search for papers was done through Google Scholar while the reference lists of the initially included papers. Papers discussing advantages and application of ultrasonic irrigation in endodontics were screened for useful information. No limitations were posed on date, language, age of participants, or publication type.

DISCUSSION

Many advantages were reported for using ultrasonic irrigation in endodontic treatment. These include facilitated access to the entry holes of the root canal systems, filling and shaping canals, cleaning, and reducing the rates of endodontic surgeries and obstruction of intracanal materials.[7] In the current literature, two different types of ultrasonic irrigation have been reported for use in endodontic treatment. The first type includes a combination of simultaneous instrumentation and ultrasonic irrigation. The second type is passive ultrasonic irrigation, usually performed without simultaneous instrumentation.[8] Reports show that the first type is not usually used in different endodontic treatment settings due to various reasons. These include the fact that it is usually hard to obtain the required shape of the treated root canal secondary to the limited control over cutting dentin. Moreover, it has been reported that radicular perforations, apical zips, and canal deviations can develop secondary to using ultrasonic-activated files, particularly among curved canals.[9] Accordingly, evidence indicates that these modalities should not be suitable substitutes for conventional manual instrumentation.[8,10,11] Nevertheless, among the relevant studies in the literature, it has been demonstrated that ultrasonic passive irrigation modalities might have some advantages when applied during endodontic treatment.[12,13] In 1980, Weller et al conducted the first investigation to validate the efficacy of ultrasonic irrigation without the need to perform simultaneous instrumentation, and the process was first termed passive ultrasonic irrigation.[14] The approach is based on a nun-cutting modality that can effectively treat root canal systems and develop aberrant shapes.

The chemical abilities of the irrigants in dissolving unnecessary tissues and stream action are the main factors that determine the efficacy of the irrigation system.[5] In this context, it has been shown that the stream action is weak when syringes are used. This is because it depends on the length of the needle and the diameter and anatomy of the root canal. Furthermore, it has been further shown that the irrigant solution can only extend to 1 mm below the level of the syringe's needle. Accordingly, it has been reported that debris elimination and cleaning actions are not significantly improved with increased volumes.[15] Evidence indicates that moving the irrigant solution might be the only efficacious approach to enhance the process of root canal cleaning. This is because of the inability of the mechanical instrumentation to clean the side networks of the canal.[16] In this context, it has been shown that using ultrasound has been associated with enhanced cleaning of hard-to-reach areas. In this context, it has been indicated that the efficacy of root canal cleaning is significantly correlated with using the appropriate ultrasound vibration system and irrigant solution. The role of the ultrasound is to generate a continuous movement within the used solution.[17] The current studies also show that using ultrasound vibration has been associated with significantly clearer canals secondary to a sufficient acoustic cut. The effect was also more productive than when mechanical instrumentation was used alone.

Reduced risk of deforming the canal system has been significantly associated with using finer files. Accordingly, it has been recommended to use high ultrasonic powers and small vibrating files.[12,18] It has been furtherly indicated that the efficacy of root canal cleaning is increased when ultrasonic irrigation is combined with manual instrumentation. This occurs by transmitting vibrations through the manual file to the irrigant solution. However, the incidence of deforming and touching the canal walls usually increases in these events. As a result, disinfection and debridement of wider canals at the apical region are usually improved. On the other hand, studies indicated that it is difficult to clean and prepare the most apical parts of the canal.[12,19] Accordingly, direct access to these parts might be facilitated by using finer needles (30 G calibers). In this context, Tasdemir et al concluded that the efficacy of the irrigant solution could be significantly enhanced by using safety tips for the fine irrigation needles.[20]

Two physical events are noticed during passive ultrasonic irrigation, including cavitation and stream of the irrigant solution. This is usually induced through ultrasonic waves that transmit energy from a smooth, oscillating wire or a file to the targeted irrigant. The acoustic wire has been previously defined as a quick movement of the irrigant in a vortex or a circular shape within the vibration file. On the other hand, it has been shown that cavitation usually refers to distortion, contraction, or expansion of preexisting bubbles in a liquid or creating steam bubbles.[10] Evidence from articles within the last 20-30 years shows that various modalities have been validated to agitate irrigant solutions. The efficacy of these modalities lies within their abilities to eliminate smear layer (based on the therapeutic philosophy), soft tissues elimination, and provide various mechanisms for irrigant transfer. A previous investigation by Al-Jadaa et al compared ultrasonic and sonic irrigation.[15] The authors reported that more favorable outcomes were significantly correlated with ultrasonic irrigation, which has been proven to be more efficacious in eliminating increased amounts of debris than sonic irrigation. Therefore, the authors concluded that passive ultrasonic irrigation is significantly more productive than

sonic irrigation modalities. On the other hand, previous investigations demonstrated that the efficacy of root canal treatment was similar and significantly between the two irrigation systems. However, these studies indicated that prolonged treatment time should be applied for sonic irrigation modalities to achieve this efficacy.[5,10,17,21]

It has been furtherly reported that ultrasonic irrigation can improve the capacity of irrigating solutions. This is mediated through good wetting of the smear layer and/or pulp tissue debris to dissolve the underlying tissues and enhance the efficacy of the corresponding outcomes.[3] Previous investigations have indicated the efficacy of ultrasonic irrigation systems in eliminating smear layer as a complement to various irrigant solutions.[2,7,22] It should be noted that Abbott et al reported that passive ultrasonic irrigation efficacy is modest in the activation of ethylenediaminetetraacetic acid.[8] However, previous studies reported that following adequate preparation of the root canal space to fit a post in endodontically treated teeth, it has been shown that the efficacy of root canal treatment is significantly improved with the correlation between ethylenediaminetetraacetic acid and passive ultrasonic irrigation. These favorable events were significantly noticed among apically treated parts that house the post space.[23] A previous investigation by Lottanti et al reported that the most efficacious irrigant solution is 5.25% sodium hypochlorite.[13] In this context, it has been demonstrated that the most favorable antibacterial effects were reported following the use of wave or ultrasound vibration systems combined with 5.25% sodium hypochlorite solution. The enhancing cleaning efficacy was reported to be secondary to the ability of this combination to eradicate dentin debris and unnecessary waste layer, allow heating of the irrigating substance, and enhance the process of exchange of the irrigant within the canal.[4,24]

The evidence further shows that the 5.25% sodium hypochlorite irrigation process should last 30 seconds-3 minutes. However, there are no clear guidelines or protocols about the exact duration of the irrigation process among the different studies in the literature. A previous investigation by Monley et al recommended that the process of passive irrigation should be as short as possible.[12] This prevents the file from developing aberrant forms secondary to touching the walls by being centered within the canal cavity. Another study also introduced RinsEndo, which has been even more efficacious than passive ultrasonic irrigation in root canal treatment. The system is operated through pressure-suction technology with hemodynamic activation.[25]

Many debris remnants could still be found following syringe irrigation of oval canals and canals with irregularities.[2,26,27] On the other hand, it has been shown that ultrasonic irrigation can significantly eradicate more debris from the canal through the oscillation of the file in the vicinity of canal irregularities.[10,12,16] In the same context, further studies have questioned the efficacy of using manual instrumentation for cleaning narrow root canal systems. It should also be noted that the case is not significantly different with ultrasonic irrigation as the efficacy of these modalities might also be impacted in such events. This is because of the potential restriction of the cleaning efficacy of these modalities and free vibratory movements. Accordingly, it has been shown that increased efficacy is more significantly associated with ultrasonic irrigation of wider canals. On the other hand, evidence shows that using irrigants might be difficult to reach the apex of narrow canals and achieve acceptable outcomes regarding root canal cleaning.[28] Accordingly, it has been recommended that ultrasonic irrigation be applied following the complete preparation of the root canals.[29] Moreover, improved ultrasonic effects were also noticed with free oscillation of the instrument more significantly than forced oscillation against canal walls.[5] Previous in vitro studies also reported that ultrasonic irrigation could be used as K files when smooth wires are applied in eradicating debris.[11,12]

Intermittent or continuous flushing of the irrigant is the two main flushing approaches performed during passive ultrasonic irrigation.[15] A continuous supply of the irrigant solution is usually provided in the continuous flushing approach within the root canal during cleaning. In this context, some researchers reported that the duration of root canal treatment could be efficiently reduced and obtain more favorable effects.[5] This might be attributed to the continuous effects of chloride and disinfecting abilities of NaOCl because evidence indicates that these factors are rapidly consumed during the first part of irrigation. On the other hand, cycles of injecting the irrigant into the canal with a syringe are the mechanism for intermittent irrigation, followed by oscillations and ultrasonic activation of the irrigant solution within the canal. In this approach, it has been demonstrated that the volume of irrigant solution and depth of syringe penetration into the canal significantly determine the amount of flushed irrigant solution within the apical portion of the canal. In this context, studies show that this approach cannot be conducted when continuous flushing is used. However, it should be noted that previous in vivo investigations demonstrated that the efficacy of root canal cleaning from debris and disinfection was significant for both modalities after conducting irrigation for three minutes.[10,13] Accordingly, these findings indicate the superiority of ultrasonic irrigation in root canal treatment regarding eradicating debris and eliminating bacteria.[30] However, the small number of relevant investigations might limit the current evidence, indicating the need to conduct future relevant studies.

CONCLUSION

Passive ultrasonic irrigation is more effective than manual instrumentation in eradicating debris and achieving favorable disinfection. It has been evidenced that the modality significantly reduces the time to achieve favorable treatment outcomes compared with the traditional approaches. It has been furtherly shown that

more favorable outcomes were associated with the combined use of passive ultrasonic irrigation with manual instrumentation. Therefore, it has been suggested that manual instrumentation should be used at the initial phase to achieve adequate preparation, and passive ultrasonic irrigation should be used later on to achieve root canal cleaning.

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