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REVIEW ARTICLE

PASSIVE ULTRASONIC IRRIGATION IN ENDODONTICS: A LITERATURE REVIEW

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ABSTRACT:
Passive ultrasonic irrigation (PUI) is irrigant agitation technique without simultaneous instrumentation of root canal. In present article the available literature on PUI is reviewed from a MEDLINE database search. This article presents an overview of ultrasonic irrigation and their debridement efficacy. The use of PUI for irrigant activation results in improved canal cleanliness; better irrigant penetration and flow in the canal system; necrotic tissue debridement; and removal of smear layer and bacterial biofilms. Most of the studies conducted till date have only evaluated the effect of using PUI on irrigant penetration, debris removal and microbial reduction. Whether these parameters translate into better clinical outcome or not, remains to be seen.
Keywords: ultrasonic irrigation, irrigant agitation, PUI.

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INTRODUCTION

Endodontic treatment (RCT) comprises of a combination of mechanical instrumentation of root canal system, its chemical debridement and filling with an inert material; intended to maintain or restore the health of the periradicular tissues (1). The primary aim of endodontic treatment is to obtain a clean root canal system free of microbiota and debris, which can then be sealed with a microbial-tight root canal filling. The chemomechanical preparation concept relates to the use of chemically active irrigating solutions in combination with mechanical cleansing. With the endodontic procedures at our disposal, it is impossible to shape & clean root canal completely. This is mainly due to the complex anatomy of the root canal system (2). Irregularities of the root canal walls in particular are a major concern, including oval extensions, isthmuses and apical deltas. Therefore irrigation is an essential part of a root canal treatment as it allows for cleaning in areas beyond the reach of root canal instruments.

Sodium hypochlorite (NaOCl) has been widely used in endodontic irrigation for its antimicrobial properties (3) and removal of organic tissue (4). In addition to NaOCl, the use of ethylene-diamine-tetra-acetic acid (EDTA) is a common practice in endodontic treatment to remove the inorganic component or smear layer left in the canal during root canal treatment (5). While substantial bacterial elimination from the root canal system can be achieved by chemo mechanical procedures using antimicrobial irrigants such as NaOCl, studies have demonstrated that 40-60% of root canals still have detectable levels of cultivable bacteria after chemo mechanical procedures using NaOCl as the irrigant (6). As a consequence, supplementary approaches have been proposed to improve and/or expedite root canal disinfection (7). One approach that has been recommended includes ultrasonic activation of root canal irrigant (8).

The concept of using ultra sonic (US) in endodontics was first introduced by Richman (9). Two types of ultrasonic irrigation have been described in the literature: one where irrigation is combined with simultaneous ultrasonic instrumentation (UI) and another without simultaneous instrumentation, so called passive ultrasonic irrigation (PUI). During UI the file is intentionally brought into contact with the root canal wall. UI has been shown to be less effective in removing simulated pulp tissue from the root canal system or smear layer from the root canal wall than PUI (10). This can be explained by a reduction of acoustic streaming and cavitation (11). As the root canal

anatomy is complex, it is very difficult for an instrument to contact the entire root canal wall. This could result in aberrant cutting of the root canal wall without effective cleaning.

Passive ultrasonic irrigation was first described by Weller et al (10). The term 'passive' related to the 'non-cutting' action of the ultrasonically activated file. PUI relies on the transmission of acoustic energy from an oscillating file or smooth wire to an irrigant in the root canal. The files are designed to oscillate at ultrasonic frequencies of 25-30 KHz and operate in a transverse vibration, setting up a characteristic pattern of nodes and antinodes along their length (12). It enhances irrigant-canal wall interaction by transmitting acoustic energy from an oscillating instrument to the irrigant, causing acoustic microstreaming and transient cavitation (12). Acoustic microstreaming, comprising rapid movement of fluid in a vortex motion, generates shear stresses that enhance debridement. Transient cavitation generates bubbles that, when collapsed, produce radiating shock waves and temperature rise. The induced acoustic streaming leads to jets of irrigant that are directed toward the root canal wall. These jets are responsible for the removal of dentin debris from artificial holes in the root canal wall. This cleaning effect can be observed from the coronal to the apical part of the root canal.

The objective of present article is to present an overview of PUI and its advantages and limitations in relation to conventional irrigation procedures in the light of observations made in the literature.

REVIEW OF LITERATURE:

DEBRIDEMENT OF ROOT CANALS

The effectiveness of irrigation relies on both the mechanical flushing action and the chemical ability of irrigants to dissolve the tissue. The flushing action from the syringe irrigation is relatively weak, and passive ultrasonic irrigation (PUI) has been reported to increase the flushing action and improve the efficacy of irrigants in removing remnants of pulp tissue and debris (13-20) and planktonic bacteria (21-25). In most of studies NaOCl was used as the irrigant while the study of Spoleti et al. (22) and Weber et al. (23), where sterile saline and chlorhexidine and NaOCl was used respectively as irrigant.

Lee et al concluded that ultrasonic irrigation ex vivo is more effective than syringe irrigation in removing artificially created dentine debris placed in simulated uninstrumented extensions and irregularities in straight, wide root canals (15). One another study concluded that rotary instrumentation using Ni-Ti files associated with final irrigation of 1% NaOCl energized by ultrasound leads to better debris removal from the apical third of mesio-distally flattened root canal (16). Mayer et al found no significant difference between PUI and syringe irrigation in dentine debris removal from the root canal (25).

Gutarts et al (18) histologically compared the in vivo debridement efficacy of hand/rotary canal preparation with that of a hand/rotary/ultrasound technique using an ultrasonic needle in a Mini- Endo unit in the mesial root canals of vital mandibular molars. The authors concluded that the 1-minute use of the ultrasonic needle after hand/rotary instrumentation resulted in significantly cleaner canals and isthmi in the mesial roots of mandibular molars. Burleson et al confirmed that biofilm/necrotic debridement efficiency was significantly increased in the mesial roots of mandibular molars after 1 minute of UI through an irrigation needle directly connected to a Mini-Endo unit (19). Passive ultrasonic irrigation significantly increases temperature of hypochlorite thereby enhancing the tissue dissolving capacity of sodium hypochlorite (11, 26). Efficacy of PUI also appears to increase with increase in concentration of hypochlorite (21). The PUI is also found to be effective in curved canals (17, 18, 27-29). When compared with syringe irrigation (17, 18, 29) PUI performed significantly better. PUI results in significantly more removal of debris from isthmi as compared to syringe irrigation, which explains that PUI has more efficacy than syringe irrigation to remove pulp tissue and dentine debris from remote areas of the root canal system untouched by endodontic instruments.

MICROBIAL LOAD REDUCTION

Numerous studies investigated the bacterial reduction with passive ultrasonic irrigation (21-25, 30-32). PUI with 12% NaOCl as irrigant almost completely removed different types of planktonic bacteria from a parallel-sided canal by a streaming effect through the dentinal tubules (21). Spoleti et al compared the syringe irrigation and ultrasonic irrigation and found that there are more number of surviving bacterial colonies in group in which ultrasonic was not used (22). Carver et al found that the use of ultrasonic irrigation following hand/rotary instrumentation in vivo produced a significantly greater reduction in colony forming unit (CFU) counts in infected necrotic human molars (24). Siqueira et al (30) found that there is no significant bacterial reduction with ultrasonic agitation as compared to agitation with hand files. Beus et al (31) in a clinical study compared the results of a nonactivated single-irrigation protocol (NAI) with a passive ultrasonic multi-irrigation protocol (PUI) in rendering canals bacteria free; found that there is no statistical difference between the groups. Paiva et al (32) found that supplementary disinfection with either PUI or a final rinse with chlorhexidine can reduce the number of cases with positive culture and polymerase chain reaction results for bacteria, however many cases still remain with detectable bacteria in the main root canal. In a vivo study Paiva et al evaluated the effects of passive ultrasonic irrigation (PUI) as a supplementary disinfecting step after root canal preparation using molecular microbiology method and found supplementary PUI approach did not succeed in

significantly enhancing disinfection beyond that achieved by chemomechanical preparation. A recent study by Layton et al (33) reported that continuous ultrasonic irrigation generates high fluid velocity and shear stress in apical third resulting in enhanced reduction of strictly adherent bacterial biofilm as compared to intermittent ultrasonic irrigation and syringe irrigation.

SMEAR LAYER REMOVAL

Studies evaluating smear layer removal by PUI has shown inconclusive results, Cameron (23) found complete removal of smear layer with 3% sodium hypochlorite with 3 and 5 min of PUI; the results were also confirmed in a subsequent study (34). Alac¸am (35) found complete removal of smear layer after 3 min of PUI with 5% NaOCl while Huque et al. (21) after 20 s PUI with 12% NaOCl. A 5% NaOCl solution during 3 min PUI could remove more smear layer than 0.5% NaOCl from the apical and middle part of the root canal (36). Cheung & Stock (13) found incomplete removal of the smear layer using 10 s PUI with 1% NaOCl, although PUI was significantly better than syringe irrigation. In the studies of Ciucchi et al. (37) and Abbott et al. (38) ultrasound did not enhance the removal of the smear layer when EDTA or a combination of EDTA and NaOCl was used as irrigant. On the other hand, PUI could significantly improve the smear layer removal of Savlon (0.03% chlorhexidine, 0.3% cetrimide). PUI with water as irrigant is unable to remove the smear layer (21, 23, 34, 36, 39). All studies show increased removal of the smear layer primarily from the coronal part of the root canal wall rather than the apical part, except for one study (36). All these studies used the SEM technique to investigate the presence of smear layer. A disadvantage of this methodology is that only a very small part of the root canal can be evaluated and this is often not standardized. Only study evaluated the effect of passive ultrasonic irrigation on clinical outcome. A recent randomized control trial conducted by Liang et al showed that there is no significant difference in radiographic healing of periapical lesions in maxillary anteriors with and without additional ultrasonic activation of irrigant (40).

DISCUSSION:

PUI is found to be more effective than conventional syringe irrigation in removing necrotic tissue and dentinal debris. This may be attributed to the fact that ultrasound creates a higher penetration and flow of the irrigant in the canal during irrigation, thereby improving irrigation dynamics leading to better access of the irrigant to canal irregularities (41). With regard to the elimination of the smear layer, the accumulated evidence indicates that PUI with water as irrigant does not eliminate the smear layer (12), but a complete elimination of the smear layer using PUI with 3% NaOCl has been reported (23). These results were confirmed in subsequent studies using different concentrations of NaOCl (21). Therefore, an effective irrigant must be combined with the use of a technique that facilitates access to the difficult areas of the canal. Other studies show less conclusive results for the efficacy of ultrasonic irrigation in removing the smear layer. Despite the fact that PUI proved to be significantly better than needle irrigation, a study (42) reports that the smear layer was not completely eliminated when using PUI with 1% NaOCl for 10 seconds. Numerous researchers have shown that the use of PUI after manual and rotary instrumentation significantly reduces the number of bacteria, achieving significantly better results than needle and syringe irrigation (22-24). These positive results could be due to two main factors; firstly high power ultrasound produces a breakdown of microbial biofilms in the root canal by the action of the acoustic current. The deconstruction of bacterial biofilms gives rise to planktonic bacteria that are more susceptible to the bactericidal activity of NaOCl. Cavitation may also produce a temporary weakening of the cell membrane making bacteria more permeable to NaOCl (33). However, some studies show that although the number of surviving colonies is reduced when ultrasonic activation is used; no technique is able to ensure complete disinfection (27).

A review of literature dealing with success following ultrasonic irrigation revealed only one previous study (40). These non significant results can be explained by that Liang et al performed study on maxillary anterior teeth; Maxillary anterior teeth have less complex anatomy and wider diameter canals which allows adequate irrigation with conventional syringe irrigation.

CONCLUSION

Based on this literature review it can be concluded that PUI appears to be more effective than syringe irrigation in removing debris and bacteria from root canals. Despite its several purported advantages, there is paucity of studies exploring clinical effectiveness of passive ultrasonic irrigation. More well-designed prospective randomized controlled trials are needed to determine the effect of passive ultrasonic irrigation on clinical outcome.

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