Original Article

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THE EFFECT OF PHOTON-INITIATED PHOTO ACOUSTIC STREAMING ON IRRIGANT PENETRATION INTO STIMULATED LATERAL CANALS OF EXTRACTED TEETH

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ABSTRACT:

Aim: to evaluate the effect of photon-initiated photoacoustic streaming (PIPS), passive ultrasonic irrigation (PUI) and manual dynamic activation (MDA) on the penetration of the irrigant into stimulated lateral canals.

Material and methods: A total of thirty single rooted human extracted teeth were selected for this study. The length of each canal was visually determined by placing a #15 into the canal until the tip of the file was visible at the apex. The working length was determined by subtracting 1 mm from the length of the file. The canals were prepared up to # 40 using standard method. After decalcification, three stimulated canals were created at 2mm, 4mm and 6 mm levels from the apices of the teeth. After clearing the sample, the teeth were divided randomly into three groups (n==10) according to the activation method: Group 1: PIPS, group 2: PUI and group 3: MDA. Before the activation, NaOCl 5.25% was mixed with Indian ink and delivered into the canals. The samples were examined under the stereoscope and the data were recorded. Statistical analysis was performed.

Results: At all levels, PIPS group showed the highest irrigant penetration values followed by PUI group, and MDA group showed the lowest irrigant penetration values. However, the difference between PIPS group and PUI group wasn't statistically significant.

Conclusion: PIPS was able to achieve penetration of the irrigant contrast solution into the lateral stimulated canals, so it can be used clinically as an effective method in irrigation.

Key words: PIPS, PUI, MDA, irrigant.

INTRODUCTION:

Necrotic tissue remnants in the root canal system are considered a nutritional source of bacteria (Siqueira Jr and Rôças, 2008).The presence of organic tissue and smear layer reduce the effectiveness of antimicrobial protocols and canal filling (Harrison and Hand, 1981; Shahravan et al., 2007). Regardless of the instrumentation technique, 35% or more of the root canal surfaces remains uninstrumented. The success of root canal treatment depends on the thorough disinfection of the root canal system. Disinfection can be accomplished by a combination of instrumentation and irrigation (Bronnec et al., 2010). Thus, the outcome of endodontic treatment depends upon mechanical instrumentation and effectiveness of irrigating solutions (Haapasalo et al., 2005). Chemical irrigants play an essential role in the success of debridement of root canals during shaping and cleaning procedures (Babb et al., 2009; Jainaen et al., 2009).

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several activation techniques and devices are available for root canal system cleaning including manual dynamic activation (MDA), intermittent passive ultrasonic irrigation (IPUI), continuous ultrasonic irrigation (CUI), Passive ultrasonic irrigation (PUI) and laser activated irrigation (LAI). MDA Manual dynamic irrigation can be performed with hand files, brushes, or a well- fitting tapered gutta-percha point (Basrani, 2015). Files designed for passive ultrasonic irrigation oscillate at ultrasonic frequencies of 25–30 kHz, operating in a transverse vibration, forming a pattern of nodes and antinodes along their length (Van der Sluis et al., 2007).

A new laser activation method photon induced photoacoustic streaming (PIPS) has been proposed. This method is different from other activation methods that the tip of laser is placed into canal orifice. In this technique, an erbium/yttrium–aluminum–garnet (Er/YAG) laser is used with a radial and stripped tip of novel design at subablative power settings (0.3 W). PIPS showed significantly better removal of the smear layer, and it has the ability to drive the irrigant solution to the end of the canal without any damage to the apical tissues.(DiVito and Lloyd, 2012).

Final irrigation with PIPS could possibly help the irrigants to penetrate the lateral canals. Hence, the aim of this study is to evaluate the effect of final activation with PIPS, PUIA, and MDA on irrigant penetration into simulated lateral canals.

MATERIALS AND METHODS:

A total of thirty single rooted human extracted teeth were selected for this study. Teeth were examined under a stereoscope for any external or internal resorption, cracks and caries. The length of each canal was visually determined by placing a #15 into the canal until the tip of the file was visible at the apex. The working length was determined by subtracting 1 mm from the length of the file. The canals were prepared up to # 40 using standard method. Each canal was irrigated by 5 ml 5.25% NaOCl after every change of file.

After the instrumentation, the teeth were subjected to modified clearing protocol using techniques described previously (De Gregorio et al., 2012; Robertson and Leeb, 1982). Teeth were submerged in 5% nitric acid for 36 hours, for decalcification, with the solution being replenished every 8 hours. After completeness of decalcification the teeth were cleaned under tap water for 3 minutes, to remove any traces of acid, if presented. Lateral canals were then created inserting 06C^{+}files at 2mm, 4mm and 6mm from apex the buccal and lingual walls perpendicularly to the external surface. Samples were then dehydrated by subjecting to 60% ethyl alcohol for 12 hours followed by 80% for 1 hour and 96.6% for 1 hour. Finally, they were cleared and stored in 99.9% methyl salicylate. Teeth were mounted in rubber-based impression material to mimic the

presence of surrounding periodontal tissues.

Contrast solution:

Contrast solution was prepared by mixing 40% of Indian ink with 60% of sodium hypochlorite (5.25%) in ration (2:3).

Experimental groups:

Teeth were divided into three groups (n=10) according to the activation methods:

First group (MDA):

A well-matching gutta percha master cone whose taper is slightly less than the taper of the canal is selected. 1 mm at the tip of the cone was trimmed to get the tug back. The canal was filled with the contrast solution and manual agitation of the master cone was started with an up and down motion and a 2 mm amplitude at a frequency of approximately 50 strokes during 30 sec.

Second group (PUI):

The canals were filled with contrast solution Ultrasonic activation was applied using a ultrasonic size 25# file (Satelec, Acteon, Merignac, France) mounted on P5 ultrasonic unit (satelec). The ultrasonic file was inserted into the canal 1mm short of the working length. The file was activated for 30 seconds using a power of five.

Third group PIPS:

PIPS activation was done by an Er:YAG 2940 nm laser (Fidelis AT, Fotona). in the higher institute of laser researches and applications in Damascus university. A 14-mm long and conical, cylindrical (tapered) 300-lm fiber tip was applied at 0.3 W, 15 Hz and 20 mJ per pulse. The water and air on the laser system were turned off. Canals were filled with contrast solution and then the laser's tip was inserted 1mm below the canal orifices and activated for 30 seconds.

Evaluation criteria:

The teeth were exanimated under the stereoscope and the irrigant penetration was recorded according to the following criteria:

0 = if penetration was <50% of the lateral stimulated canal.

1 = if penetration was >50% of the lateral stimulated canal.

The results of each level (2, 4, and 6 mm) was recorded independently. Figure (1, 2 and 3)

Statistical analysis:

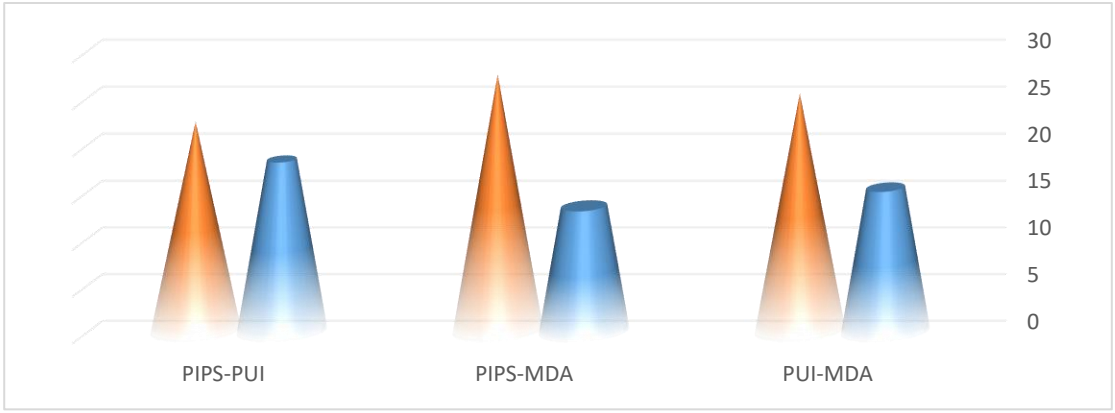
SPSS 20 was used for analysing the results. Statistical analysis was performed with nonparametric tests by using Kruskal-Wallis analysis for overall comparisons and a series of Mann-Whitney tests for pairwise comparisons. A P-value < 0.05 was considered to be significant.

RESULTS:

Results obtained from the study are summarized in tables (1,2 and 3) and graphs (1,2 and 3).

Table 1: Mann-whitney test at level 2 mm.

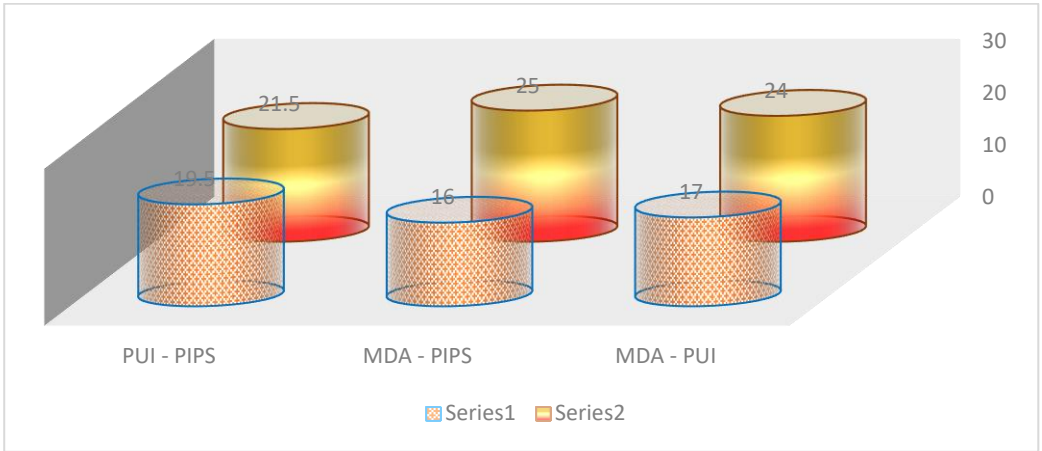
Activation method	Mean rank 1	Mean rank 2	Mann-Whitney U	P value
MDA - PUI	15.50	25.50	100.000	**.000**
MDA - PIPS	13.50	27.50	60.000	**.000**
PUI - PIPS	18.50	22.50	160.000	**.202**



Graph 1: the difference between each two groups at level 2mm.

Table 2: Mann-whitney test at level 4 mm.

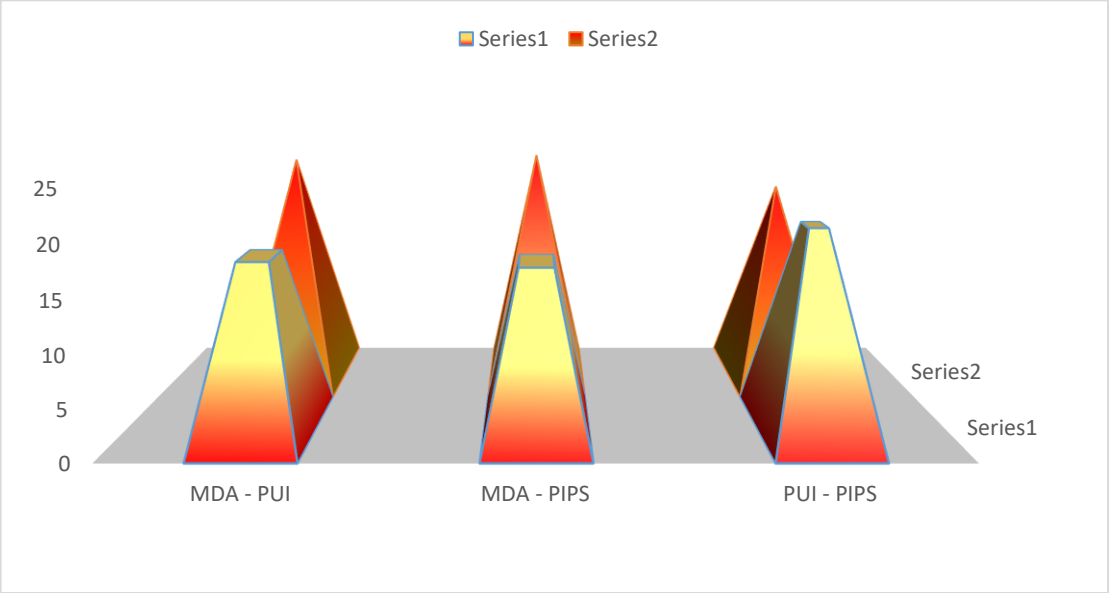
Activation Method	Mean Rank 1	Mean Rank 2	Mann-Whitney U	P value
MDA- PUI	17.00	24.00	130.000	**.029**
MDA - PIPS	16.00	25.00	110.000	**.005**
PUI - PIPS	19.50	21.50	180.000	**.496**



Graph 2: the differences between each two groups at level 4 mm.

Table 3: Mann-whitney test at level 6 mm.

Activation method	Mean rank 1	Mean rank 2	Mann-Whitney U	P value
MDA - PUI	17.00	24.00	130.000	.027
MDA - PIPS	16.50	24.50	120.000	.011
PUI - PIPS	20.00	21.00	190.000	.708



Graph 3: the differences between each two groups at level 6 mm.

This study found that at all levels PIPS group showed the highest irrigant penetration values followed by PUI group, and MDA group showed the lowest irrigant penetration values. However, the difference between PIPS group and PUI group wasn't statistically significant while the differences between PIPS and MDA, and PUI and MDA was statistically significant.

DISCUSSION:

To reach its Effectiveness the irrigant solution need to come in contact with entire root canal system. Several delivery systems and new activation devices developed for better distribution of irrigant throughout canal system which results in improved canal cleanliness (Gu et al., 2009).

In this study, irrigant penetration was evaluated by clearing the tooth and staining using irrigating contrast solution, a method which is similar to the one suggested by (Castelo-Baz et al., 2012) and (De Gregorio et al., 2012; de Gregorio et al., 2009). This method depends on the observation of the irrigant penetration three-dimensionally in extracted teeth. Resin blocks with artificial canals has not been used to evaluate irrigant penetration in this study as this method may not simulate the clinical scenario (Goldberg et al., 2001).

The results of this study showed that the penetration of the irrigant was better in both PIPS and PUI compared to MDA, and there was no significant difference

between the PIPS and PUI. This may be due to the fact that PUI transmits the energy from the activated file to the irrigant which create acoustic streaming and cavitation effects allowing the irrigant to flow into the root canal system complexities reacting the untouched areas (Kanumuru et al., 2015) while PIPS uses the ability of water to absorb Er:YAG which cause evaporation. The vapor bubbles start to expand and collapse forming shock waves help the irrigant to reach all root canal areas (Basrani, 2015; Kivanç et al., 2008).

The effectiveness of the PUI system to transmit the irrigant through the lateral stimulated canal achieved in this study is in accordance with the results of previous studies (Galler et al., 2019; Kanumuru et al., 2015; Spoorthy et al., 2013).

In a study conducted by Rajakumaran and Ganesh laser–assisted irrigant activation showed higher irrigant penetration than PUI and manual activation (Rajakumaran and Ganesh, 2019), while this study found that the irrigant penetration after PIPS activation was similar to PUI, this may be due to the difference between the type of laser as Rajakumaran and Ganesh used Nd:YAG while Er:YAG laser was used in this study. Galler et al found that PIPS associated with the deeper methylene blue penetration followed by PUI (Galler et al., 2019). This study found that the difference between PIPS and PUI as irrigant (NaOCl) activation methods was not statistically significant.

CONCLUSION:

PIPS was able to achieve penetration of the irrigant contrast solution into the lateral stimulated canals, so it can be used clinically as an effective method in irrigation.

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FIGURES:

Fig 1: irrigant penetration into lateral stimulated canals in one MDA sample.

Fig 2: irrigant penetration into lateral stimulated canals in one PUI sample.

Fig 3: irrigant penetration into lateral stimulated canals in one PIPS sample