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Comparative Study of the Effect of MTAD Irrigation Solution Activated By Laser on the Micro-Hardness of the Radicular Dentin

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Irrigation Solution, Laser Activation, Micro-Hardness, MTAD, Radicular Dentin.

ABSTRACT

The work aims to compare the influence of irrigation solution MTAD when activated by laser and without activation on the root dentin micro-hardness (MH). Thirty root samples were prepared into two equal halves for dentin MH measurements. The sixty root halves were subdivided equally into three groups (twenty samples each) according to the utilized irrigation solution: MTAD activated by laser, MTAD non-activated by laser and deionized water (control group). Samples from each group were used for dentin MH determination at baseline determination and next to treating to evaluate the variation in MH. Data were analyzed by one-way ANOVA and student's t-test for MH. MTAD non-activated by laser displayed the highest significant lowering in dentin MH ($P<0.5$). The values of the MH of radicular dentin were higher when MTAD activated by laser used. The results revealed that MTAD activated by laser was the most efficient treatment. Further clinical tests are necessary for establishment of the efficiency, safety and biocompatibility of this treatment prior to be utilized normally in vivo.

1. Introduction

Dentins are composed of a hydrated organic matrix that is mostly type 1 collagen. It constitutes 22% by weight of the substance, into which is imbedded an inorganic phase of carbonated apatite that participates to its mechanical properties [1], [2]. Root canal facility consists of the mutual act of endodontic instrumentations and irrigation solutions in order to remove the already exist organic and inorganic debris as a result of the operating process, also to decrease the microbial content and its by-products [3].

Irrigation solutions utilized in endodontic treating could give rise to variations in the chemical structure that could influence the mechanical properties of dentin. These irrigation solutions utilized in order to eliminate of smear layer could be active likewise on both the smear layer and the root dentin. As a result, it gives rise to the exposing of collagen and finally results in reduction in dentin micro-hardness (MH) [4]. Several irrigation solutions were used to investigate their influences on some major and minor elements content of root canal [5]. The results revealed that minor element had the capability of re-distributing and the mixed

irrigation solution of sodium hypochlorite and MTAD was the most efficient. In another work, contrasting effects were observed concerning the roughness after treatment of root dentin by certain chelation agents. Increasing the hardness could be useful clinically as it assists the adhesion [6]. In other studies, the influence of several irrigation solutions (including MTAD) on root dentine MH was evaluated without laser activation [7- 9]. To our knowledge, there is no study dealing with the investigation of MH of the root canal treated with MTAD irrigation solution activated by laser.

On the other hand, the aim of using lasers in endodontic treating is to merge the influence of the energy generated by various laser devices with the biomechanical practices conducted by endodontic instrumentations and irrigation solutions to assist debridement and purifying of root canal walls [10]. Both erbium:yttrium aluminium garnet (Er:YAG) 2940 nm and neodymium:YAG(Nd:YAG) 1064 nm lasers have displayed practicability in endodontic [11], [12]. An alternate laser is the 980 nm diode laser (980 DL). It is cheaper with better flexibility, due to its small dimensions [13]. The 980 DL transmits energy throughout thin flexibleness fibers, suitable with the sizes and curved forms of root canals [13], [14]. Additionally, DL wavelengths have perfect permeation potency, evaluated absorption peaks in melanin and haemoglobin, and weak interactivity with water and hydroxyapatite [15], [16]. Indeed, the permeation ability of DLs is higher than that of Er:YAG and could decrease the microbial content within the dentinal tubules [13], [16]. Similar result was observed in another study for this decreasing after DL irradiation [10].

The present work was intended to investigate the influence of MTAD root canal irrigation solutions activated by laser on the MH of the root canal dentin by Vickers MH test and compared with the same MTAD irrigation solution without activated by laser.

2. Materials and Methods

Sample sizes were chosen in accordance with other comparable study [17]. Thirty newly extracted healthy single rooted premolars were chosen and conserved in 0.1% thymol solution. The chosen specimens were decoronated at the level of cemento-enamel junction by cooled diamond impregnate disc. For longitudinal partitioning, grooves were formed on the buccal and lingual outer surface of roots avoiding penetration into the canals by a double faced water cooled diamond disc. The roots were divided into two halves by a chisel.

The samples randomly were divided into three groups (10 samples each) according to the utilized irrigation: MTAD activated by laser, MTAD non-activated by laser and deionized water (control group). Next to irrigation solution treatment, all samples were washed with deionized water in order to eliminate any trace of chemicals. Prior and next to the irrigation treatment, dentin MH was determined by a Vicker's MH tester with MST-10 DMLM from LEICA Company. The specimens were separately set on Vicker's MH tester and indentations were marked with a Vicker's diamond indenter at 100 g load and dwell time of 20 s for determining baseline data.

After that, the samples were subdivided into three groups (20 samples each) according to the same utilized irrigation: MTAD activated by laser, MTAD non-activated by laser and deionized water for 5 minutes. Again, samples were washed with deionized water in order to eliminate any trace of chemicals. After that, new MH determinations were carried out as mentioned earlier. The variations in MH were evaluated prior and next to irrigation in each protocol. Statistical analyses were performed using SPSS software.

3. Results

Results of variations in dentin MH prior and next to irrigation treatment as well as between groups are shown in Figure 1.

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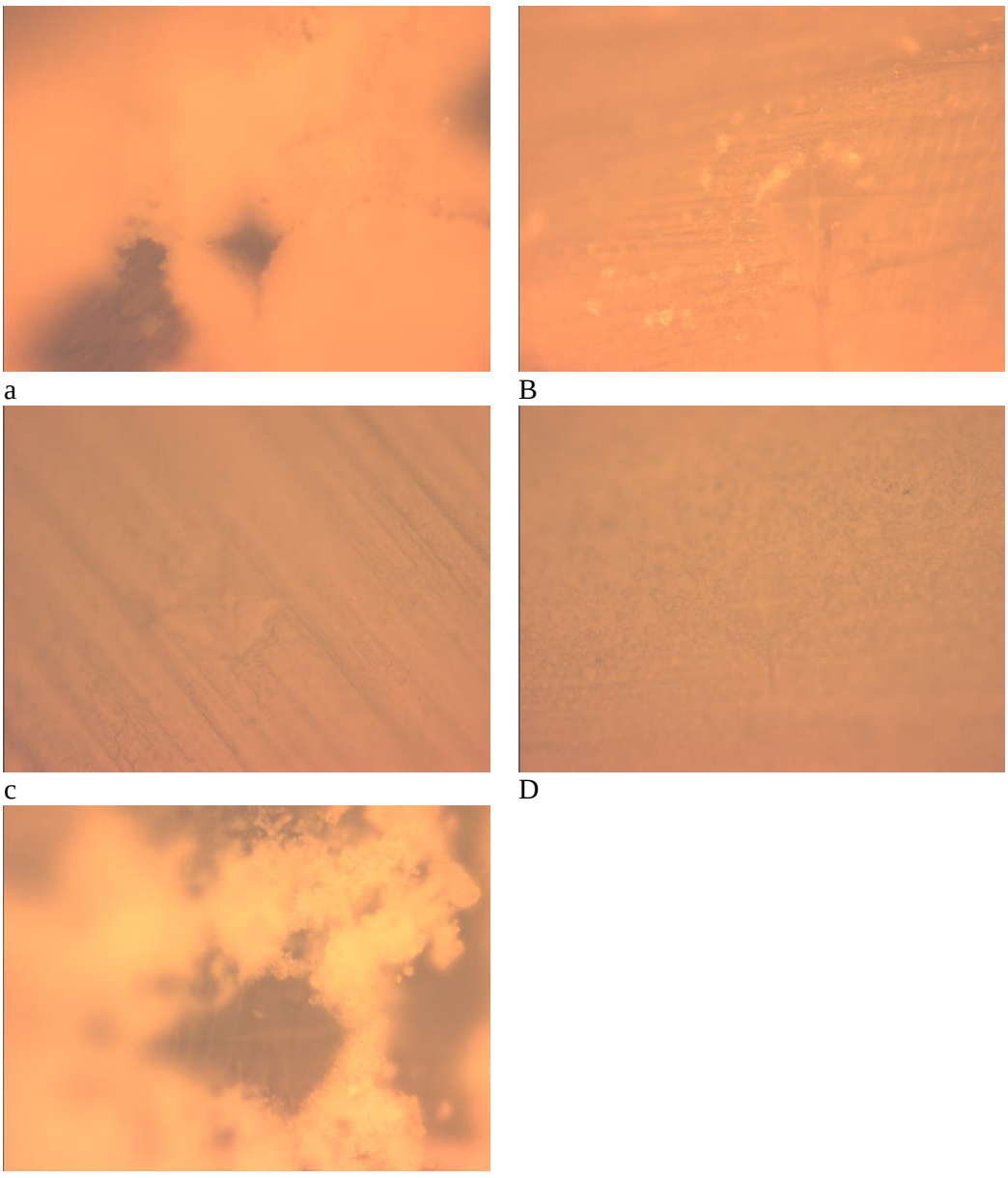

Figure 1 Micro-hardness measurements for each studied group, a) In the group MTAD activated by laser, b) In the group MTAD non-activated by laser, c) In the group MTAD activated by laser after the irrigation d) In the group MTAD non-activated by laser after the irrigation and e) In the group control deionized water

The compare of mean MH within the three groups was conducted prior to the irrigation using the one-way ANOVA test. The P-value was 0.07 (> 0.05) that was statistically not significant (Table 1). Consequently, the mean MH of dentin in all the three groups before the irrigation solution treatments used was comparable.

Table 1 One-way ANOVA test for mean micro-hardness according to the protocol used

Protocol used	Micro-hardness (HV) (Mean±standard deviation)				
	MTAD activated (n=10)	MTAD non-activated (n=10)	Distilled water (n=10)	F value	P-value

Before irrigation solution (n=30)	126.28±4.24	104.24±8.90	116.56±5.26	2.935	0.070*
After irrigation solution (n=30)	118.50±5.33	87.30±7.98	112.85±4.66	7.282	<0.003**

*not significant; ** significant

Similarly, the compare of mean MH within the three groups was conducted next to the irrigation. The P-value was 0.003 (< 0.05) that was statistically significant. Consequently, statistically significant difference in the mean MH within the three groups next to irrigation solution treatments was observed. Figure 2 shows the mean MH according to the studied stage and the irrigation used.

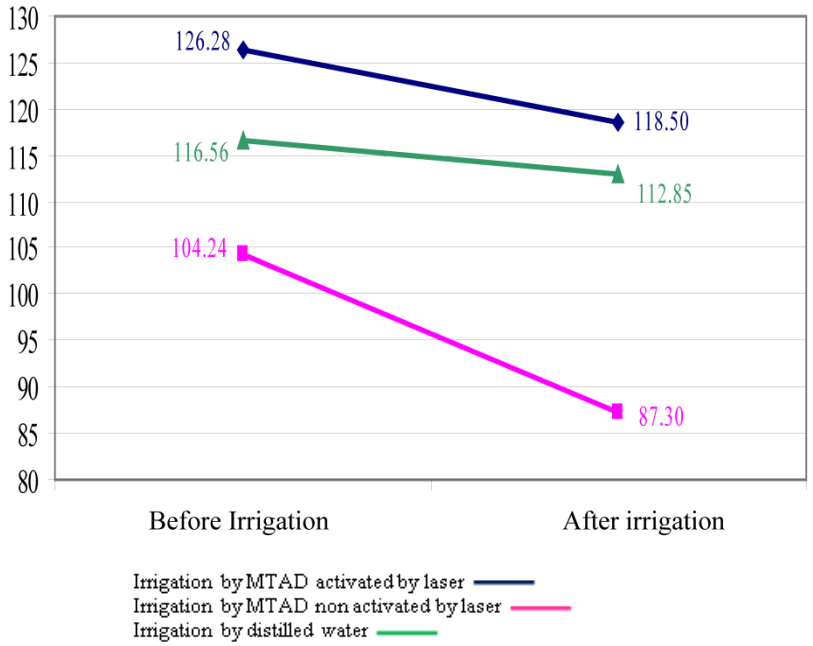

Figure 2 The mean micro-hardness according to the studied stage and the irrigation used

Next, the pair-wise comparison of MH between each pair group next to irrigation solution treatments was performed using Post-hoc Turkey test. The pairs MTAD activated by laser-distilled water had a P-value of 1.0 (> 0.05) that was statistically not significant (Table 2). Therefore, no difference in the mean MH next to the irrigation between these pairs was observed.

Table 2 Post-hoc Turkey test for micro-hardness between each pair group

Pairs	P-value	Significance
MTAD activated by laser-MTAD non-activated	< 0.004	Significant
MTAD activated by laser-distilled water	1.000	Not significant
MTAD non-activated-distilled water	< 0.020	Significant

On the other hand, for MTAD activated by laser-MTAD non-activated and MTAD non-activated-deionized water, these two pairs had a P-value of < 0.004 and < 0.020, respectively (< 0.05) that were statistically significant (Table 2). Therefore, statistically significant differences in these pairs were obtained.

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Additionally, the compare of mean MH within the three groups prior and next to irrigation was performed using paired t-test (Table 3). The irrigation solutions (MTAD activated by laser and distilled water) had no significant difference ($P > 0.05$) in the MHs of teeth. Nevertheless, statistically significant difference in the mean MH was noticed in the group of MTAD non-activated by laser ($P < 0.05$).

Table 3 Paired t-test for mean micro-hardness within the three groups prior and next to irrigation

Group	Micro-hardness (HV) (mean±standard deviation)		t-value	P-value
	Before treatment	After treatment		
MTAD activated by laser	126.28 ± 4.24	118.50 ± 5.33	0.6844, df=19	0.501986*
MTAD non-activated	104.24 ± 8.90	87.30 ± 7.98	22.532, df=19	<0.001**
Distilled water	116.56 ± 5.26	112.85 ± 4.66	1.926, df=19	0.069*

*not significant; ** significant

Thus, it may be concluded that when irrigation solution MTAD non-activated by laser was used, a statistically significant decrease in the mean MHs of dentin next to irrigation was observed, whereas no variation was noticed when using the irrigation solutions MTAD activated by laser and distilled water.

4. Discussion

Chemicals utilised within endodontic treating could give rise to modifications in root dentin and alter its chemical and physical properties [9], [18]. Furthermore, reduction in the MHs could influence the adhesion and sealing capability of the sealers to the root dentin walls [9], [19]. Within irrigation treatment both the coronal and radicular dentin are exposed to the act of irrigation solutions that could give rise to modifications in the physical and chemical properties of root canal dentin that include MH [4]. Indeed, MH of dentins could differ extremely between teeth. Therefore, for the establishment of rational valuation for the influence of the irrigation treatments on the teeth surface, the MH determinations were carried out for all samples at baseline and next to irrigation solution treatments. Post-treating indentations were carried out on all samples at same regions which were at symmetric fixed dots of the baseline for two directions of the root canal [9], [20]. On the other hand, MH measurement is vastly utilised to examine accurate level modifications in the hardness, either intended or incidental. It is among the simplest and non-destructive tests. The MH of teeth could be determined by Vicker's MH method (for deep dentin). Vicker's MH method was utilised due to its appropriateness and practicality for investigating the variation in the surface in profounder rigid tissue structures. Vicker's MH method is vastly acceptableas a result ofits considerably precise measurements and the using of only one type of indentation for all kinds of surface treating [21]. The MH of the root dentine could differ vastly between root dentine due to its dependence on the tubular density. The latter is inversely proportional to the root dentine [22], [23]. In addition, The MH of root dentine is relied on the level of mineralization and the content of hydroxyapatite [23], [24].

In our study, the midsections of root dentin were chosen to minify structural variances and to achieve regular baseline data for valuation. Ground polishing of the specimens were effectuated to remove any surface anomalies and to achieve a mirror-like finishing [3]. When the irrigation solutions were used, it was observed that MTAD activated by laser had no influence on the MH of teeth compared by control. This was agreed with the other work [17]. As Er:YAG laser has weakly permeation capability in dental tissue due to its elevated absorption coefficients in water and hydroxyapatite. Consequently, it reacts mostly with the apparent surfaces of the teeth and enhances variations in MH up to 60 μm [10].

In our study, we are different with the results utilising EDTA activated by 808 nm DL for 40 second that displayed remarkably higher decrease in MH in comparison with EDTA non-activated or EDTA with ultrasonic agitation [25]. This was due to the different of irrigation solution (MTAD) used in our study and the using of Er:YAG laser. Also, in our study we are different with the study reported by [26] showing comparable decrease in MH values of root canal dentine because the EDTA irrigation solution was used and activated with analogous lasers, while in our study the MTAD was used.

In the present study, MTAD non-activated by laser was observed to decrease the dentin MH. The decrease in the MH could be associated to its chelating property. This was in accordance with the other studies [23], [27]. Another study displayed that root dentins were weaken when exposed to calcium hydroxide, mineral trioxide aggregate or sodium hypochlorite for five weeks [23], [28]. Another study demonstrated that EDTA, EGTA, EDTAC and tetracycline HCl with and without following NaOCl treating also displayed a decrease in MH levels [23], [29]. Similarly, chelating agents displayed a considerable diminution in root dentine MH [7], [8], [23]. On the other hand, cavitation is the concept on which laser activated irrigation works. It is recognized to take place as a result of the absorption of water with mid-infra length lasers which leads to vapour including bubbles. This phenomenon leads the irrigation to apply shear force on the root canal walls further complementing the act of the irrigation [23]. Also, this was in accordance with the other studies utilised MTAD [8], [9] showing a decrease in the MH of root canal dentin due to collapse of the teeth matrix structure. Moreover, the influence of MTAD on reduction of dentin MH could be associated as mentioned previously to its chelating property. The 3% doxycycline hyclate component of MTAD is a tetracycline isomer with a low pH. Therefore, it could react as a calcium chelating agent and leads to the demineralization of root surface. In addition, MTAD is composed of 4.25% citric acid that is able of dissolving the mineral tenors of teeth [30].

5. Conclusion

Within the limitations of this in vitro study, it could be deduce that all the utilized irrigation solutions had influence on the MH of root canal dentin. In the reported work, it was observed that the utilization of MTAD activated by laser had no significantly effect on the dentin MH in contrary to MTAD non-activated by laser. Further clinical tests are necessary for establishment of the efficiency, safety and biocompatibility of this treatment prior to be utilizednormally in vivo.

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