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Effect Of Nd:Yag (1064-Nm) And Diode Laser (980-Nm) Irrigant Agitation On Root Dentin Microhardness – An *In Vitro* Study

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Introduction

Irrigation is one of the key elements on the road to endodontic success. It helps in the removal of vital and necrotic remnants of pulp, as well as in the elimination of micro-organisms and microbial toxins from the root canal system. [1,2] Growing advances in nickel titanium instruments alone cannot completely clean the root canal system owing to the intricate nature of its anatomy leaving canal fins, isthmi, and cul-de-sacs unaffected by the preparation. [3,4] Retention of the smear layer produced by various instruments during an endodontic procedure further aggravates this problem as it acts as a physical barrier between the filling material and the canal walls, undermining sealer penetration and forming intratubular tags. [5] Studies have shown that removing the smear layer helps dissolve the attached microbiota and their toxins from the root canal walls and reduce the potential of bacterial survival and reproduction. [6] Thus, irrigation helps overcome the limitations of cleaning accomplished by root canal instrumentation alone.

An ideal irrigant would help achieving all of the above mentioned goals. However, no such irrigant currently exists. Sodium Hypochlorite (NaOCl) has good antimicrobial properties and can also dissolve organic tissues. [7] Ethylenediaminetetraacetic Acid (EDTA) is a chelating agent which is known to dissolve inorganic component of the smear layer. Chlohexidine has a more pronounced residual antibacterial effect and lower toxicity as compared to Sodium Hypochlorite. [8] Thus, contemporary endodontic practice may demand use of multiple irrgants as initial and final rinses so that each may complement the shortcomings of the other. [9,10]

Various studies have been performed in the past to understand how the contact of irrigants to the root canal walls may be enhanced. [11] Agitating these agents has been shown to promote penetrability and accentuated effects on the walls of the root canal dentine. [12]

Laser activated irrigation using Nd:YAG (Neodymium-doped Yttrium Aluminium Garnet) 1064 nm and Diode 980nm has shown immense applicability in terms of disinfection [13] and removal of smear layer [14]. However, Laser assisted irrigation would expect to cause certain changes in the dentine. To assess this, the most satisfactory and reproducible results have consistently been produced with measurement of cross-sectional micro-hardness [15]. Contemporary irrigants such as Sodium hypochlorite, EDTA and Chlorhexidine have been chosen to add to the relevance of this study and allow us to scientifically assess the changes induced both by the irrigant as well as the mode of activation. However, before we consider Laser activated irrigation as an alternative protocol in endodontic therapy, we must first evaluate how these devices will affect the root dentine on an ultrastructural level.

Therefore, the aim of this in-vitro study was to evaluate the effects of agitation of 3 contemporary irrigants using Nd:YAG (1064 nm) and Diode (980 nm) on the cross-sectional microhardness of root dentine.

Materials & Methods

75 freshly extracted human mandibular premolar teeth were used in this study. The teeth were examined under a microscope to select those with similar size, similar morphology, absence of cracks and absence of surface defects. A periodontal scaler was used to remove any calculus or periodontal tissues present. The selected teeth were then sectioned transversally along the cemento-enamel junction using a water cooled diamond disc. The root canals were prepared using Protaper Rotary instruments (Dentsply Maillefer, Ballaigues, Switzerland) upto an apical file size 30 or F3. During instrumentation, irrigation was performed using saline solution. The roots were then sectioned in a bucco-lingual direction to obtain root halves. The specimens were then horizontally embedded in autopolymerising acrylic resin. The two halves were then stabilised using adjusting screws that were drilled into the acrylic before execution of irrigation protocol. The size of the block was 25mm x 30mm x 30mm. The specimens were ground with abrasive papers and a grinding machine under running water. An ultrasonic cleaner was then used to clean the specimens.

A 980 nm Diode Laser (Photon Plus, Zolar Technology & Mfg Co. Inc, Mississauga, Canada) equipped with a 10W power source was used. The Laser delivery system used in this study was at 2W in pulsed mode. A 1064 nm wavelength Nd:YAG Laser (Fotona, Ljubljana, Slovenia) at 2W in pulsed mode using a 200 μm flexible fibre.

After adapting the acrylic block using the screws, the apexes of the teeth were sealed with wax to prevent the extrusion of any irrigant. Following irrigation protocols were then followed:

Group (1) Distilled water (negative control) The root canal was irrigated for 60 seconds and then dried with paper points

Group (2) No activation (positive control group): Canal was irrigated for 60 seconds with respective irrigant without any activation. This was followed by a final rinse of saline for 60 seconds.

Group (3) Manual Dynamic Activation: Canal was irrigated with respective irrigant and agitated for 60 seconds using an F3 GP point. This was followed by a final rinse of saline for 60 seconds

(4) Irrigant with 50 sec Diode Laser activation: The root canal was filled with irrigant, and the laser fiber agitated the solution with 2 W in continuous waves for 10 sec. This procedure was repeated five times, so that the total agitation was 50 sec. This was followed by a final rinse of saline for 60 seconds

(5) Irrigant with 50 sec Nd:YAG Laser activation. The root canal was filled with irrigant, and the laser fiber agitated the solution with 2 W in continuous waves for 10 sec. This procedure was repeated five times, so that the total agitation was 50 sec. This was followed by a final rinse of saline for 60 seconds.

Each group was further divided into 3 subgroups consisting of the three different irrigants used. (1) Sodium Hypochlorite (5.25% NaoCl) (2) Ethylenediaminetetraacetic Acid (17% EDTA), and (3) Chlorhexidine (2%).

Indentations were made with a Vickers diamond indenter (Vicker's Microhardness Tester, Reichert Austria Make, Sr. No. 363798) at three different points for each sample, on the coronal, middle and apical third, such that they were equidistant from each other. The indentations were made on the top surface of each specimen using 100g load. The three values were averaged to produce one hardness value for each specimen. These measurements were converted into Vickers numbers. One way ANOVA and Tukey's test were performed for statistical analysis of results obtained.

Results

Distilled water presented no significant change in dentine microhardness ($p > 0.05$). Laser activated irrigation showed a significant reduction in root dentine microhardness as compared to the Groups 1, 2 & 3. ($p < 0.05$) Also, 5.25% sodium Hypochlorite and 17% EDTA showed a significant reduction in root dentin microhardness as compared to 2% Chlorhexidine irrespective of the mode of activation. ($p < 0.05$)

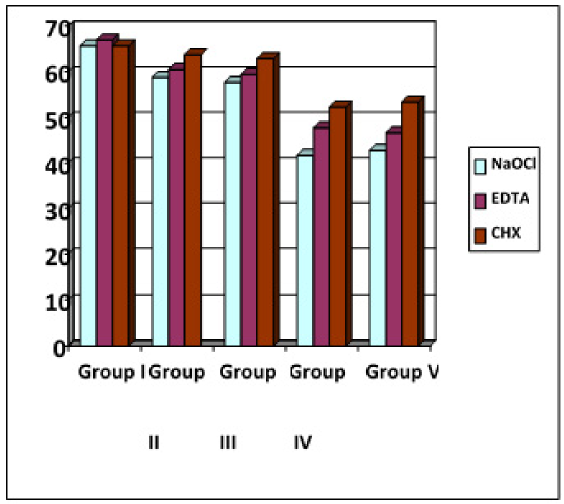

Figure 1: *Graphical representation showing change in microhardness across all groups.*

Discussion

The advantages and limitations of the 3 contemporary irrigants used in this study have been well documented. [16] Agitation of these irrigants may supplement their action but it is important to assess the ultrastructural changes that these techniques may induce on the root canal dentine. It is also important to note that a decrease in the microhardness has been known to have a direct correlation to the adhesion and sealing ability of the sealers to the root canal walls. [17] Determination of microhardness changes is a good indirect method of assessing the effects of activation of these irrgants on the dentine. [18] Numerous other studies have shown the applicability of Vicker Microhardness Test [19-21] as well as the Knoop indenter method [22-24] Vicker's was the chosen method in this study due to its suitability and practicality.

The microhardness of the root dentine may vary widely across root dentine as it depends on the tubular density. As noted by Pashley, the tubular density is inversely proportional to the root dentine [25] the intrinsic hardness of root dentine depend on both, the degree of mineralization as well as the amount of hydroxyapatite. [26] The selection of the three equidistant locations at the coronal, middle and apical third and the averaging of the same to arrive at the Vicker's hardness value helped in the standardization of this study.

Distilled water was used initially in this study as it has no effect on the microhardness of root dentine [27] and thus served as a negative control. In this study, both EDTA and NaOCl showed a reduction in the microhardness irrespective of the mode of agitation. This was in accordance with the study by Saleh., *et al.* [28] Studies by White., *et al.* showed that exposure of root dentine to calcium hydroxide, mineral trioxide aggregate or sodium hypochlorite for 5 weeks resulted in weakening of the root dentine. [29] A study by Sayin., *et al.* also proved that EDTA, EGTA, EDTAC and tetracycline HCl with and without subsequent NaOCl treatment also showed a reduction in microhardness values. [30] Cruz-Filho., *et al.* showed that chelating agents showed a significant loss in root dentine microhardness. [31] However, our study showed a greater reduction in microhardness with sodium hypochlorite as compared to EDTA. This may be due to the amount of time the canals were irrigated for. As per Serper, EDTA application for 5 minutes showed a much more substantial decrease in dentin microhardness as compared to its 1 minute application. [32] Chlorhexidine in comparison with EDTA and NaOCl did not show a substantial decrease in mircohardness of root canal dentine. Hale Ari., *et al.* showed similar results for Chlorhexidine in comparison to other irrigants. [33]

Lasers in endodontics have shown immense promise as they help in elimination of micro-organisms from the root canal system, [14] removal of smear layer and improved adhesion of sealer to the root canal walls [34]. Laser Activated irrigation works on a principle called cavitation which is known to occur due to absorption of water with mid-infralength lasers resulting in vapor containing bubbles. This phenomenon causes the irrigant to exert shear force on the root canal walls further supplementing the action of the irrigant. Studies by Arslan., *et al*. showed that EDTA activated by 808 nm Diode Laser for 40 sec showed significantly greater reduction in microhardness as opposed to ultrasonic agitation. [35] The current study which used a 980nm diode laser for activation for 50 seconds showed greater reduction in microhardness as opposed to the irrigants alone or by manual agitation. It is also important to note that both Lasers caused similar levels of reduction of microhardness which may be attributed to the fact that both the lasers show similar degrees of water absorption. [36] Studies by Macedo., *et al*. showed similar reduction in microhardness levels of root canal dentine when EDTA was activated with similar Lasers. (37) The reduced microhardness levels obtained due to Laser activated inrrigation in this study could be explained by the interaction that occurs between the lasers and the root dentine. Esteves-Oliveira., *et al.* noted that the wavelength of these lasers results in increased root dentine permeability. [37] This, coupled with the use of irrigants such as EDTA result in deeper mineral removal thus causing reduced microhardness. Previous studies have proven the effect seen by these Lasers is due to the cavitation effect [38,39]. Thus, it may be established that these lasers also help in efficient cleaning of canal walls.

Further studies are however needed to assess the changes in surface roughness values as Laser assisted irrigation has been suspected of increasing dentine erosion. These erosive effects may affect interaction of the dentine wall with root canal filling material, decrease the resistance to penetration of bacteria and apical leakage.

Conclusions

Within the limitations of this study we may conclude the following:

Laser activated irrigation using Diode (980 nm) and Nd:YAG 1064 nm significantly reduces microhardness of root dentin as compared to Manual or no agitation.

NaOCl caused maximum reduction in microhardness followed by EDTA while Chlorhexidine showed least reduction of microhardness values irrespective of the mode of agitation.

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