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Analysis of Push Out Bond Strength of Root Canal Sealer with Different Irrigants and Laser Application: An Original Study

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ABSTRACT

Objectives: The aim of study was determination of effect of different irrigants and laser on sealer adhesion to dentin.

Materials and Methods: Sixty-eight anterior teeth were decoronated, access openings were made and canals prepared upto Protaper F_3 size. Samples were randomized into experimental and control groups based on irrigation and laser protocols: Distilled water (Negative control), 3% NaOCl and 17% EDTA alternate irrigation (Positive control), Er:YAG laser irradiation following alternate irrigation (Group 3) and Er:YAG laser activation of NaOCl (Group 4). Samples were obturated and push out bond strength was evaluated. Failure modes were analysed using Scanning Electron Microscopy (SEM). Analysis of Variance (ANOVA) test was applied for study parameters comparison.

Results: Significant difference was observed among the groups ($p<0.05$) in terms of mean bond strength values (MPa). The measured values were highest in Group 3 and least in Group 1.

Conclusion: Er:YAG laser irradiation after conventional irrigation showed significant sealer adhesion to dentin.

Keywords: Er:YAG laser; Electron Scanning Microscopy, Push out bond strength.

INTRODUCTION

The accomplishment of comprehensive endodontic treatment relies on complete elimination of microorganisms and smear layer from the root canals along with acquisition of hermetic seal. The extensive canal debridement and frequent delivery of intracanal irrigants to the desired site plays a critical role in successful treatment outcome. There are numerous factors concerned with treatment failure. Amongst them, the factor of greatest concern is inadequate obturation and sealing of canal space.[1] Other factors could be the escape of tissue fluids which encompasses the improper obturation and subsequently results in bacterial proliferation and their aggregation.[2] The mineralized tooth tissues are not consistently removed during instrumentation but are distorted to result in *smear layer* generation that obscures tubular orifice. The smear layer is an amorphous and uneven layer of mineralized tissues which conceals both prepared and unprepared root canal walls. The varied techniques of rotary instrumentation lead to the production of smear film around root canal walls and dentinal tubules.[3] The existence of smear layer within root canals generates an unfavorable environment for appropriate sealer adhesion to canals.[4] Therefore, elimination of this layer is of paramount importance. Various techniques of eliminating smear layer had been discussed in the prior studies.

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The most prevalent are chemical removal, use of chelators, lasers and ultrasonics. Also, a non-instrumentation hydrodynamic technique had been advocated.[5] Chelators like EDTA functions by binding to calcium ions present in dentin and form soluble complexes. In a previous research, it was analyzed that EDTA caused demineralization up to 20-30μm depth within 5 mins but was ineffective at apical thirds of canals.[6] An extensive variety of lasers are being used now in endodontic treatment. Nd:YAG lasers are claimed to produce glazed surface of dentin free of organic tissues by melting and recrystallisation of smear layer.[7] It had been demonstrated that the use of Er:YAG lasers causes destruction of peritubular dentin contributing towards smear layer elimination.[8] In the former studies, the effects of laser irradiation and alternate irrigation of EDTA with Sodium hypochlorite on the elimination of smear layer was determined separately. Therefore, this study intended to determine the effect of various irrigants and laser on adhesion of endodontic sealer to canal walls.

MATERIALS AND METHODS

The present study was performed after approval from ethical committee at Research Cell, King George's Medical University, Lucknow (U.P.) vide reference code *84th ECM IIB-Thesis/P4.* The study was done with an objective to estimate the effect of various irrigation agents and laser on bonding of sealer to root canal walls. Sixty-eight freshly extracted anterior teeth free from anatomic variations were selected. The extracted teeth samples were preserved in 0.1% Thymol (fungicide). Decoronation of teeth samples with diamond disc (Horico dental, Germany) and straight handpiece (Marathon-4, Saeyang) was done under water coolant. Access openings and preparation of glide path upto # 25 K-file was done. Biomechanical preparation was completed with rotary Protaper files upto size F3. Prepared samples were then randomized based on laser and irrigation protocols as: Negative control (Samples irrigated with distilled water), Positive control (Alternate irrigation of 3% NaOCl and 17% EDTA), Experimental group (The irrigation protocol was same as Group II followed by Er:YAG laser irradiation), Experimental group (Er:YAG laser activation of hypochlorite). Er:YAG laser (Fotona, model Fidelis, Slovenia) was utilized for irradiation of dentin at a power setting of 50 mJ, frequency of 20 Hz, for 1 minute. Excess moisture from canals was eliminated using absorbent points. AH Plus sealer was manipulated and obturation accomplished with corresponding Gutta percha cones. Cold lateral condensation was done to achieve dense compaction.

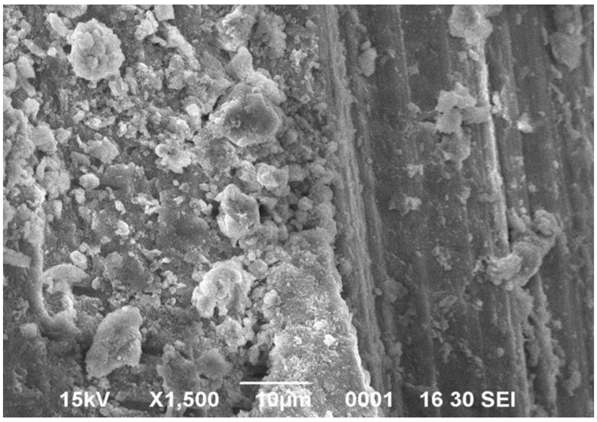


Fig 1: SEM photograph of Group 1

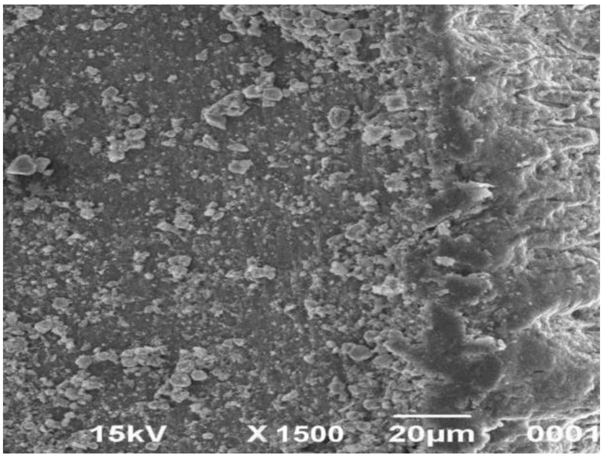


Fig 2: SEM photograph of Group 2

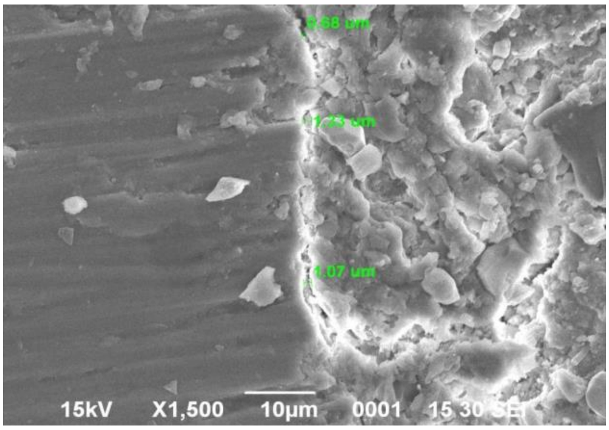


Fig 3: SEM Photograph of Group 3

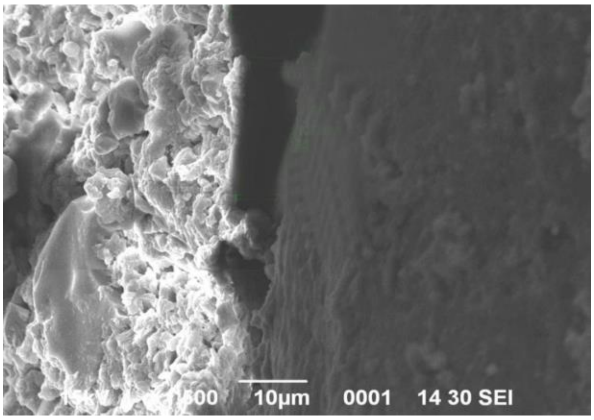


Fig 4: SEM Photograph of Group 4.

The obturated samples were stored in 100% relative humidity for a week to permit complete sealer polymerization. Specimens were then sectioned perpendicular to prepare thin dentin discs of thickness 4 mm. The discs were mounted with self-cured acrylic inside Aluminum rings and oriented vertically on the platform of Universal testing machine (Model No. 3382 Instron Corp., USA) with narrow diameter facing upwards. This permits apical displacement of gutta percha. The push out test was applied by placing the plunger of Universal testing machine against the central portion of prepared specimen using a crosshead speed of 1mm./min. until obturation was displaced. The maximum failure load at the dentin-gutta percha interface was recorded in MPa. Some of the tested specimens were split longitudinally and evaluated under Scanning Electron Microscope (SEM) for estimation of bond failure mode at the junction of dentin and gutta percha (Figure 1-4).

RESULTS

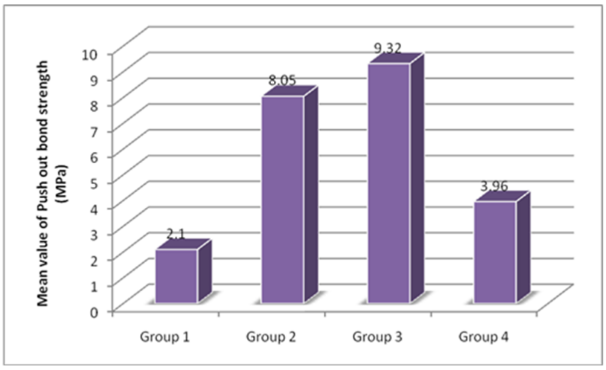
The results are depicted in mean±SD. One way analysis of variance followed by Tukey's post-hoc tests were used to compare push out bond strength among the groups. The data analyses was carried out on the Statistical Package for the Social Sciences (SPSS) 16.0 version (Chicago, Inc., USA). The results obtained in present study presented a significant difference ($p<0.05$) in mean push out bond strength (MPa) compared among all the groups. The highest mean values for push out bond strength were identified in Group 3 (Er:YAG laser irradiation following alternate EDTA and NaOCl irrigation) (Graph 1). Comparison of push out bond strengths among various groups was done. There was significant (p=0.0001) difference present in mean values among the groups (Table 1).

Table 1: Comparison of Push out bond strength among the groups.

Groups	Push out bond strength (Mean±SD)
Group 1	2.10±0.85
Group 2	8.05±1.67
Group 3	9.32±2.96
Group 4	3.96±1.15
p-value[1]	0.0001*

*Significant

Graph 1: Comparison of Push out bond strength (MPa) among the Group.



DISCUSSION

The fundamental step towards achieving the disease free endodontic state is based on ability to completely eliminate potential sources of irritation in canal space. This involves a thorough chemical debridement and mechanical shaping to render the canals devoid of pathogenic microbes and smear layer. The smear layer is generally scarce in non-instrumented canals and becomes quite appreciable after mechanical shaping.[9] It harbors microbial flora and diminishes the patency of dentinal tubules thus restricting penetration of intracanal medicaments and sealers.[10] Hence, microleakage at the interface of tubules and sealer continues progressively. Irrigants play a key role in down regulating inflammatory mediators and endotoxins released after bacterial cell death within the root canals. The requisites for an effective endodontic irrigants consist of the ability to solubilise both vital and necrotic pulpal tissues, vigorous antimicrobial action, lubricant effect on dentinal walls and absence of cytotoxic changes in peri radicular tissues.[11] The present study was aimed at coupling the push out bond strength of endodontic sealer with different irrigants and Er:YAG laser in combination with these agents. The attainment of chemomechanical debridement with conventional irrigation protocol (alternate Sodium hypochlorite and EDTA) has been recommended for a long time. The collective approaches of using both irrigants have shown remarkable improvement in reducing microbial load and smear layer elimination. This might be ascribed to the additive effect of both irrigation agents. Frequently employed chemical irrigants are Sodium hypochlorite alone or associated with 17% EDTA, 2% Chlorhexidine, MTAD and other agents. The irrigants play a secondary role in achieving disinfection of root canals, the primary being accounted by thorough mechanical cleansing of the space.[12] Lasers are currently practiced in dentistry with multitude of applications. The lasers were introduced to endodontic practice in 1971 by Weichman and Johnson who first used Nd:YAG lasers to seal the apical foramen.[13] Er:YAG laser was used in some studies to irradiate the canals in order to eliminate the smear layer.[14] The combined application of various irrigation agents with laser have not been reported yet. Therefore, this study was performed with an objective of comparing efficiency of different irrigating protocols and laser in improving the adhesion of sealer to dentin through debridement of smear layer. The status of Sodium hypochlorite presently has been established as *Gold standard* when compared to various irrigating solutions. It is a potential germicide effective against wide spectrum of microorganisms and has tissue solvent activity for necrotic tissues. Ethylene diaminetetraacetic acid (EDTA) is mainly used as chelator during endodontic treatment. It brings about conditioning of dentin walls and removal of inorganic smear layer is accomplished.[15] The alternate irrigation of sodium hypochlorite with EDTA enhances the cleaning efficiency of root canal system than individual application of both.[16] According to many researchers, the subsequent use of both irrigants results in diminished antibacterial activity following the lack of free available chlorine which restricts the antimicrobial action.[17] The CO_2, Argon and Nd:YAG lasers were evaluated in different studies regarding their ability to produce dentinal changes under scanning electron microscopy. It was reported that the highest thermal changes were caused by Argon laser closely followed by the two lasers. Also, dentin permeability was reduced with laser irradiation and enhanced during smear layer erosion from the dentin surface.[18] The purpose of root canal sealers cannot be undermined as they accomplish several objectives: lubricating dentin while placement of gutta percha cones, adhering of cones to dentin walls, sealing canal irregularities and accessory canals which contributes towards the success of therapy.[19] In the present study, AH plus was selected as endodontic sealer. AH Plus is based on epoxy resin sealer which is a dual paste system with enhanced radiopacity and faster setting time.[20] AH plus eliminates spaces between gutta percha points and dentinal walls by penetrating into dentinal tubules and adhesion to peritubular dentin directly. In addition, good apical sealing, optimum flow, superior biological properties and micromechanical adhesion are some of its acceptable physical properties.[21] Among different groups, Er:YAG laser irradiation following conventional irrigation (Group 3) have shown a remarkable improvement in adhesion of sealer to canal walls. Within the groups comparison was statistically significant and difference was observed between experimental and control groups (Group3> Group2> Group 4> Group1). The alternate use of EDTA and Sodium hypochlorite (Group 2) resulted in dissolution of both organic and inorganic portions of smear layer. In the present study, the higher mean values of push out bond strength were observed in Group 3 than Group 2. These findings could be justified based on the ability of laser to open dentinal tubules obliterated with remaining smear layer and tissue debris. The results obtained demonstrated significantly greater values of push out bond strength of Group 2 than Group 1 which corroborates with the earlier research done by Mc Comb and Smith.[22] The distilled water left scattered debris and smear layer on instrumented canal surfaces. This may have accounted for diminished bonding of sealer to dentin surface. Comparison between Group 1 (Distilled water) and Group 4 (Laser activation of sodium hypochlorite) showed significantly higher values for Group 4. These findings are in agreement with the previous study in which the removal of smear layer was performed with 5% Sodium hypochlorite along with Er: Cr YSGG laser that caused ablation of canal walls. The smear layer was eliminated partially owing to melting and fusion of the layer with Er: Cr YSGG laser. Sodium hypochlorite however, had little influence on the smear layer removal.[23] The observed mean bond strength values for Group 4 were found to be significantly less than Group 2. This might be justified by the fact that the irrigation with Sodium hypochlorite alone is inefficient in removing inorganic component of smear layer. However, it was successful in dissolving the necrotic tissue remnants. In the present study, significant difference was present between Group 3 and Group 4 with higher mean values obtained for Group 3. The result could have emerged due to complete elimination of debris and smear tissues by a combined approach of utilizing laser with conventional irrigation protocols. The Sodium hypochlorite irradiation with Er:YAG laser on the contrary, was ineffective in displacing the smear layer in the absence of chelating agent. The push out test was performed subjected to the fact that it closely replicates the clinical environment.[24] In the study, the Scanning Electron Microscopy (SEM) was done to assess the bond failure mode at sealer dentin interface. Other methods reported for examining interface between dentin and sealer is Confocal laser scanning microscopy (CLSM) and dye penetration tests. The mode of bond failure can be classified as adhesive (Type I), cohesive (Type II) and mixed failures (Type III).[25] Group 1 and Group 4 had adhesive bond failures. Group 2 was observed to have cohesive bond failure at the interface. Mixed bond failures (Cohesive and adhesive) were seen in Group 3. The limitations of the present study are 1) Test specimens were obtained only from middle thirds of canals. 2) The tip of Er:YAG laser in the study was end firing which resulted in ablation of smear layer more along the long axis rather than the canal walls (side firing).

CONCLUSION

Er: YAG laser irradiation supplemented with conventional irrigation regimes of NaOCl and EDTA may show promising results in improving sealer adhesion to dentin. Further investigations and long term randomized studies are required for obtaining desired results.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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