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RESEARCH ARTICLE

Comparative Evaluation of Root Canal Dentin on Efficacy of Smear Layer Removal with Nd:YAG Laser and EDTA after Rotary Instrumentation – SEM Study

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ABSTRACT

Aim: To evaluate and compare the efficacy of Ethylenediaminetetraacetic Acid (EDTA) and Neodymium-Doped Yttrium Aluminum Garnet (Nd:YAG) laser in removing smear layer on root canal dentin after rotary instrumentation.

Materials and methods: Sixty extracted maxillary incisor teeth were taken, decoronated and standardized to working length of 14 mm from the apex. All the canals were prepared with NiTi rotary files, rinsed with 1% sodium hypochlorite (NaOCl) and divided into three groups. Group 1 constituted the negative control and was rinsed with saline, group 2 with EDTA and group 3 was exposed to Nd:YAG radiation. The specimens were split longitudinally into two halves and examined under SEM with 1,000× magnification at levels of 2 and 6 mm from apical foramen. Photomicrographs were evaluated by the Hulsmann scoring system and results were tabulated. Scores 1 and 2 were grouped as clean walls and scores 3, 4 and 5 were grouped as smear layer present.

Results: Group 1 showed inefficiency in removing smear layer with only 15% clean walls in middle one-third and no clean walls in apical one-third. Group 2 (NaOCl + EDTA) showed 55% clean walls in middle one-third while 15% clean walls in apical one-third while group 3 showed 70% effectiveness in middle one-third and only 15% effectiveness in apical one-third.

Conclusion: EDTA and Nd:YAG were found more efficient in smear layer removal than saline. Results of EDTA and Nd:YAG were comparable in apical one-third while Nd:YAG was found to be more efficient than EDTA in middle one-third.

Keywords: Ethylenediaminetetraacetic acid, Neodymium-Doped:Yttrium Aluminum Garnet, Sodium hypochlorite.

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INTRODUCTION

Successful root canal therapy is attributed to effective chemomechanical preparation of the root canal system. Various instrumentation techniques leave a layer of organic and inorganic material known as smear layer, which contains debris, small particles of mineralized collagen matrix, odontogenic processes, necrotic tissue, bacteria and their by products. This is present in the canal as amorphous smear layer of 1 to 2 µm thickness with smear plugs which are impregnated up to 40 µm into dentinal tubules.[1] Whether to retain or remove the smear layer has remained a subject of controversy for long. Drake et al. proposed that this smear layer may prevent initial penetration of bacteria in the dentinal tubules.[2] However, Berutti et al. observed that this amorphous layer may harbor bacteria and proposed that removal of smear layer improved dentin permeability.[3] Studies by Ostravik and Haapasalo showed that removal of smear layer enhances diffusion of intracanal medicaments thus improvising their action.[4] Various agents like Ethylenediaminetetraacetic Acid (EDTA), MTAD, maleic acid and lasers have been proposed for removal of smear layer so that the effect of irrigants and intracanal medicaments can be maximized.

Neodymium-Doped Yttrium Aluminum Garnet (Nd:YAG) laser is useful for removal of smear layer and resulted in evaporation, melting, fusion and recrystallization of root dentin in both middle and apical third.[5] Comparative studies have shown that Nd:YAG laser beam is more effective in increasing cleanliness of root canal wall compared to conventional technique.[6] Also Nd:YAG altered the morphology of root surface and improved fluoride uptake on the root surface,[7,8] increase in power and frequency of Nd:YAG laser irradiation produced more visible morphological alterations than lower settings.[9] Studies by Lars Ramskolde, Cheng Fong et al. have shown thermal effects and antibiotic properties of energy levels required to sterilize stained root canals with Nd:YAG laser and opined that lasing cycle of 3 J/s to 15 seconds with 15 seconds interval can be continued for prolonged periods without risk of thermal damage to surrounding tissues,[10] Wan Honlan et al. evaluated temperature elevation on root surface during Nd:YAG laser irradiation at apical one-third with pulsed Nd:YAG laser at 50, 80, 100, 150 and 200 mJ/pulse and 20, 25, 30 pulses/sec and observed that temperature elevation did not exceed 10 C only when laser output was below 100 mJ/pulse and under 20 pulses/sec.[11] Matthias Folwaczny observed that Nd:YAG laser has antimicrobial effects in root canals even in the absence of photosensitizing dyes but causes considerable temperature rise.[12] On the other hand, Bergman observed antibacterial effect of Nd:YAG at 1.5 W, 15 Hz four times for 5 seconds on endodontic faecalis and proposed significant reduction

of bacterial load with 99.7% kill but no sterilization. Also three cycles of indirect laser treatment showed no morphologically intact bacteria of *Actinomycosis naeslundii* or *Streptococcus aeruginosa* and biofilms were difficult to eradicate even upon direct laser exposure.[13] Likewise on pulsed Nd:YAG exposure endodontic faecalis Gram-positive cocci displayed heat tolerance.[14]

Cheng fei Zhang studied the effects of different laser initiators on root dentin and proposed that laser treatment alone had no obvious effects on root canal wall. They observed that root canal surfaces prepared by laser with black ink or 38% $Ag(NH_3)F$ revealed melting, smear layer evaporation and open dentinal tubules and black ink was more effective than $Ag(NH_3)F$ as Nd:YAG initiator.[15] Similarly, FJHW Depraet observed that Nd:YAG laser radiation with black ink increased the amount of melted and ablated dentin areas compared with that of without black ink. Also Nd:YAG lasing in association with black ink did not result in reduction of coronal and apical microleakage in root filled teeth.[16] Park Lee observed the effects on apical leakage of obturated root canals and found that laser radiation significantly reduced apical leakage.[17] Koba studied that postoperative percussion pain was significantly less when exposed to Nd:YAG at 1 W, 15 pps, 1 second.[18] Moritz observed that construction of cell wall is crucial for individual sensitivity to laser treatment as structural damage of Gram-negative bacteria occurred at cellular level with Nd:YAG radiation while Gram-positive required repeated application of irradiation.[19] Gasp et al. demonstrated that Nd:YAG laser at high power setting of 1.5 W reduced the intensity of amide peak and thus alters chemical structure of root proteins.[20] Interestingly studies by Viducic, Jukic showed that the use of Nd:YAG laser alone is capable of softening gutta-percha and addition of solvents did not improve retreatment, either in terms of time required for procedure or in terms of area of remaining gutta-percha on root canal walls.[21]

Literature shows conflicting reports about the efficacy of Nd:YAG laser in removal of smear layer. Aric, Taclubara studied the effect of Nd:YAG, CO_2 and argon lasers and observed that there was statistically significant difference in permeability between lased groups with and without a smear layer in the cervical third of the root canal following lasing, while in the middle third all three laser types induced permeability increase in groups with a smear layer. In the apical third, statistically significant decrease in permeability was observed among CO_2 laser and Nd:YAG compared with the control group.[22] On the other hand, Bagdagul Helvacioglu studied the effect of unlased, Nd:YAG and Er:YAG lasers on root dentin and found no statistically significant difference between the groups. They thus concluded that Nd:YAG and Er:YAG were not effective in removing smear layer.[23]

The aim of present study is to compare the efficacy of removal of this smear layer using EDTA and Nd:YAG laser.

MATERIALS AND METHODS

Sixty extracted intact human maxillary incisor teeth were taken and stored in 0.1% Thymol solution at 4°C until use. Teeth were radiographed from buccal and mesial aspects to ensure closed apices and for similar root canal lengths. They were decoronated into standardized working length of 14 mm root apices were covered with sticky wax. NiTi rotary instrumentation was done with crown down technique where preparation was done up to F5 file and irrigation done with 1ml of 1% sodium hypochlorite (NaOCl). Samples were divided into three groups of 20 teeth each and irrigated with saline, EDTA and Nd:YAG laser.

Group 1: 1% NaOCl + saline (Negative control)

Group 2: 1% NaOCl + 17% EDTA solution for 1 minute

Group 3: 1% NaOCl + Nd:YAG.

Group 3 specimens were exposed to Nd:YAG (Fotona) with hand piece of 300 µm size with settings of 1.5 W, 100 ml and 15 Hz in pulsed mode. An uninitiated tip was placed in the canal 1 mm short of working length and worked in apicocoronal direction. Each specimen was irradiated four times at a speed of 2 mm/sec with 20 seconds interval between applications.

The root canals were dried with absorbent paper points and teeth were left to dry at the room temperature for 24 hours before being prepared for SEM exam. Using carborundum disks, deep grooves were cut on the buccal and palatal surfaces of the roots without perforating the canals. Roots were then split longitudinally with a chisel and a hammer. The paired halves were examined under SEM at 1,000× magnification at levels 2 and 6 mm from the apical foramen (IICT Hyderabad). Specimens were coded, gold sputtered and examined under SEM. Photomicrographs were taken at 1,000× magnification and two calibrated examiners scored the changes and smear layer removal on 5 point scale by Hulsman.[24]

Score 1: No smear layer, all dentinal tubules open

Score 2: Small amount of smear layer, some dentinal tubules open

Score 3: Homogenous smear layer covering the root canal wall, few dentinal tubules open

Score 4: Complete root canal wall covered by a homogenous smear layer, no open dentinal tubules

Score 5: Heavy homogenous smear layer covering the complete root canal wall.

Samples were coded and randomly mixed to blind the examiners and independent scorings were obtained.

RESULTS

The results are summarized in Table 1.

Table 1: Scores for the three groups at 2 mm (apical one-third) and 6 mm (middle one-third) from apical foramen

Score	Group I		Group II		Group III	
	Middle	Apical	Middle	Apical	Middle	Apical
1	0	0	2	0	3	0
2	3	0	9	3	11	3
3	8	4	6	7	5	7
4	5	7	2	7	1	8
5	4	9	1	3	0	2

All results were then grouped into 'clean canal wall' (scores 1 and 2) or smear layer present (scores 3 and 5).[25]

STATISTICAL ANALYSIS

Attributed scores were tabulated and analyzed using non-parametric Mann-Whitney U-test to determine the differences between the groups. Inter- and intraexaminer variability was done by the Kappa test.

In the control group of 20 samples, in the middle one-third, only three samples (15%) presented clean canal walls (Fig. 1) and 17 teeth (85%) showed smear layer while none of the samples showed clean walls in the apical one-third (Fig. 2). In EDTA group, at the middle one-third, 11 samples (55%) presented with clean walls (Fig. 3), while in apical one-third, only three of 20 (15%) showed clean walls (Fig. 4). In Nd:YAG laser group, 14 samples (70%) showed clean canals in middle one-third (Fig. 5), and six samples showed smear layer (30%), while in apical one-third three samples (15%) showed clean walls while 17 teeth (85%) presented with smear layer covering the dentinal walls (Fig. 6). Photomicrographs taken with SEM revealed increased number of visible dentinal tubule openings due to effective removal of smear layer in both EDTA and Nd:YAG group. Samples exposed to Nd:YAG laser showed melting, fusion and recrystallization of root dentin in both middle and apical third and these changes were more in middle one-third samples than the apical one-third.

DISCUSSION

Effective chemomechanical preparation plays a pivotal role in successful root canal treatment. The efficacy of sodium hypochlorite as a proteolytic and antimicrobial agent remains indisputable in endodontics. The dual irrigation regime of sodium hypochlorite and EDTA has been used for removing

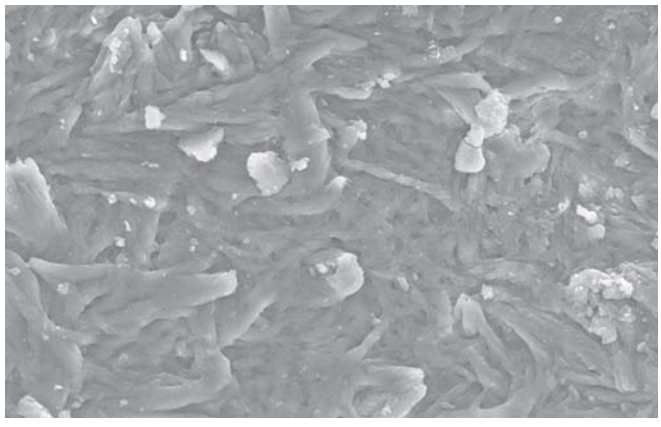

Fig. 2: Group 1—1% NaOCl and saline: SEM apical third of root canal

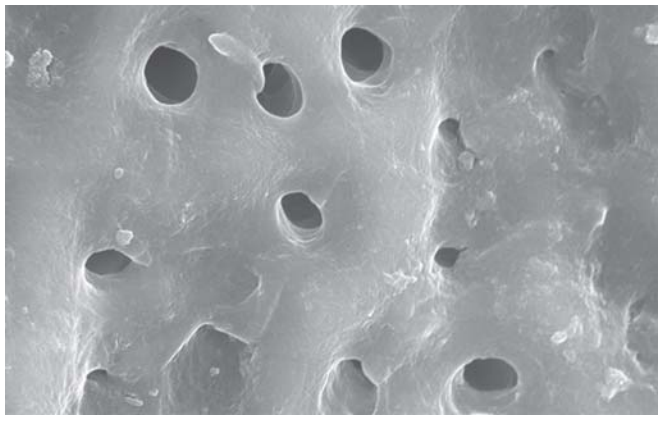

Fig. 3: Group 2—1% NaOCl and EDTA: SEM middle third of root canal

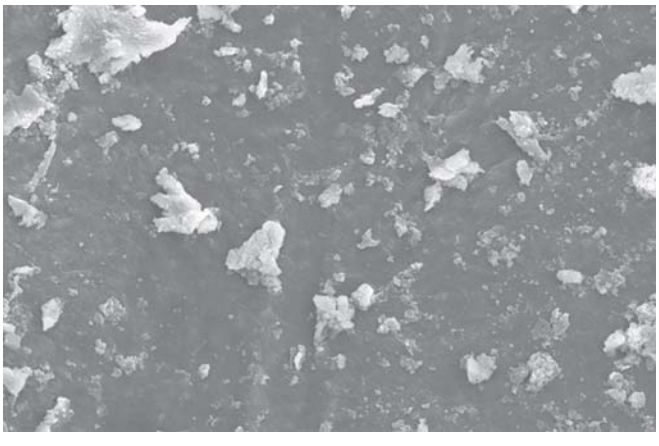

Fig. 1: Group 1—1% NaOCl and saline: SEM of middle third of root canal

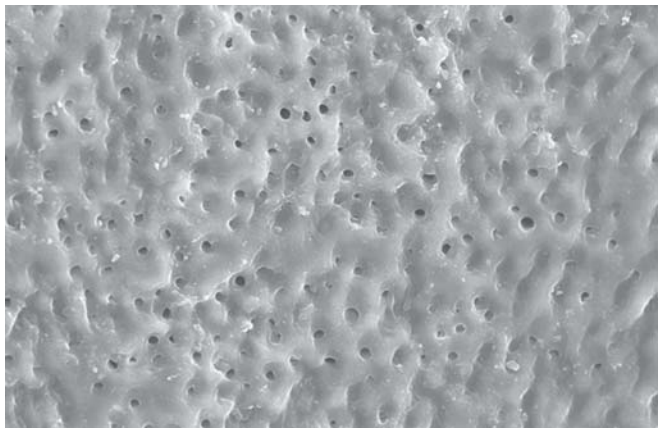

Fig. 4: Group 2—1% NaOCl and EDTA: SEM apical third of root canal

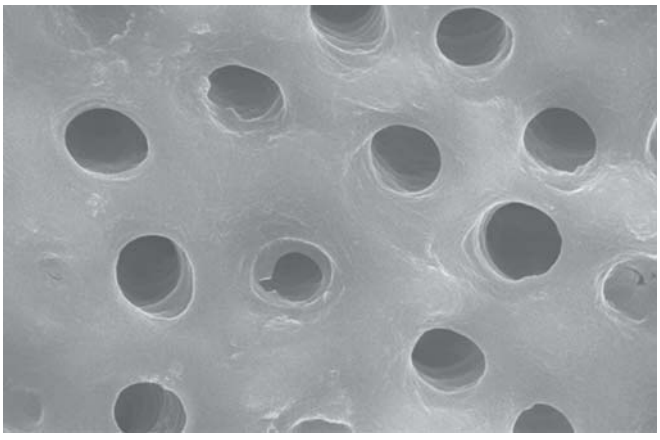

Fig. 5: Group 3—NaOCl and Nd:YAG radiation: SEM middle third of root canal

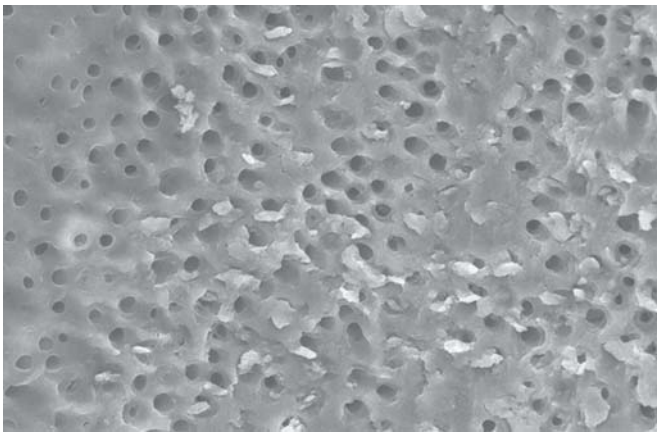

Fig. 6: Group 3—NaOCl and Nd:YAG radiation: SEM apical third of root canal

debris and smear layer for successful debridement. Taskin Gurbuz exposed root canals to different irrigating solutions like saline, 5% NaOCl, 2% CHX, H_2O_2, and EDTA along with Nd:YAG laser and lower scores for root cleaning were obtained using EDTA + Nd:YAG,[26] pumped sodium Nd:YAG slowed antibacterial effect depending on radiation frequency, however 5.25 % NaOCl is more effective.[27]

However, studies by Saeed Rahim et al. showed that 1% NaOCl along with Nd:YAG was effective even in *E. faecalis* biofilms.[28] Hence, all the samples were treated with 1% NaOCl as an irrigant during endodontic instrumentation. Also rotary instrumentation is found to generate more amount of smear layer than conventional hand instrumentation. Hence, all the root canals were prepared with Protaper rotary system and apical one-third is enlarged till F5 size to allow adequate penetration and action of irrigating solutions at the apical areas as appropriate instrumentation at the critical apical one-third of canal is considered as one of the keys to success of root canal therapy. Usman et al. demonstrated the importance of larger instruments over smaller ones in this critical apical one-third as they harbor pathogenic bacteria in this area and proposed that preparations should be enlarged to minimum of 35 to 40 size files.[29] Nevertheless clinically all the root canal morphologies do not dictate enlargement of apical one-third till F5 size file. Samples from all the three groups showed cleaner walls in the middle one-third compared to apical one-third which could be attributed to better circulation and action of irrigating solutions in this area. Nd:YAG laser is useful for removal of smear layer and resulted in evaporation, melting, fusion and recrystallization of root dentin in both middle and apical third[5] which supports our study. Nd:YAG showed better results in the middle one-third compared to the apical one-third which probably could be attributed to the tip diameter where it should be modified to reach apical one-third effectively.

CONCLUSION

EDTA and Nd:YAG were found to be more efficient in smear layer removal than saline. Results of EDTA and Nd:YAG were comparable in apical one-third while Nd:YAG was found to be more efficient than EDTA in middle one-third. Further studies with improved sample size are required to substantiate statistical significance.

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