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ORIGINAL RESEARCH

The Effect of PIPS on Three Different Types of Dentin: A Surface Observational Study

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ABSTRACT

Aim: To study the effect of 17% EDTA with PIPS on dentinal surfaces of pediatric, adolescent and geriatric teeth using scanning electron microscope (SEM).

Background data: The debriding ability of an Er:YAG laser system equipped with a new tapered and stripped tip of 400 micron diameter and auxiliary irrigating solutions after mechanical preparation.

Materials and methods: For each group, 20 single rooted human mandibular premolars were selected. The groups were categorized as group 1 pediatric, group 2 adolescent and group 3 geriatric. These groups were further divided as subgroup A (control)—saline and subgroup B—EDTA and PIPS. Access opening was done for all the samples and respective irrigation protocol was followed. The samples were then sectioned and observed under SEM.

Results: The observational study shows that the efficacy of smear layer removal was better in the pediatrics group followed by adolescent and geriatric groups.

Conclusion: The PIPS technique resulted in effective debriding and decontamination of the root canal system in all the three types of dentin.

Keywords: PIPS, EDTA, Er:YAG, SEM.

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INTRODUCTION

Debridement of the root canal by instrumentation and irrigation is considered the most important single factor in the prevention and treatment of endodontic diseases.[1] The traditional technique used mechanical instrument ultrasonics along with chemical attempt to shape, clean and decontaminate the root canal system. These techniques still could not remove all the debris and infective microorganisms. Therefore, appropriate to search for new materials, techniques and technologies that can improve the cleaning and decontamination.[2]

Among the newer technologies, the laser has been widely used in endodontics since the early 1990s.[3] Studies reported that near infrared lasers are highly efficient in disinfecting the root canal surfaces and dentinal walls (up to 750 microns with the 810 nm diode laser and up to 1 mm with the 1064 nm Nd:YAG laser). On the other hand, these wavelengths did not show effective results in debriding and cleansing the root canal surfaces and also caused characteristic morphological alterations of the dentinal wall. The smear layer was only partially removed and the dentinal tubules primarily closed as a result of the melting of inorganic dentinal structures.[4]

Recent studies have reported how the use of an Er:YAG laser, equipped with the newly designed radial and stripped tip, used along with 17% EDTA solution, using a very low pulse duration (50 microseconds) and low energy (20 mJ) resulted in effective debris and smear layer removal with minimal or no thermal damage to the organic dentinal structure through a photoacoustic technique called photon induced photoacoustic streaming or 'PIPS™'.[5,6] Based on the available literature, this study was formulated to evaluate the efficiency of 17% EDTA with PIPS on the dentinal surface of three different age groups.

MATERIALS AND METHODS

A total of sixty freshly extracted, single rooted human teeth were selected for the study. The teeth were selected based on the age groups and categorized as: Group 1 (n = 20)—pediatric (primary teeth), Group 2 (n = 20)—adolescent (teeth from patients aged 15-21 years), group 3 (n = 20)—geriatric (teeth from patients aged above 60 years). Access opening was done for all the specimens. The patency was established using a #10 k-file and it was confirmed by the appearance of the file at the root apex. Working length was determined, root canals were prepared using the hand Protaper files up to F3. Canals were irrigated with 2 ml of saline between file sizes.

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These groups are further divided based on the irrigating systems as follows:

- Subgroup A (control group) was hand activated for 40 seconds in saline solution-wetted canal.
- Subgroup B was laser-irradiated using PIPS for 40 seconds in 17% EDTA-wetted canal. Laser settings were 20 Hz, 40 mJ, with air/water spray off.

During laser irradiation, the root canals were continuously irrigated with 2 ml of 17% EDTA to maintain hydration and fluid levels using a 25-gauge needle in a sterile syringe. The laser tip was positioned in the coronal aspect of the tooth. The prepared samples were then sectioned longitudinally and examined with a scanning electron microscope (SEM).

OBSERVATION AND RESULTS

The images were analyzed by three observers evaluated the amount of remaining smear layer. SEM images at magnification 4000× were used for this quantitative assessment (Figs 1 to 6). A mean smear layer score was calculated for each specimen, according to the scoring system proposed by Torabinejad et al.

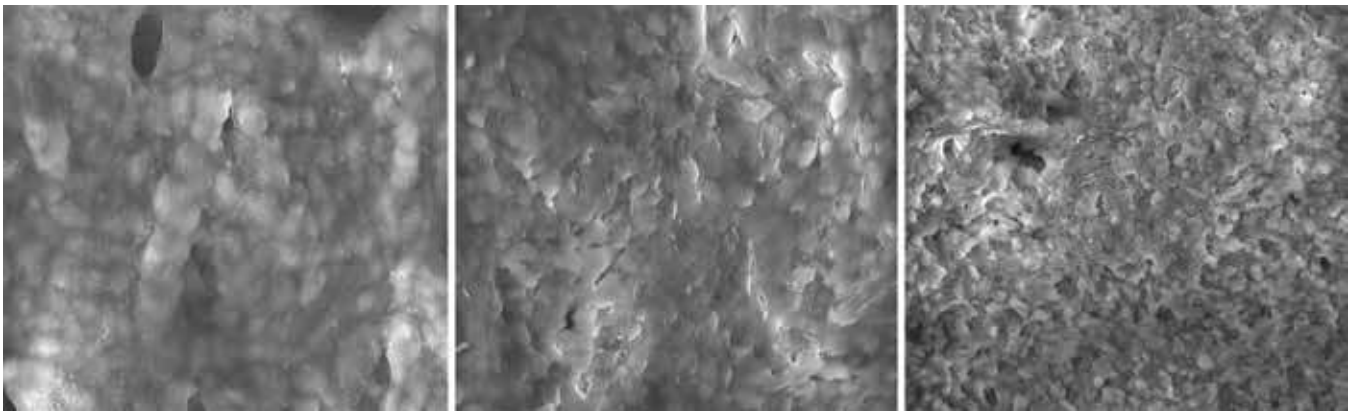

Fig. 1: Group 1A: saline (control group); pediatric teeth: SEM images of coronal third—heavy smear layer, score 2 middle third—heavy smear layer, score 2 apical third—heavy smear layer, score 2

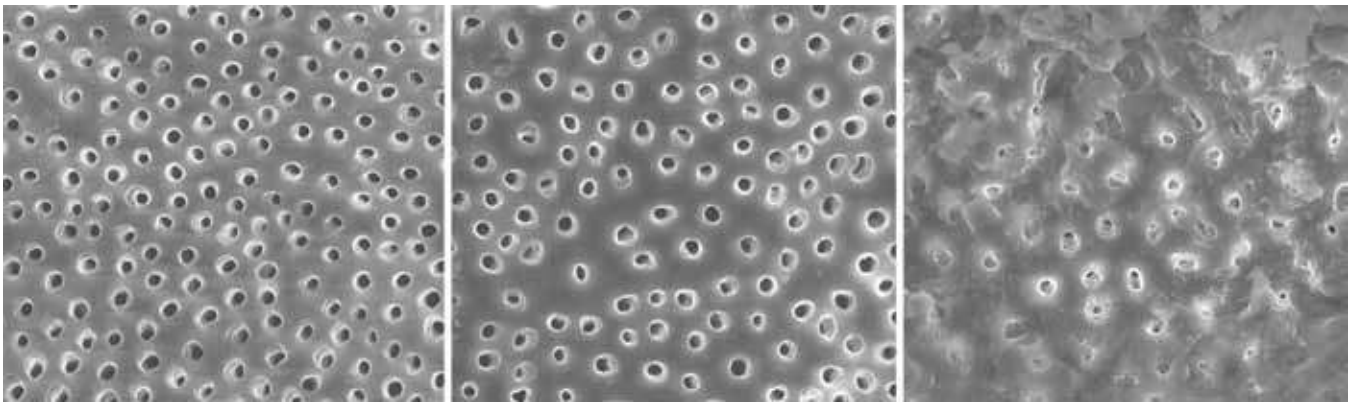

Fig. 2: Group 1B: PIPS group; pediatric teeth: SEM images of coronal third—no smear layer, score 0 middle third—no smear layer, score 0 apical third—no smear layer, score 0

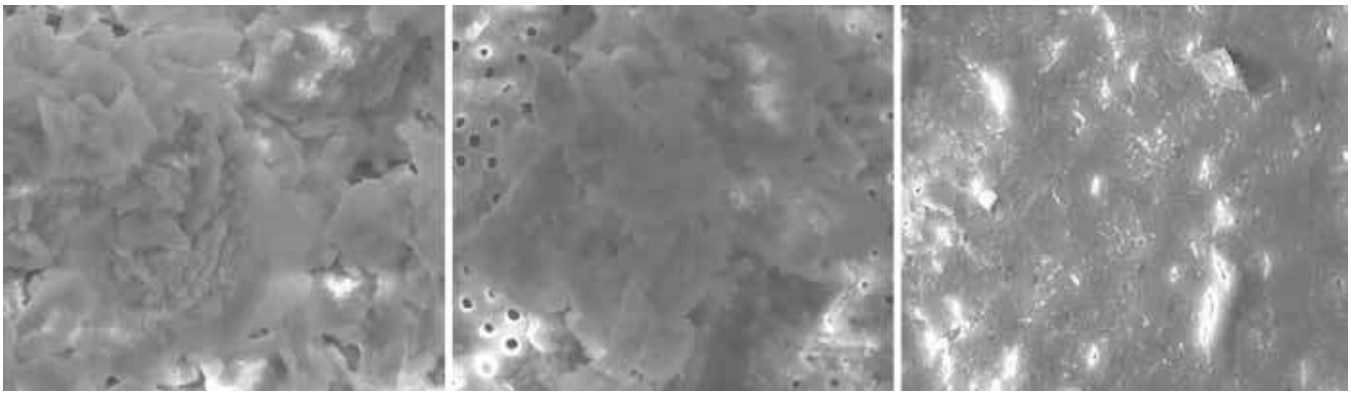

Fig. 3: Group 2A: saline (control group); adolescent teeth: SEM images of coronal third—heavy smear layer, score 2 middle third—moderate smear layer, score 2 apical third—moderate smear layer, score 2

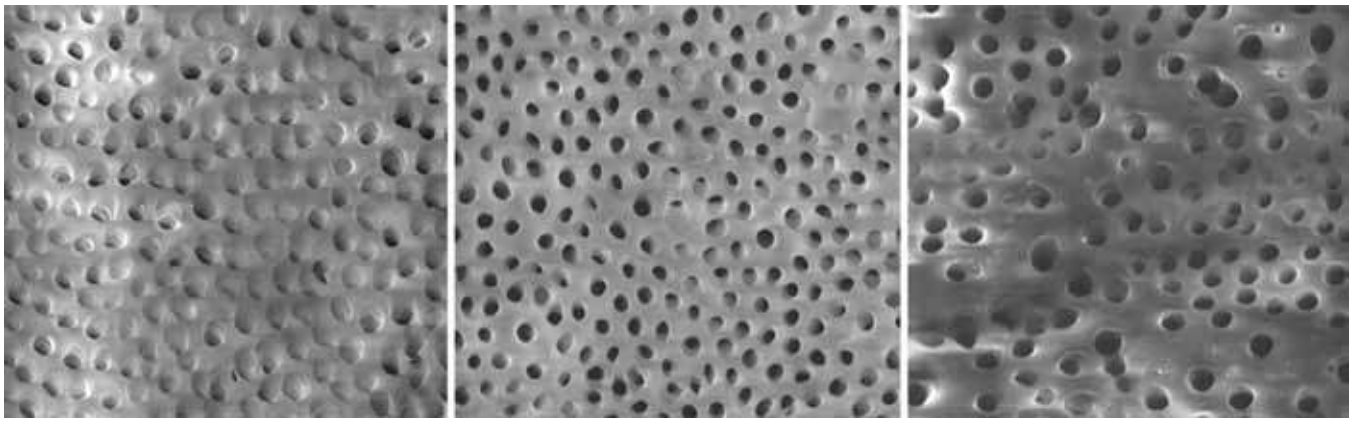

Fig. 4: Group 2B: PIPS group; adolescent teeth: SEM images of coronal third—no smear layer, score 0 middle third—moderate smear layer, score 0 apical third—no smear layer, score 0

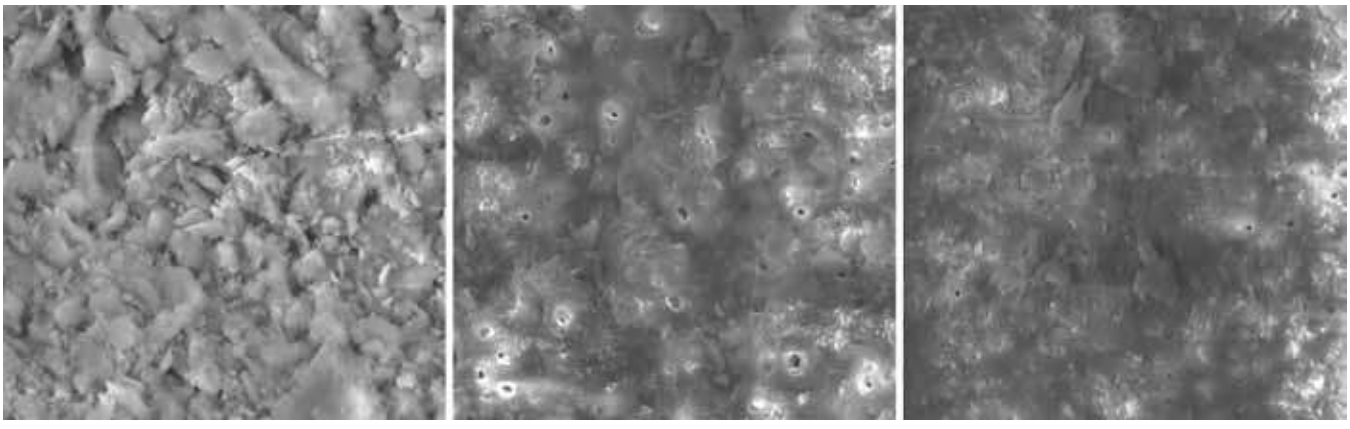

Fig. 5: Group 3A: saline (control group); geriatric teeth: SEM images of coronal third—heavy smear layer, score 2 middle third—moderate smear layer, score 2 apical third—moderate smear layer, score 2

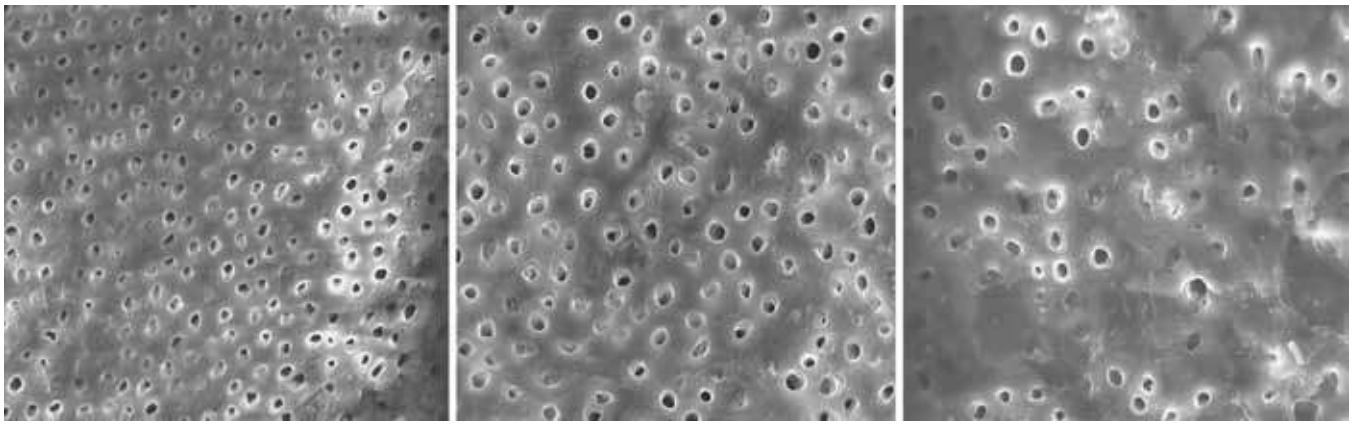

Fig. 6: Group 3B: PIPS group; geriatric teeth: SEM images of coronal third—no smear layer, score 0 middle third—no smear layer, score 0 apical third—no smear layer, score 0

0—no smear layer, no smear layer on the root canal surface, with all the tubules clean and open; 1—moderate smear layer; 2—heavy smear layer, smear layer covers the root canal surface and the tubules.

DISCUSSION

In this study, teeth of three different age groups were used—the primary dentition, the adolescent dentition and the geriatric dentition. Many morphological changes take place in the dental pulp. Gradually, pulp becomes smaller through environmental effects and aging which have been concluded in several studies of dentin formation and calcifications.[7,8] The different types of dentin—primary, secondary and tertiary dentin.[9] However, the changes in the histological and physiological characteristics of dentin in relation to age is not thoroughly documented. Hence, the efficacy of smear layer removal in this study was compared between the pediatrics group, adolescent and geriatric groups.

Whittaker and Kneale[10] have studied mineralizing front at the dentin—predentin interface in human teeth. The younger teeth are almost or completely fused in terms of shape of calcospherites (ultimate fusion of many centers of calcification). Even in older teeth though the shape of calcospherites in the coronal part of the pulp cavity had a similar appearance to that of the younger teeth. In the mid-root and apical-root areas, the appearance of calcospherites was replaced with a less regular surface and fewer tubules.

The most commonly used irrigant in endodontics is sodium hypochlorite because it has bactericidal properties and causes tissue dissolution.[11,12] Among other substances used for this purpose, EDTA has been superior in the removal of the smear layer in comparison with other substances in the final irrigation,[13-17] justifying its use in the present study. In a study by Calt and Serper it was concluded that 10 minutes application of 10 ml of 17% EDTA caused excessive peritubular and intertubular dentinal erosion when compared with irrigation with for 1 minute which was effective in removal of smear layer.[18-20] Baumgartner, Mader and Abbott et al observed an effective cleaning action on coronal, middle and apical thirds even when different quantities of solutions and times of irrigation were employed.[21,22] Results for the apical third agree with those of other studies done by Goldman et al, Barkhordar et al, O'Connell et al, Calt and Serper which showed that it is difficult to remove the smear layer in the apical region.[23,24] Garberoglio and Becce, although noticed that the presence of smear plugs in some of the specimens, they reported that using EDTA for 30 seconds cleaned the apical third.[25] In the present study, there was no smear layer appreciated in all the three levels, i.e. coronal, middle and apical third on using PIPS.

This study introduced several modifications to the commonly used laser-assisted techniques and protocols, to reduce the thermal effect of laser radiation on dentinal walls. FDA has approved Erbium:Yttrium-Aluminum-Garnet laser (Er:YAG, 2940 nanometer wavelength) for cleaning, shaping and enlarging of the root canal. Previous studies tested the ability and the effects of this laser on root canal walls and indicated that the Er:YAG laser is a suitable instrument for removal of the smear layer in root canals.[26-32] Furthermore a 2008 paper, investigated the ability of both Er:YAG and Er,Cr:YSGG lasers equipped with conical shaped radially firing tips and plain tips, for removing smear layer from the apical third; the results showed a laser activation of EDTA and a better performance of conical fibers compared to plain fibers for improving the action of EDTAC in dissolving smear layer.[33] In traditional irrigation protocols, syringe tip is placed closer to working length. Using this new laser system, the laser tip was not placed within the canals themselves. Tips are confined to the coronal chamber above the access opening which allows easy access for the photomechanical effects to occur within the root canal for cleaning of root canals.

The Er:YAG laser equipped with a novel 400 micron diameter radial and stripped tip using a subablative parameters of average power 0.3 W, 20 mJ at 15 Hz is proved to be effective at removing the smear layer. A possible explanation for this finding could be contributed when light energy is pulsed in liquid is seen with photomechanical effect.[34-36] In fact, a profound 'shockwave-like' effect was observed when radial and striped tips were submerged in a root canal which is filled with liquid; due to very small volume this may remove the smear layer and decrease the bacterial load within the root canal system.[37-39]

We speculate that this phenomenon is responsible for the removal of smear layer in PIPS group, in which laser irradiation was combined with EDTA have an effect on smear layer removal. With the usage of lower subablative energy (20 mJ) and restricted placement of the tip to within the coronal portion of the orifice, the undesired effects of the thermal energy were avoided.[27-32] The SEM images verified the efficient and minimally disruptive effects on the canal walls, dentinal tubules and even on the hydroxyapatite surfaces. No thermal damage was found in PIPS treated samples in the adolescent and the geriatric groups, whereas melting of the dentinal surface has been observed in the apical third of the pediatric group.

CONCLUSION AND SUMMARY

The findings of our studies on SEM analysis demonstrated that:

The efficacy of smear layer removal was better in the pediatrics group followed by adolescent and geriatric groups.

Within the study group, there was no smear layer appreciated in all the three levels, i.e. coronal, middle and apical third on using PIPS.

The PIPS technique resulted in effective debriding and decontamination of the root canal system.

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