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ORIGINAL RESEARCH

Effect of Smear Layer on the Apical Seal of Endodontically Treated Teeth: An *ex vivo* Study

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ABSTRACT

Aim: The purpose of this study was to evaluate the effect of smear layer on apical seal of endodontically treated teeth.

Materials and methods: Sixty freshly extracted human maxillary central incisor teeth were selected and were randomly divided into two experimental groups. Group A of 25 teeth and group B of 25 teeth and a control group of 10 teeth. Cleaning and shaping of the root canals were performed using endodontic K-files up to no. 50 size file in step-back technique. During the process, in root canals of group A, 17% EDTA (ethylenediamine-tetraacetic acid) followed by 3% NaOCl (sodium hypochlorite) was used as root canal irrigant.

In group B, MTAD (mixture tetracycline citric acid and detergent) was used as a root canal irrigant.

In control group, saline was used as root canal irrigant. The root surfaces were then coated with nail polish of both experimental groups and control group. The samples were then immersed in India ink dye for 1 week at 37°C.

Results: The statistical analysis of the results showed that the apical leakage was significantly more in teeth, where smear layer was not removed.

Conclusion: The removal of smear layer improves the long-term apical seal and success of endodontically treated teeth.

Clinical significance: The development and maintenance of apical seal is desirable and considered to be a major prerequisite to improve the outcome of root canal treatment.

Keywords: Apical seal, EDTA, Sodium hypochlorite, Smear layer.

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INTRODUCTION

The ultimate goal of root canal instrumentation and use of irrigating solutions is to prepare a clean, bacteria and debris free canal for three-dimensional obturation. Most failures of root canal treatment are caused by percolation of fluid from inflamed periapical tissues into improperly obturated root canals.[1]

Allen[2] and Strindberg[3] have shown that incomplete seal of the root canal system is one of the most important causes of long-term treatment failures and they propose a fluid-tight seal for the entire root canal system.

Mc Comb et al[4] reported the formation of smear layer over the surfaces of instrumented root canal walls. Smear layer is an amorphous, irregular entity containing organic (pulp tissue, bacteria) and inorganic (dentin) material.

The removal of smear layer has been the subject of controversy for several years. The smear layer contains bacteria and bacterial by products and, thus, it must be completely removed from the root canal system.[5]

Haapasalo et al[6] suggest that removal of the smear layer can allow intracanal medicaments to penetrate the dentinal tubules in infected root canals more readily and consequently cause a better disinfection procedure. It also has been suggested that smear layer may prevent the complete locking and adherence of root canal filling materials into the dentinal tubules.[4]

The aim of the present study was to evaluate the effect of smear layer on the apical seal of endodontically treated teeth.

MATERIALS AND METHODS

Sixty freshly extracted, intact human maxillary central incisor teeth were collected from the Department of Oral Surgery, Purvanchal Institute of Dental Sciences, Gorakhpur. Inclusion criteria: Noncarious, nonfractured, nonrestored, straight, single-rooted teeth. Exclusion criteria: Carious, fractured, curved, restored and multirooted teeth. After cleaning the teeth of all calculus and surface deposits,

the teeth were stored in 10% neutral formalin until used and the selected specimens were used within a month of extraction and storage.

All teeth were radiographically investigated to ensure that they have single canal and there is no calcifications. All the teeth were decoronated with a diamond disk using a low speed straight handpiece at the level of cementoenamel junction. Access opening was prepared using a No. 2 endo access bur (Dentsply, Tulsa, Okla) and canals were located. Working lengths for all the teeth were determined using a size 10 K-file (Dentsply/Maillefer, Tulsa, Okla) and radiographs were taken and recorded.

Before instrumentation, samples were randomly divided into two experimental groups; group A of 25 teeth and group B of 25 teeth and a control group of 10 teeth. Cleaning and shaping of the root canals were performed using endodontic K-files (Dentsply, Tulsa, Okla) up to No 50 size file in step-back technique in circumferential filing motion to ensure standardization.

During the process of cleaning and shaping of root canals, in experimental group A, 17% EDTA and 3% NaOCl were used alternatively as root canal irrigant.

In experimental group B, MTAD (mixture tetracycline citric acid and detergent) was used as a root canal irrigant, whereas in control group, saline was used as root canal irrigant.

After completion of the instrumentation, root canals of both experimental and control groups were dried with absorbent paper points (Dentsply-Maillefer, Okla) and then obturated with gutta-percha (Dentsply-Maillefer, Okla) in lateral condensation technique using AH-Plus sealer (Dentsply-Maillefer, Okla).

The coronal seal was obtained using Cavit-G as temporary restorative material with a minimum thickness of 3 mm and allowed to set according to manufacturer's instructions. Then the surfaces of all the teeth except the apical 3 mm were sealed using two coats of nail polish and one coat of sticky wax.

All the teeth were then immersed in India ink dye and in the dye solution the teeth were kept in incubator at 37ºC for 1 week. After the time period of immersion, the teeth were removed from the dye and they were thoroughly rinsed under running tap water, dried and the nail polish was completely removed with a scalpel. The teeth were longitudinally sectioned with a diamond separating disk and gutta-percha and filling materials were removed from the root canals.

The linear dye penetration was measured using a stereomicroscope in one tenth of millimeters. Average dye penetration was calculated for each group and statistical analysis was performed using independent sample t-test.

RESULTS

Statistical Results

Stereomicroscopic analysis was done to analyze the degree of dye penetration. The statistical analysis was done using independent sample t-test.

Maximum and minimum dye penetration in group A were 3.1 and 0.4 mm respectively with the average dye leakage of 1.56 mm. Maximum and minimum dye penetration in group B were 1.8 mm and zero mm respectively with the average dye leakage of 0.65 mm. Maximum and minimum dye penetration in control group was 4 and 2 mm respectively with the average dye leakage of 3 mm (Table 1).

There was significant difference in the degree of dye penetration between the experimental groups of A and B with that of the control group as (p-value = 0.001). Group B showed significantly better apical seal compared to group A and control group.

DISCUSSION

The purpose of the obturation phase of endodontic treatment is to prevent the reinfection of root canals that have been biomechanically cleaned, shaped and disinfected by instrumentation, irrigation and medication procedures.[8,21] Successful obturation requires the use of materials and techniques capable of densely filling the entire root canal system and providing a fluid-tight seal from the apical segment of the canal to the cavosurface margin in order to prevent reinfection.[22]

Smear layer is one of the major factor that may affect the apical microleakage and thus compromise the long-term success of the treatment.[9,10] It is a thin film composed of organic and inorganic portions, and is produced during canal instrumentation.[7] Should the smear layer be preserved, modified or completely eliminated during instrumentation, is a subject of controversy.

The purpose of the irrigation is to remove the smear layer from instrumented canal walls. Irrigation with EDTA alone can only remove the inorganic portion of smear layer.[11] Therefore, to eliminate smear layer completely, it should be combined with an organic solvent, such as NaOCl.[12-14] On the other hand, using sodium hypochlorite

Table 1: Mean dye penetration of different groups

Groups (experimental and control)	*Root canal irrigants used*	*Mean dye penetration (mm)*
Group A (experimental)	17% EDTA + 3% NaOCl	1.56
Group B (experimental)	MTAD	0.65
Group C (control)	Normal saline	3.00

p-value: 0.001

alone for irrigation produces clean canal walls having the smear layer still present.[13]

Yang et al[15] showed that in removing the smear layer, there was no significant differences between saline and NaOCl irrigation. These results indicate that to remove the smear layer efficiently NaOCl (organic tissue dissolving activity) should be coupled with a chelating agent, such as EDTA. The later removes the calcium ions from dentin, forms calcium combinations and decalcifies dentin around the tubules. Considering studies by the Baumgartner et al[13] and Yamada et al[14] for efficient and complete removal of smear layer.

In the present study of group A, 3% NaOCl and 17% EDTA were alternatively used as root canal irrigants during instrumentation, but the average dye leakage values in group A were more compared to group B, as the smear layer was not totally eliminated in group A, whereas in group B, MTAD was used as the root canal irrigant during root canal instrumentation, as their was complete removal of smear layer the average leakage values were less compared to group A and control group.

The recent introduction of Biopure MTAD (Dentsply, Tulsa, OK), an endodontic irrigant, which represents an innovative approach in simultaneous removal of endodontic smear layer and complete disinfection of root canals.

It is commercially available as Powder-Liquid system. Part A is liquid and is supplied in syringes (5 ml, 20 ml single, multiple doses). It contains 4.25% citric acid and 0.5% polysorbate 80 detergent (Tween 80). Part B is powder supplied in bottles (single, multiple doses-150 mgs, 600 mgs).[16] It contains doxycycline hyclate which is a broad spectrum antibiotic effective against a wide range of microorganisms.

Its low pH 2.15 contributes to its role as a calcium chelator, thereby causing root surface demineralization thus helps in the removal of smear layer.[17]

Tween 80 (polyoxyethylene sorbitan monooleate) is a detergent present in MTAD and is a nonionic surfactant, helps in reducing the suface tension of the root canal irrigant, thereby enhancing the flow and penetration of irrigating solutions like MTAD deeper into the dentinal tubules. It has a pH of 7.0 and is a biologically acceptable material.[18]

There is statistical significant difference in the dye leakage values of group B (Fig. 1) with that of group A (Fig. 2) and control group (Fig. 3).

Different methods, such as electrochemical, radioisotope spectrometry, radiolabeled isotopes and apical leakage techniques, have been introduced for evaluating the apical seal. Because of its simplicity, dye leakage studies are one of the most widely used tests. If the unwanted variables are eliminated and the experimental conditions are standardized, dye leakage studies prove valid.[19] Since, dye molecules are much smaller than bacteria, studies using dye leakage method may be less applicable to *in vivo* conditions compared to bacterial leakage techniques.

The hypothesis of this study shows, when MTAD was used as the root canal irrigant during instrumentation, smear layer was completely eliminated with effective demineralization of peritubular dentin[23] thus leaving the dentinal tubules widely open helping for better penetration

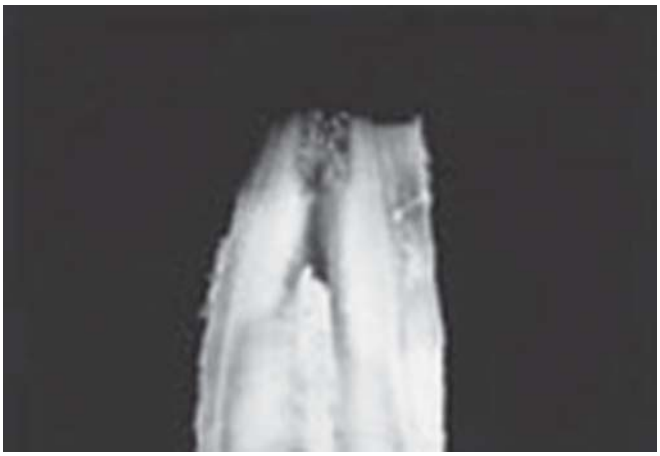

Fig. 1: Group B: Minimal dye leakage is seen

Fig. 2: Group A: Maximum dye leakage is seen

Fig. 3: Control group: Maximum dye leakage is seen

of root canal irrigants and for mechanical locking of sealer into dentinal tubules thus increasing the adhesion surface area between walls of the root canal and endodontic filling materials.[24] As in the present study apical seal is significantly increased when smear layer is removed.

Due to variations in the experimental conditions and lack of standardization of the protocols, these kind of studies are not completely and exactly comparable with each other. Furthermore, Pommel et al[20] showed that there is a lack of correlation among methods (fluid filtration, electrochemical, dye penetration) of evaluating apical leakage.

CONCLUSION

The results of this *ex vivo* study show that removal of smear layer before obturation of the root canal system improves the apical seal significantly. Further *in vivo* studies are required before drawing any definite conclusion regarding the efficiency of MTAD as a root canal irrigant in clinical situations for the removal of smear layer.

REFERENCES

1. Ingle John I, Bakland Leif K. Textbook of Endodontics (5th ed). Chapter 10: Endodontic cavity preparation: 503-05.
2. Allen DE. Hermetic sealing of root canals, value in successful endodontics. J Dent Radiogr Photogr 1964;37:85-90.
3. Fukumoto Y, Kikuchi I, Yoshioka T, Kobayashi C, Suda H. An ex vivo evaluation of a new root canal irrigation technique with intracanal aspiration. Int Endod J 2006;39:93-99.
4. Grossman L. Endodontic Practice. Philadelphia, Lea and Febiger 1981;10:279.
5. Pashley DH, Michelich V, Khel T. Dentin permeability: Effects of smear layer removal. J Prosthet Dent 1981;46:531-37.
6. Haapasalo M, Orstavik D. In vitro infection and disinfection of dentinal tubules. J Dent Res 1987;66:1375-79.
7. Vojinovic O, Nyborg H, Brannstrom M. Acid treatment of cavities under resin fillings: Bacterial growth in dentinal tubules and pulpal reactions. J Dent Res 1973;52:1189-93.
8. Kennedy WA, Walker WA, Gough RW. Smear layer removal effects on apical leakage. J Endod 1995;12:21-27.
9. Evans JT, Simon JHS. Evaluation of the apical seal produced by injected thermoplasticized gutta percha in the absence of smear layer and root canal sealer. J Endod 1986;12:101-07.
10. Mader CL, Baumgartner C, Peters DD. Scanning electron microscopic investigation of the smear layer on the root canal walls. J Endod 1984;7-10:477-83.
11. Hoen MM, Pink, Frank E. Contemporary endodontic retreatments: An analysis based on clinical treatment findings. J Endodon 2002;28:834-36.
12. Gettleman BH, Messer H, ElDeeb ME. Adhesion of sealer cements to dentin with and without the smear layer. J Endod 1991;17:15-20.
13. Farhad A, Elahi T. The effect of smear layer on apical seal of endodontically treated teeth. Journal of Research in Medical Sciences 2004;3:130-33.
14. Yamada RS, Armas A, Goldman M, Lin PS. A scanning electron microscopic comparison of a high volume final flush with several irrigating solutions. J Endod 1983;2(9):137-42.
15. Yang SE, Bae KS. Scanning electron microscopy study of the adhesion of prevotella nigrescens to the dentin of prepared root canals. J Endod 2002;6:433-37.
16. Mahmoud Torabinejad, Yongbum. The effect of various concentrations of sodium hypochlorite on the ability of MTAD to remove the smear layer. J Endod 2003:29(4):233-40.
17. Fugen Tasman, Cehreli Zafer C. Surface tension of root canal irrigants. J Endod 2000;26(10):586-87.
18. Marvan Abou-Rass, Patonai Frank J. The effects of decreasing surface tension on the flow of irrigating solutions in narrow root canals. Oral Surgery 1982;4(5):524-26.
19. Roig M, Ribot J, Jane L, Canalda C. Evaluation of the apical leakeage by fluid filtration method following obturation. An in-vitro study. J Endod 1996;14:21-27.
20. Pommel L, Jacquot B, Camps J. Lack of correlation among three methods for evaluation of apical leakage. J Endod 2001;5: 347-50.
21. Chugal NM, Clive JM, Spångberg LSW. Endodontic infection: Some biologic and treatment factors associated with outcome. Oral Surg Oral Med Oral Pathol Oral Radio and Endod 2003;96:81-90.
22. Sjogren U, Hagglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodontic treatment. J Endodon 1990;16:498-504.
23. Tay FR, Dai L, Khan S, Gillen B, Loushine B, Wimmer C, et al. The effect of QMix, an experimental antibacterial root canal irrigant, on removal of canal wall smear layers and debris. J Endod 2011;37:80-84.
24. Tay FR, Gutmann JL, Pashley DH. Microporous, demineralized collagen matrices in intact radicular dentin created by commonly used calcium-depleting endodontic irrigants. J Endod 2007;33: 1086-90.

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