Original Article

The Effect of Smear Layer on Apical Seal of Endodontically Treated Teeth

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Abstract

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

Methods: Sixty extracted single–rooted human teeth were randomly divided into two experimental groups (n=25) and two control groups (n=5). The teeth were instrumented with K–type files to size 40 and then flared. Apical patency was ensured in all teeth. 5% sodium hypochlorite and 17% Ethylenediamine tetraacetic acid was used as irrigants to remove the smear layer in the second experimental group. The experimental groups were obturated by laterally condensed gutta – percha with Roth 801 sealer. The positive control group was obturated with gutta – percha without sealer. The root surfaces were then coated with nail polish and sticky wax except for the apex in the experimental groups and positive control group. The roots were completely covered in the negative control group. The samples were then immersed in India ink for 1 week at 37°C.

Results: The statistical analysis of the results showed that the apical leakage was significantly increased in obturated canals with smear layer.

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

Key words: Apical Seal, EDTA, Removal, Sodium Hypochlorite, Smear Layer.

The ultimate aim of root canal instrumentation and irrigation is to prepare a clean, bacteria and debris – free canal for obturation. Ingle[1] believes most unsuccessful cases of root canal treatment are caused by percolation of fluid from inflamed periapical tissue into improperly obturated canals. 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 and Smith[4] reported the formation of a layer of sludge material (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. Pashley et al[5] believe that smear layer contains bacteria and bacterial by-products and thus it must be completely removed from the root canal system. 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]. On the other hand, smear layer may prevent unwanted bacterial activities by sealing the bacteria into the dentinal tubules; it also blocks the entry of bacteria in contaminated canals into the dentinal tubules, thus acting as a barrier against the free movement of bacteria into or out of open dentinal tubules[7].

The aim of this in vitro study was to assess the effect of smear layer on apical seal of endodontically treated teeth.

Materials and Methods

60 freshly extracted human teeth (maxillary centrals and canines, mandibular premolars) were selected

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for this experiment. The teeth had the following characteristics: (1) All had single canal, (2) The roots did not have fractures, caries, and open or resorbed apices and (3) All roots were straight or had slight curvature (5° to 10°). In order to clean the surface of the teeth, they were placed in 5% sodium hypochlorite for 1 week. All teeth were radiographically investigated to ensure that they have single canal and there is no calcifications. The teeth crowns were separated at CEJ using a diamond disk. Using a number 10 k-file (Mani- Japan) and rubber stop the working length was determined for each root. Before instrumentation, samples were randomly divided into two experimental groups (group A and B, 25 each) and two control groups (5 each). To ensure standardization, all roots were filed to a number 40 k- file, and the coronal part was flared to number 60 k- file using step back technique. A number 10 k-file was used to ensure apical patency between each file used for filing and flaring. Normal saline was used as irrigant during instrumentation of canals in group A (with smear layer) and control groups. In group B (without smear layer) to eliminate the smear layer, 5% sodium hypochlorite (NaOCl) was used during instrumentation of canals and in completion each canal was irrigated with 10 ml of 5% NaOCl, 10 ml of 17% Ethylenediamine tetraacetic acid (EDTA) and 10 ml of 5% NaOCl. After completion of the instrumentation phase, the canals in groups A and B were dried with paper points and then obturated laterally using number 40 gutta-percha as master cone and number 25 gutta-percha as accessory cones (Aria Dent-Iran). Roth 801 (Roth International LTD- USA) was used as sealer in this experiment. After obturation phase, the coronal 2-3 mm of each canal in groups A and B was sealed using Citodur temporary filling. To ensure setting of the sealer, the samples in groups A and B were separately placed in glass containers and were kept in 100% humidity with 37°C temperature for 48 hours. Then all surfaces of the teeth except for the 2-3 mm of apical root were sealed using two coats of nail polish and one coat of sticky wax. The remaining ten roots were randomly divided into two groups of five for positive and negative controls. In the positive control group, the canals were dried and obturated without using sealer; all surfaces except for the 2-3 mm of apical root were sealed with nail polish and sticky wax. In the negative control group, canals were dried and obturated with gutta- percha and sealer; all surfaces of the teeth including the 2-3 mm of apical root were completely sealed with nail polish and sticky wax. The teeth in the two experimental groups (A and B) and the two control groups were placed in India ink and kept in incubator for 1 week. After removing the samples from the incubator, they were thoroughly washed with water and the nail polish and sticky wax were eliminated from the surfaces. A diamond disk was used to make buccal and lingual grooves on the root surfaces; using a spatula the roots were separated into two parts and the gutta-percha and filling materials were removed from the canals. The linear dye penetration (maximum point) was measured using a stereomicroscope in one tenth of millimeters. Average dye penetration was calculated for each group and statistical analysis (independent sample t-test) was performed.

Results

In the positive control group, the dye were leaked throughout the canal in all samples. In the negative control group, penetration of dye was not observed in any of the samples. Maximum and minimum dye penetration in group A (with smear layer) were 3.1 mm and 0.4 mm respectively (the average dye leakage was 1.56 mm). Maximum and minimum dye penetration in group B (without smear layer) were 1.8 mm and zero respectively (the average dye leakage was 0.65 mm). There was a significant difference in dye penetration between group A (with smear layer) and B (without smear layer). The experimental group without smear layer had a significantly better apical seal compared to the experimental group with smear layer.

Discussion

A three dimensional obturation and a complete coronal and apical seal is one of the important aims of root canal treatment. Since microorganisms may remain in the root canal system after instrumentation, a tight apical seal is desired to prevent bacteria and their by – products from invading the apex. Smear layer is one of the factors that may affect the apical microleakage and thus compromise the long term success of the treatment. This layer is a thin film composed of organic and inorganic portions, and is produced during canal instrumentation. Whether smear layer should be preserved or

eliminated during instrumentation is a subject of controversy. Kennedy et al[8] reported that removal of the smear layer reduced the apical microleakage and might improve the obturation seal. Evans et al[9] showed that smear layer had no significant effect on apical microleakage. The factors that may be considered in obtaining these conflicting results are: technique of instrumentation, type of sealer used, sealer thickness, type of filling technique, type and concentration of chelating agents used, and the technique used to remove the smear layer. Since the smear layer blocks the dentinal tubules and prevents sealer cements and filling materials from adhesion to the dentin[10, 11, 12], in the present investigation it was decided to remove this layer in one of the experimental groups and thus show its effect on the apical seal.

One 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. Therefore to eliminate smear layer completely, it should be combined with an organic solvent such as NaOCl[13, 14]. On the other hand, using sodium hypochlorite 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 irrigation 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 ion 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, alternate irrigation with 5% NaOCl and 17% EDTA was used.

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[16]. 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 experiment was that removing the smear layer and the demineralization of peritubular dentin leaves the dentinal tubules widely open causing the penetration and mechanical locking of sealer into dentinal tubules and increasing the adhesion surface area between canal walls and filling materials. This hypothesis is supported by the result of the present study which shows that apical seal is significantly increased when smear layer is removed. The studies published in literature to date report similar and often conflicting results compared to the results obtained in this investigation[8, 9]. In fact, due to variations in the experimental conditions and lack of standardization of the protocols, these kinds of studies are not completely and exactly comparable with each other. Furthermore, Pommel et al[17] showed that there is a lack of correlation among methods (fluid filtration, electrochemical, dye penetration) of evaluating apical leakage.

In summary, the results of this in vitro study shows that removing the smear layer before obturation of the root canal system improves the apical seal. Further comparable in-vivo researches are needed before drawing any definite conclusions.

References

1. Ingle JI. Endodontics. 2 nd ed; Philadelphia: lea & Febiger, 1976; 43.
2. Allen DE. Hermetic sealing of root canals, value in successful endodontics. Dent Radiogr photogr 1964; 37: 85-90.
3. Strindberg LZ. The dependence of the results of pulp therapy on certain factors. Acta Odontol Scand 1956; 14(suppl 21): 1-175.
4. McComb D, Smith DC. A preliminary scanning electron microscopic study of root canals after endodontic procedures. J Endodon 1975; 1:238-42.
5. Pashley DH, Michelich V, Khel T. Dentin permeability: effects of smear layer removal. J Prosthet Dent 1981; 46: 531-7.
6. Haapasalo M, Orstavik D. In vitro infection and disinfection of dentinal tubules. J Dent Res 1987; 66: 1375-9.
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 Endonon 1995; 12: 21-7.
9. Evans JT, Simon JHS. Evaluation of the apcial seal produced by injected thermoplasticized gutt-percha in the absence of smear layer and root canal sealer. J Endodon 1986; 12: 101-7.
10. Mader CL, Baumgartner C, Peters DD. Scanning electron microscopic investigation of the smear layer on the root canal walls. J Endodon 1984; 7-10: 477-83.
11. Wennberg A, Orstavik D. Adhesion of root canal sealers to bovine dentin and gutt-percha. Int Endod J 1990; 23: 13-9.
12. Gettleman BH, Messer H, ElDeeb ME. Adhesion of sealer cements to dentin with and without the smear layer. J Endodon 1991; 17:15-20.
13. Baumgartner JC, Mader CL. A scanning electron microscopic evaluation of four root canal irrigation regimens. J Endodon 1987; 13: 147-57.
14. Yamada RS, Armas A, Goldman M, Lin PS. A scanning electron micorscopic comparison of a high volume final flush with several irrigating solutions: part 3. J Endodon 1983; 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 Endodon 2002; 6: 433-437.
16. Roig M, Ribot J, Jane L, Canalda C. Estudio de la filtracion apical de cuatro cementos de obturatcion. Endodoncia 1996; 14: 21-7.
17. Pommel L, Jacquot B, Camps J. Lack of correlation among three methods for evaluation of apical leakage. J Endodon 2001; 5: 347-350.