Original Article

The Influence of Hemostatic Agents and Cordless Gingival Retraction Materials on Smear Layer: An *Ex vivo* Scanning Electron Microscope Analysis

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Abstract

Context: Cordless gingival retraction materials are now routinely used method for gingival retraction. Although evidence-based information is available on the effect of gingival displacement cord and cordless system on the effectiveness of displacement and the periodontal health, there is a lack of literature regarding the effect of cordless retraction agents on enamel and dentin substrates. **Aim:** The purpose of this investigation was to analyze the changes on the smear layer induced by the hemostatic agent and cordless retraction material at scanning electron microscopic level. **Materials and Methods:** Ferric sulfate (15.5% m/v), expasyl, and magic foam cord were evaluated. Buccal surfaces of 16 recently extracted mandibular premolars were prepared for metal-ceramic crowns, and four teeth each were exposed to ferric sulfate solution, expasyl, and magic foam cord, respectively, for 5 min. Teeth in the control group were exposed to distilled water. The assessment of changes was performed using a scanning electron microscope (SEM). **Results:** SEM exhibited smear layer covering the dentin and occluding the dentinal tubules in the control group. Exposure to ferric sulfate caused the opening of few of the dentinal tubules whereas expasyl caused the partial removal of smear layer with dentinal plugs partially occluding the openings of most of the dentinal tubules. The specimens treated with magic foam exhibited a smear layer similar to the control group. **Conclusions:** The smear layer was affected most with ferric sulfate solution, followed by expasyl and magic foam cord. Magic foam cord did not affect the smear layer.

Keywords: *Aluminum chloride, astringents, ferric compounds, gingival retraction, hemostatics, smear layer, tooth preparation*

Introduction

Gingival retraction is one of the important and routine procedures in the fixed prosthodontic therapy. There are many methods of gingival retraction. Among them, the application of chemically impregnated retraction cords is the most common procedure. However, over the time, a new method of gingival retraction named cordless retraction has been developed. Expasyl and magic foam cord are the cordless technique of gingival retraction. Expasyl comes in a paste form containing kaolin and aluminum chloride. Magic foam cord is an expanding addition polymerize vinyl polysiloxane retraction material.

The minimum time for which the cord should be placed in the sulcus is reported to be 4 min.[1] Therefore, tooth structure routinely comes in contact with the chemicals used in retracting the gingival tissue.

Several authors have reported that the tooth preparation with rotary instruments creates a smear layer on the remaining dentin.[2] The term, smear layer, applies to any debris produced iatrogenically by cutting, not only of dentin but also of enamel and cementum, including root canal dentin.[2] Smear layer in few cases may also contain microorganisms.[3,4] However, complete removal of smear layer may increase dentin permeability and cause increased sensitivity.[5-8] Various authors have shown that hemostatic agents used with retraction cord can remove the smear layer and open the orifices of dentinal tubules to varying degrees.[9-12] Clinicians should recognize the significance of this layer particularly, if they plan restorative procedures that depend on bonding.[12-17]

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Evidence-based information is available on the effect of gingival displacement cord and cordless system on the effectiveness of displacement and the periodontal health.[18,19] However, there are very few articles in the literature concerning the effect of ferric sulfate hemostatic agent on dentin.[20-22] Furthermore, there is a lack of literature regarding the effect of cordless retraction agents on enamel and dentin substrates.[23] Therefore, a study was planned to analyze the changes in the smear layer induced by different retraction materials.

Materials and Methods

Three retraction materials were selected for the study: (i) 15.5% ferric sulfate (Astringedent; Ultradent Products), (ii) expasyl (Kerr corporation, Orange, California), and (iii) magic foam cord (Coltene/Whaledent Inc, Cuyahoga Falls, Ohio).

Sixteen recently extracted mandibular premolars were obtained. The teeth were extracted for orthodontic reasons and stored in normal saline solution. Each of the experimental retraction agent, i.e., ferric sulfate, expasyl, and magic foam cord was tested on four extracted teeth (n = 4). Four extracted teeth served as control.

The buccal surfaces of the teeth were prepared by conventional diamond rotary instruments (Dia Burs TR11 (ISO 199/016) and SF12 (ISO 111/014); Mani Inc, Utsunomiya, Japan). The prepared teeth were dried with three short blast of air. Four teeth each were then exposed to ferric sulfate solution, expasyl, and magic foam cord for 5 min [Figure 1]. The agents were allowed to remain on the dentin for 5 min to simulate a typical clinical situation.[11,21,22] Exposed dentin was then rinsed with 10 ml distilled water. Teeth in the control group were exposed to distal water only. The teeth were then stored in distilled water, till the scanning electron microscope (SEM) examination.

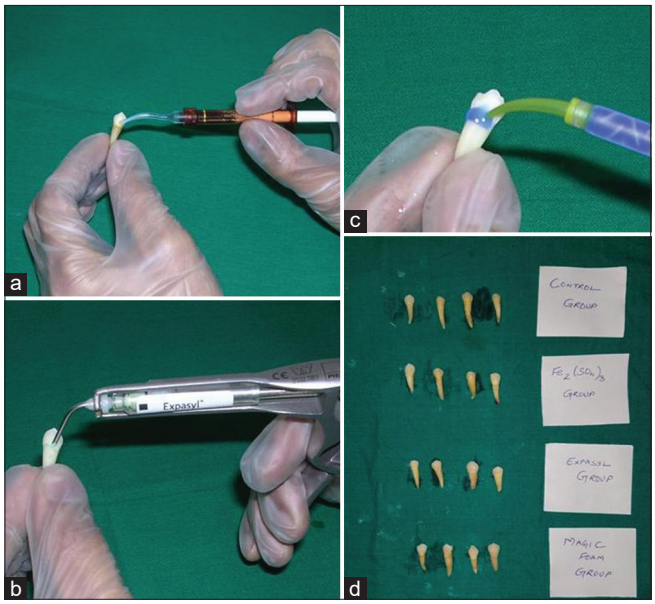

Figure 1: (a) Application of ferric sulfate. (b) Application of expasyl. (c) Application of magic foam cord. (d) Samples prepared for scanning electron microscope examination

The specimen was examined under environmental scanning electron microscope (Quanta200; FEI, Hillsboro, Ore). The photomicrograph of each specimen was made at the best magnification, such that the surface characteristics were clearly visible. The photomicrograph was then examined to evaluate the changes in the smear layer.

Results

SEM of the untreated specimen, i.e., control group, manifests the presence of smear layer [Figure 2]. This smear layer appeared as amorphous, featureless cutting debris over the dentin and completely occluding the dentinal tubules. However, few dentinal tubules appeared as depressions below the surface. This appearance was due to the presence of surface debris which entered the tubules. Few grooves were observed which were the marks left by the burs while preparation.

After 5 min of exposure to ferric sulfate, the smear layer was partially removed [Figure 3]. Dentinal plugs were found to be partially occluding the openings of most of the dentinal tubules. Few of the dentinal tubules were fully exposed. The peritubular dentin was discernible and relatively intact. Intensification of peritubular dentin was observed around orifices of dentin.

The smear layer was partially removed when the dentin surface was treated with expasyl for 5 min [Figure 4]. Only the thin smear layer was present over the prepared tooth surface. Few dentinal tubules were found with intact peritubular dentin. Some cracks were visible in the smear layer covering the dentinal tubule orifices. These cracks

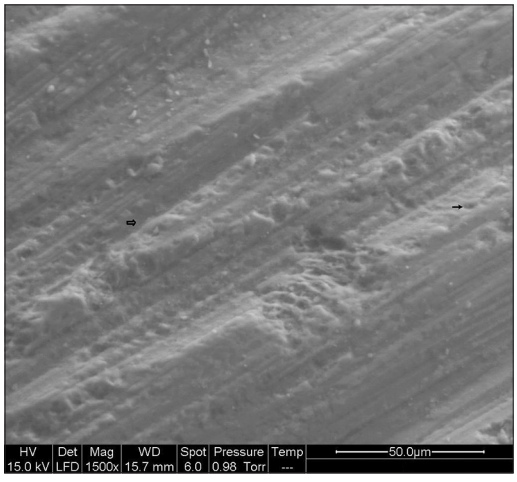

Figure 2: Scanning electron microscope photomicrograph of dentin surface prepared and irrigated with distilled water (control). Amorphous featureless smear layer obscuring the dentinal tubules. Few tubules appeared as depressions below surface (solid arrows). Grooves left by cutting can be seen (block arrows) (×1500)

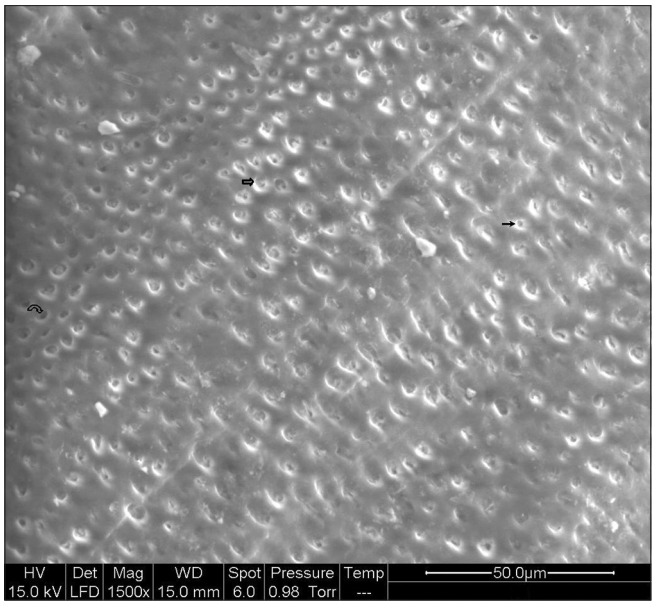

Figure 3: Scanning electron microscope photomicrograph of dentin surface prepared and treated with $Fe_2(SO_4)_3$ for 5 min. Smear layer partially removed. Most of dentinal tubules partially occluded by dentinal plugs (block arrows). Note intensification of peritubular dentin (solid arrows). Few open dentinal tubules are visible (curved arrows) (×1500)

might be artifacts produced during tooth preparation. The specimens treated with magic foam for 5 min, exhibited smear layer similar to the control group [Figure 5]. Orifices of dentinal tubules were completely covered by smear layer.

Discussion

The term smear layer applies to any debris produced iatrogenically by cutting, not only of dentin but also of enamel and cementum, including the dentin of the root canal.[2] It is challenging to find out who first introduced the concept of smear layer. The initial experiment to study the prepared tooth surface was possible only through the use of light microscope. Later technological advancement led to the launch of scanning electron microscope and energy dispersive X-ray analysis which made it possible to study the prepared tooth surface in detail. Gwinnett appears to have been among the first to describe in greater detail, using scanning electron microscopy, the nature of the surface deposits *in situ*.[2] Gwinnett also appears to have been the first to describe and demonstrates the presence of what they called a "smear layer" on surfaces of cut enamel.[2]

Gwinnett described the morphological qualities of smear layer.[2] Instrumentation of teeth surfaces creates surface debris and surface anomalies such as grooves obliterating the normal structural features of enamel and dentin. This surface debris contains both organic and inorganic components. The thickest deposit is produced when preparation is done under dry condition, and the smear layer is not always firmly attached or continuous over the tooth surface.[2]

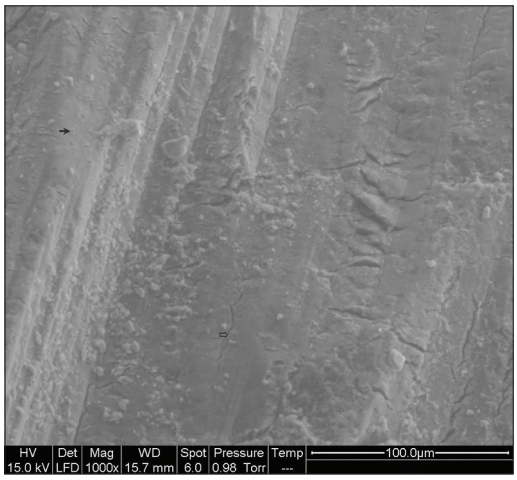

Figure 4: Scanning electron microscope photomicrograph of dentin surface prepared and treated with expasyl for 5 min. Surface covered with thin smear layer. Occasional tubules are visible with intact peritubular dentin (solid arrows). Few cracks are visible (block arrows) (×1000)

In clinical practice, the duration of contact between the retraction material and the tooth varies. It varies with the dentist and the type of procedure performed on the patient. Nevertheless, the chemicals used for the gingival retraction will definitely come in contact with the prepared tooth surface specifically if the margin of the preparation is extended into subgingival sulcus. Hence, the overall evaluation of gingival retraction material is incomplete without analyzing their effects on prepared tooth surface. However, there is a lack of literature regarding the effect of cordless retraction agents on smear layer. Therefore, an SEM evaluation was carried out to study and compare the effects of retraction materials on prepared tooth surface.

After 5 min exposure to ferric sulfate, the smear layer was partially removed although the peritubular dentin remained discernible and relatively intact. The appearance was similar to score 2 as per the scoring system given by Meryon *et al*.[9] The effect of 5 min application of ferric sulfate on dentin was similar to the application of 37% phosphoric acid for 60 s.[9] Previous studies showed that 5 min application of ferric sulfate resulted in severe etching, which is consistent with the SEM micrographs from the current study.[10-12,20-22] Furthermore, the peritubular dentine seems unaffected in the previous study.[10-12,20-22] However, the dentinal tubules remained partly occluded.[11,12,21,22] It was postulated that collagen or plasma proteins could have been coagulated by the ferric sulfate.[16,22]

On application of expasyl, for 5 min, thin smear layer with plugs still blocking orifices of most of dentinal tubules was observed. The appearance was similar to score 1 as per the scoring system given by Meryon *et al*.[9] Similar to the findings of the present study, Lahoti observed that expasyl paste treated samples revealed partially removed smear layer with occluded dentinal tubules. Along with that, some of the dentinal tubules were showing recognizable tubular

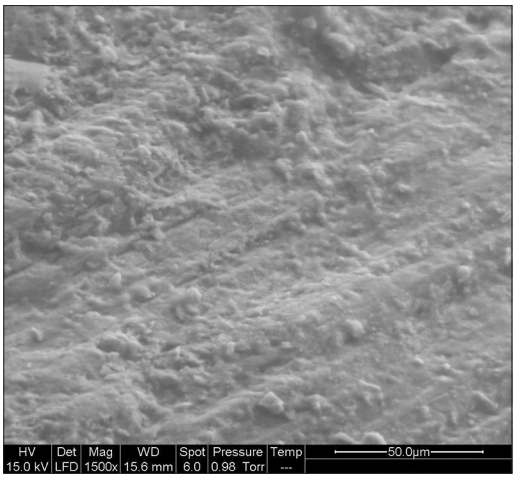

Figure 5: Scanning electron microscope photomicrograph of dentin surface prepared and treated with magic foam cord for 5 min. Surface covered by thick smear layer completely obliterating the dentinal tubules (×1500)

pattern with cracks across tubular opening.[23] Al Baker *et al*. concluded that the use of expasyl gingival retraction system can negatively affect bond strength of adhesives and have suggested to rinse and cleanse the dentin with self-etching adhesive systems after expasyl application.[17]

Application of magic foam cord did not affect the smear layer, and thick smear layer was observed completely covering the surface with no tubules visible. There is a lack of studies in the literature regarding the effect of magic foam cord retraction on dentin.

There are important clinical ramifications due to the effect of the gingival retraction materials on the prepared dentin. Review of literature on smear layer reveals two extreme points of view.[4] One view is that smear layer is beneficial as it reduces the permeability of dentin. Reeder *et al*.; Pashley *et al*.; Boyer and Svare; and Pashley *et al*. indicated that most of the resistance to the flow of fluid across dentin is due to the presence of smear layer.[5-8] Therefore, removal of smear layer can result in sensitivity of dentin due to exposure of patent dentinal tubules to the oral cavity.

On the other hand, there is also a view that smear layer interferes with the adhesion of certain restorative materials to dentin[13,14,16,17] and that it may allow microorganisms to get trapped and multiply,[3,4] both of which are harmful to the restoration as well as abutment.

Brannstrom suggested that the prepared dentin surfaces should get rid of the superficial smear layer and the remaining smear plugs should be preserved and treated antiseptically.[4] The study exhibited that expasyl and magic foam cord when used as per the protocol followed in the study does not remove the dentinal plug. That is an application of expasyl for 5 min results in partial removal of smear layer, but the dentinal plug remains intact while application of magic foam cord for 5 min does not affect the smear layer.

The present study has some limitation also. *In vivo* experiment might give different result because of dilution and the buffer effect dentinal fluid which exudes from the freshly prepared dentin. The study observed the effect of gingival retraction material on the inorganic constituents of the prepared tooth but its effects on the organic constituents cannot be determined by SEM examination. Hence, other techniques should be employed to observe the effect on organic constituents of tooth, including the pulp.

Conclusions

The smear layer was affected most with ferric sulfate solution, followed by expasyl and magic foam cord. Magic foam cord did not affect the smear layer. The low pH hemostatic agent should be used cautiously, and exposure to prepared dentin close to the pulp should be avoided as it leads to opening of few of dentinal tubules.

Ethical clearance

The study was approved by the Institutional Ethics Committee of Nair Hospital Dental College.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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