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ORIGINAL RESEARCH

Morphological Analysis of Dentin Surface after Conditioning with Two Different methods: Chemical and Mechanical

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ABSTRACT

Background: Alternative pretreatment strategies of dentin and adhesionare constantly being developed and studied with the goal of improving the adhesion of resin restorative materials with this tissue. The objectives of the present study were to evaluate the ability of airborne-particle abrasion (APA) with aluminum oxide on dentin to remove the smear layer and the effects produced on the dentin microstructure.

Materials and methods: The phosphoric acid (PA) was used for a comparison. For that, 20 human third molars were randomly allocated into two experimental groups, according to the dentin pretreatment method used: G1 (N = 10) – PA, G2 (N = 10) – APA. For dentin surface analyses, an environmental scanning electron microscope (ESEM) was employed to observe dentin surfaces before and after the procedures. Before pretreatment, the specimens of both groups were smear covered.

Results: After pretreatment, the G1 images revealed dentin tubule orifices opened, enlarged and some erosive effects. (G2) exposed tubule orifices without enlargement, but crack-like alterations were observed on the surfaces. In this way, APA with aluminum oxide was able to remove the smear layer.

Conclusion: The influences of the dentin roughness on adhesion and the consequences on dentin integrity and hardness need further investigations.

Clinical significance: A good conditioning of the dentin before cementation is necessary in order to obtain a satisfactory rehabilitation in adhesive dentistry. So, it is necessary to know all methods to do it.

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INTRODUCTION

The creation of reliable dentin adhesion is a challenging task. The improvements in this field have been related to the creation of a trustworthy hybrid layer.[1,2] A conventional process for dentin hybridization removes the smear layer to expose the collagen network of the intertubular dentin to allow the infiltration of the adhesive luting.[3-7] In dentistry, phosphoric acid (PA) is the most commonly used method to remove the smear layer.[3,5,7-9] However, the evolution of adhesive systems allowed the emergence of self-adhesive resin cements, and therefore, new methods of treatment dentin surface were required.[10-13] In this line, airborne-particle abrasion (APA) was recently suggested to clean the dentin surfaces, performing a mechanical pretreatment.[2,9,14,15]

Airborne-particle abrasion is a method that uses oxide particles to introduce modifications on different surfaces.[2,14,16] The advantage of using this method for caries removal and dentin cleansing is the possibility to preserve the dentin structure, which can be accidently cut with burs. Currently, airborne abrasion is most commonly used to generate roughness in ceramic restorations and increase the bond surface area, which might improve the bonding values. The rationale behind this procedure indicates that this method can also improve the dentin bonding.[14,17] Therefore, the evaluation of the effects of this procedure on the smear layer and on the dentin structure is mandatory to establish a possible protocol.[2,9,14,18]

The objectives of the present study were to evaluate the ability of airborne-particle abrasion to remove the smear layer and EVALUATE through scaning electron microscopy analysis, the effects produced on dentin microstructure as consequence of conditioning treatment with two different methods: chemical, using phosphoric acid and mechanical, with airborne abrasion. The null hypotheses formulated for the present study were that there are no differences between PA and APA: (1) on the ability of smear layer removal; and (2) on the production of different effects on dentin microstructure.

MATERIALS AND METHODS

Specimen Selection and Specimen Preparation

Twenty un-erupted third molars, recently surgically extracted, were kept in 0.2% sodium azide at 4°C, for no longer than 7 days. The teeth were collected after the patients' informed consent had been obtained following the reviewed protocol and approved by the Ethics Committee, Nucleus of Collective Health Studies, Veiga de Almeida University, RJ, Brazil.

Mid-coronal dentin surfaces were obtained by removing the occlusal of the third molar crowns using an Isomet low-speed saw (Buhler Ltd, Lake Bluff, NY) with a diamond disc (125 × 0.35 × 12.7 mm – model 330ºC) and continuous water irrigation to prevent overheating. The absence of enamel and pulp tissue on the exposed dentin surface was controlled using a stereo-microscope (Wild; Wild M5A; Heerbrugg, Switzerland).

Dentin Pretreatments

The specimens were randomly assigned into two experimental groups using a computer algorithm[19] (N); computation was based on previous studies.[2,14]

In G1 (N = 10), the specimens were chemically treated with 37.3% PA. On each specimen, 1 ml of 37.5% PA gel (VOCO; Cuxhaven, Germany) was applied over the dentin surfaces for 5 seconds, and then rinsed thoroughly with 3 ml distilled water irrigation.[20,21]

In G2 (N = 10), the specimens were mechanically treated with APA, using a jet device BioArt Micro-jet (BioArt, SP, Brazil), coupling to the pneumatic outlet of the dental chair, following the manufacturer's instructions. The tip of the micro-jet was positioned 5 mm from dentin surfaces and a stainless steel device was used to standardize this distance. Oxide aluminum particles of 50 µm were pressured against the surface specimens with 60 psi, for 5 seconds. After the procedure, the surfaces were rinsed thoroughly with 3 ml distilled water.

Environmental Scanning Electron Microscope Analyses

For dentin surface analyses, an environmental scanning electron microscope (ESEM), FEI Quanta 300 (FEI Company™, Oregon), was employed, using low vacuum conditions (~0.3 Torr pressure, 25 kV voltage). The dentin specimens were scrutinized in two stages of the present investigation. The first analysis (A) was performed before the dentin pretreatment was employed, to evaluate the presence of the smear layer in the dentin surfaces.[22] The second analysis (B) was performed after dentin pretreatment procedures, in G1 and in G2, to observe the effects produced. A blinded microscope operator for the different pretreatment groups captured several images of each specimen using the secondary electron mode with a work distance of 7.5 to 12 mm and with magnifications ranging from 2000× to 16,000×.

RESULTS

The images captured with ESEM clearly revealed different effects on dentin surfaces, intimately related to the stage of analysis – before (A) and after pretreatment (B) – and to the type of pretreatment employed – PA (G1) and APA (G2).

The first ESEM analysis – A – revealed dentin surfaces covered with a smear layer. The images captured of the control group demonstrated tubule orifices that were completely or partially blocked (Fig. 1).

In G1 images, the demineralization effects were evident after PA treatment. The dentin tubule orifices were opened and enlarged (Fig. 2). In addition, erosive effects were also noted inside the tubule walls (Fig. 3).

The effects caused by APA treatment in G2 specimens were completely different. The tubule orifices were exposed in general, although a certain amount of debris was present on dentin surfaces (Figs 4 and 5). The tubules were not enlarged, but crack-like alterations could be

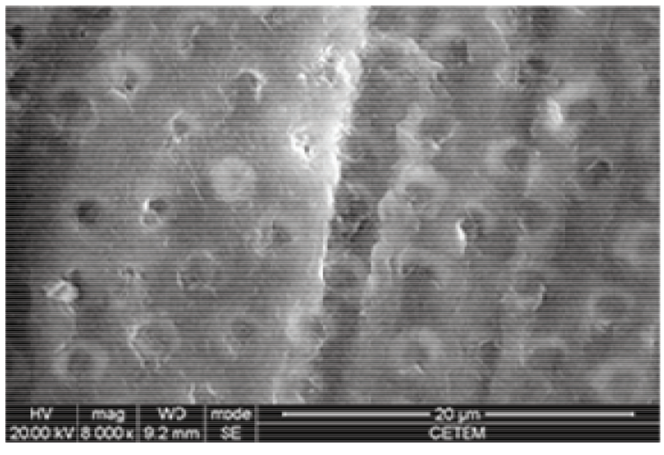

Fig. 1: Scanning electron microscope images of dentin surfaces of control group where no treatment was performed on dentinal surface (8000×)

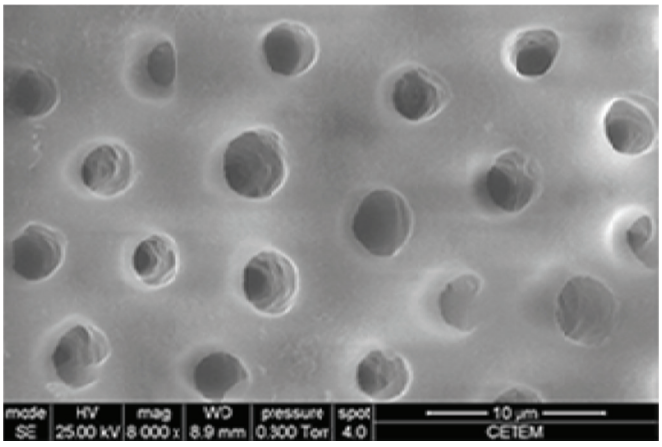

Fig. 2: Scanning electron microscope image of dentin surfaces of experimental groups – phosphoric acid etching (8000x)

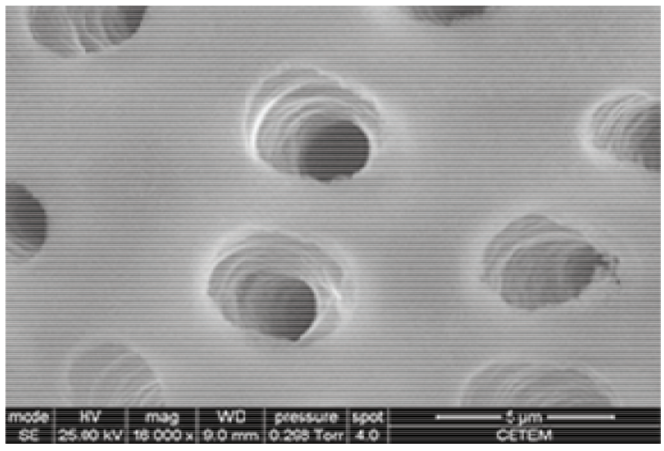

Fig. 3: Scanning electron microscope image of dentin surfaces after etching with phosphoric acid, showing erosion in walls of tubules (16,000x)

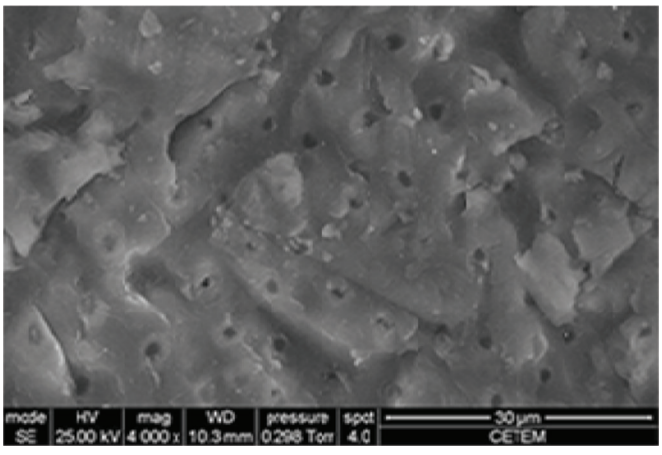

Fig. 4: Scanning electron microscope image of dentin surfaces of experimental groups – airborne-particle abrasion (4000x)

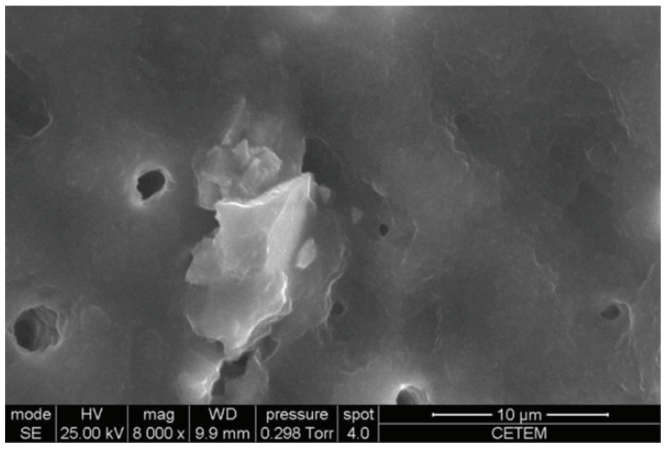

Fig. 5: Scanning electron microscope images of dentin surfaces after airborne-particle abrasion at 8000x, showing changes in surface relief

observed on the tubule borders and on intertubular dentin (Figs 5 and 6).

The effects of PA and APA on intertubular dentin morphology were evidently different. The clean and plain PA specimen surfaces in G1 contrast with the roughness produced by APA on G2 specimens (Figs 2 and 4).

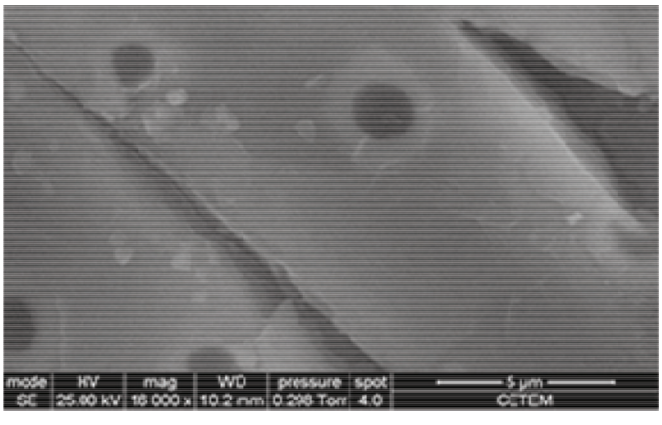

Fig. 6: Scanning electron microscope image of surface of dentin after airborne-particle abrasion (16,000x). It is shown in figure cracks and presence of impurities in surface

DISCUSSION

The dentin tubule orifices exposure, observed after pretreatment on all ESEM images, indicates that both methods were able to remove the smear layer. Then, the first hypothesis was accepted. The ESEM images also demonstrated different effects on the dentin-treated surfaces. Thus, the second hypothesis was rejected.

The use of ESEM in the present study, instead of a conventional SEM, was particularly important because this microscopy technique does not require specimen metallization. This allowed evaluations before and after the dentin pretreatments in the same specimens. In this way, each specimen served as its own control.[22] In fact, the analysis of the cut specimen demonstrated a similar pattern of smear-covered dentin surfaces among all specimens. Thus, it assured the use of a similar baseline among the experimental groups for the present study, offering a more reliable comparative analysis.

The ability to remove the smear layer is a well-known effect of PA pretreatment.[3,5,6,8,9] In contrast, there are only a few documented effects of APA on dentin surfaces.[2,14]

In the present study, different effects on the intertubular dentin were observed on the images obtained after pretreatment. Phosphoric acid produced regular and plain dentin surfaces, while a rough surface was observed on APA images. These findings corroborate with previous reports.[2,14]

For years, dentin bonding was guaranteed to the mechanical interlocking of the hybrid layer, resulted in the penetration of the adhesive into the dentin tubules. Therefore, the smear layer removal protocol had always been related to the exposure and enlargement of the tubule orifices. That is one of the main reasons for the popularity of the PA pretreatment method. However, it has since been demonstrated that sealer or adhesive penetration into dentin tubules only has a small influence on the final adhesion.[20,21] Actually, it is the result of three important features: mechanical interlocking, surface adhesion and, mainly, the collagen network. In this way, the quality of the available intertubular dentin might be the key to achieve a reliable adhesion.[5,6] Considering these evidences, the available intertubular dentin has a critical role in adhesion and should be preserved and treated properly. In the present study, the pretreatment with APA preserved the original diameter of the dentin tubule orifices and, consequently, the amount of available intertubular dentin. In addition, it also generated roughness on dentin surfaces, enlarging the contact area for adhesion. Conversely, some studies demonstrated that APA resulted in the worst dentin bonding when it was associated with a self-adhesive resin luting cement.[2,10-13,17]

The cracks and flaws on APA dentin surfaces specimens also deserve some attention. Onisor et al[15] demonstrated that APA did not reduce the integrity of the marginal adaptation on resin composite restorations. However, the large bulk size of the cracks observed in the present study suggests implications for dentin hardness and structural integrity. In addition, a new finding was also demonstrated – the presence of some debris on dentin surface. This might be related to small pieces of oxide aluminum particles or dentin chips removed from the surface during the jet application. The debris might also influence the dentin bonding performance.

CONCLUSION

The judicious SEM analysis performed in the present study revealed that APA was able to remove the smear layer. Further studies are necessary to evaluate the influence of the dentin roughness produced by this mechanical pretreatment method on dentin bonding. In addition, the effect of this method on dentin integrity and hardness should be investigated.

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