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# Influence of Gingival Retraction Agents on Dentin Surface Integrity and Smear Layer: An In Vitro Scanning Electron Microscopic Evaluation

**Patel Ruchi[1], Agrawal Sachin[2], Vaishnav Kalpesh[3], Patel Surbhi[4], Joshi Ravi[3], Makhecha Hima[2]**
[1]Professor & Head, [2]Postgraduate Student, [3]Professor,[4]Senior Lecturer,
Department Of Prosthodontics,
Karnavati School of Dentistry, Gujarat, India

***Corresponding Author:**
**Dr. Hima Makhecha**
Post Graduate Student, Department Of Prosthodontics and Crown & Bridge,
Karnavati School of Dentistry, Gujarat, India

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## Abstract

**Background:** Gingival retraction agents are widely used during restorative and fixed prosthodontic procedures to control bleeding and improve access to subgingival margins. Owing to their acidic nature, these agents may alter dentin surface morphology and affect the smear layer, which plays an important role in dentin bonding and permeability.

**Aim:** To evaluate the effect of 20% ferric chloride and 25% aluminum chloride on dentin surface integrity and smear layer characteristics using scanning electron microscopy.

**Study setting and design:** This in vitro observational study was conducted on extracted human premolars to assess dentin surface changes after exposure to gingival retraction agents for different time intervals.

**Materials and methods:** Thirteen extracted human premolars free from caries, cracks, and restorations were selected, disinfected, cleaned, and embedded in acrylic resin blocks. The specimens were divided into three groups: deionized distilled water as control, 20% ferric chloride, and 25% aluminum chloride. The experimental groups were further subdivided according to exposure time of 30 seconds and 2 minutes. After treatment, all samples were air-dried, sputter-coated with platinum, and examined under scanning electron microscopy at magnifications ranging from 100x to 5000x. Surface alterations were assessed descriptively based on dentin morphology and smear layer changes.

**Statistical analysis used:** As the study was based on qualitative SEM observations, descriptive analysis was performed and no inferential statistical analysis was applied.

**Results:** The control specimen showed a smooth and uniform dentin surface with preservation of the smear layer. Both gingival retraction agents produced surface alterations, and these changes became more pronounced with longer exposure time. The 20% ferric chloride group exposed for 2 minutes demonstrated the greatest surface alteration, characterized by smear layer removal, dentinal tubule exposure, and pinhole porosities. The 25% aluminum chloride group also produced surface changes, although these were less severe than those observed with ferric chloride.

**Conclusion:** Gingival retraction agents influenced dentin surface integrity in a time-dependent manner. Ferric chloride produced more aggressive dentin surface alteration than aluminum chloride. Careful selection of the hemostatic agent and control of application time may help minimize undesirable changes in dentin surface morphology during clinical procedures.

**Keywords**: Gingival retraction, Dentin, Smear layer, Ferric chloride, Aluminum chloride, Scanning electron microscopy

## Introduction

Moisture control and soft-tissue management are critical in restorative dentistry, particularly during impression procedures involving equigingival and subgingival margins.[1,3] Gingival retraction facilitates exposure of the finish line, thereby improving the accuracy of restorations and contributing to long-term clinical success.[1,3]

Traditional gingival retraction methods include mechanical, chemical, and surgical techniques. Among these, chemico-mechanical methods using retraction cords impregnated with hemostatic agents are widely used because they effectively control bleeding and provide adequate tissue displacement.[1,2,4]

Commonly used hemostatic agents such as aluminum chloride and ferric chloride act by protein precipitation and vasoconstriction.[4,10] However, their acidic nature raises concern regarding their effects on tooth structure, particularly dentin and the smear layer.[5,6]

The smear layer, formed during tooth preparation, remains controversial in restorative dentistry.[7,8] While it may reduce dentinal permeability and sensitivity, its removal may also enhance bonding of restorative materials.[7,8] Previous studies have shown that acidic agents can remove the smear layer and alter dentin morphology depending on their pH and duration of exposure.[5,6,9,12]

The present study aimed to evaluate the surface deterioration of the dentinal smear layer after exposure to deionized distilled water, 25% aluminum chloride, and 20% ferric chloride using scanning electron microscopy.

### Objectives

To evaluate dentin surface morphology after exposure to deionized distilled water (control).

To assess the effect of 25% aluminum chloride on the dentin smear layer after 30 seconds and 2 minutes of exposure.

To assess the effect of 20% ferric chloride on the dentin smear layer after 30 seconds and 2 minutes of exposure.

To compare the extent of surface alteration among different agents and exposure durations.

## Materials and Methods

### Study design

This was an in vitro observational study performed on extracted human premolars.

### Materials

Extracted human premolar teeth.

Deionized distilled water.

25% aluminum chloride astringent agent (Prevest DenPro Ltd., Jammu, India)

20% ferric chloride astringent agent (Voco/V-Feristate)

2% chlorhexidine solution.

Light-cure acrylic resin blocks (10 x 10 mm).

Platinum for sputter coating.

#### *Sample preparation*

Thirteen extracted premolars free from caries, cracks, and restorations were selected. The teeth were disinfected using 2% chlorhexidine and ultrasonically cleaned. Each tooth was embedded in a light-cure acrylic resin block. Standardized tooth preparation was performed using a high-speed air rotor, and uniformity was verified using a putty index.



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**Figure -1: Teeth incorporated in light cure acrylic resin**

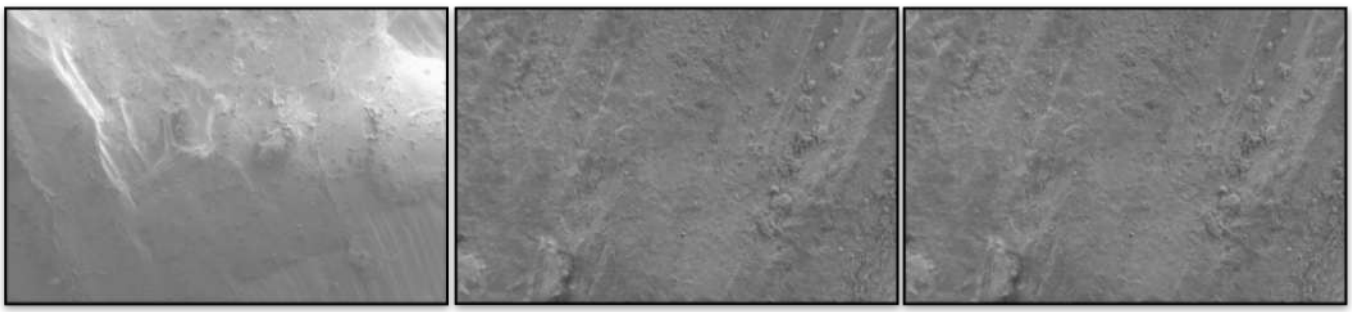
**Figure -2: Tooth preparation checked using putty index**

## Results

### Group 1: Control

SEM analysis of the control specimen revealed a smooth, uniform, continuous, and undisturbed surface morphology with preservation of the smear layer

**Figure -3: 100x Magnification** **Figure -4: 1000x Magnification** **Figure -5: 5000x Magnification**





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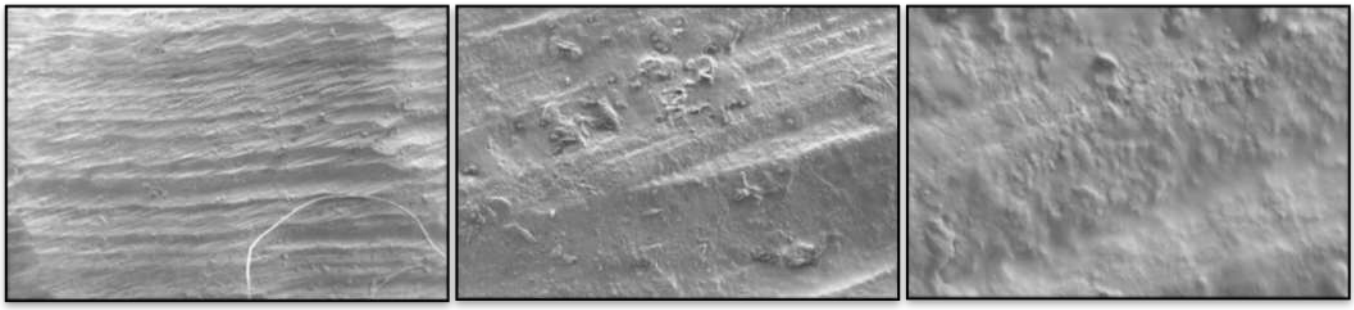
**Group 2A: 20% ferric chloride for 2 minutes**

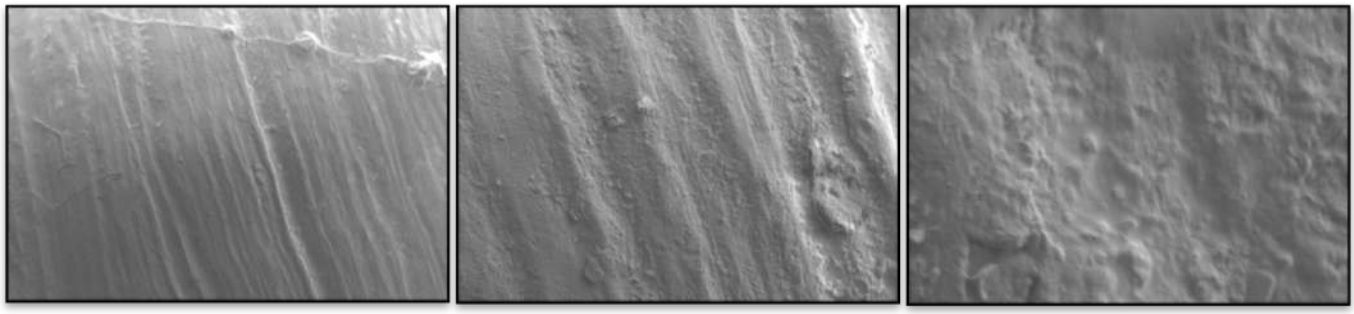
**Figure -6: 100x Magnification** **Figure -7: 1000x Magnification** **Figure -8: 5000x Magnification**



SEM analysis showed marked surface etching with numerous pinhole porosities. A large number of exposed dentinal tubules were observed, along with evident disruption of the surface layer.

**Group 2B: 20% ferric chloride for 30 seconds**

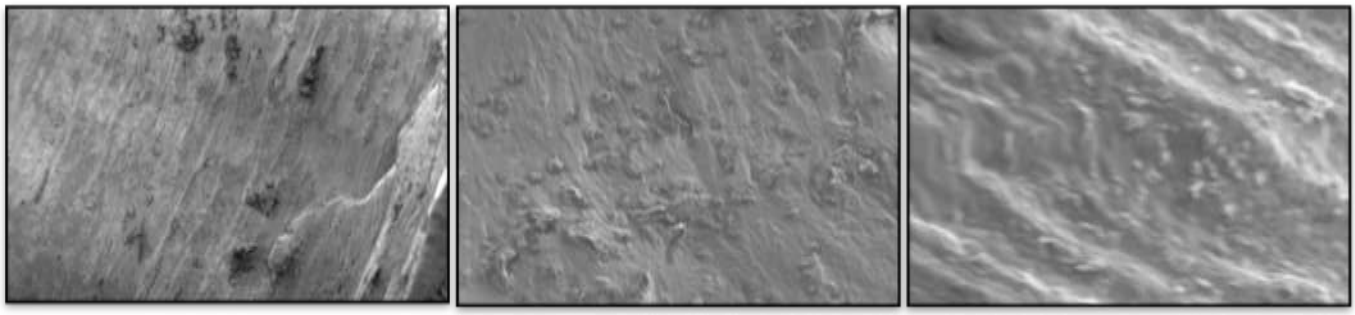
**Figure -9: 100x Magnification** **Figure -10: 1000x Magnification** **Figure -11: 5000x Magnification**



SEM analysis showed a disrupted surface with micropore formation. Pinhole porosities were present, although fewer in number than in Group 2A.

**Group 3A: 25% aluminum chloride for 2 minutes**

**Figure -12: 100x Magnification** **Figure -13: 1000x Magnification** **Figure -14: 5000x Magnification**



SEM analysis revealed surface flaws, irregularities, and an uneven dentinal tubular pattern. Surface etching and pinhole porosities were observed, although the alterations were less severe than those seen in Group 2A.



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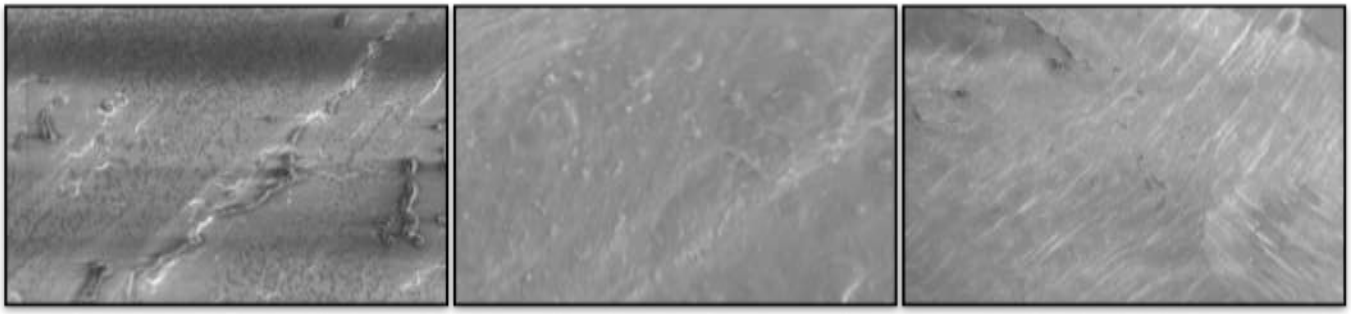
**Group 3B: 25% aluminum chloride for 30 seconds**

**Figure -15: 100x Magnification** **Figure -16: 1000x Magnification** **Figure -17: 5000x Magnification**



SEM analysis showed superficial scratches and mild abrasions with partial disruption of the dentinal smear layer. Very few pinhole porosities were observed compared with the other experimental groups.

## Discussion

The present study demonstrated that gingival retraction agents significantly affect dentin surface integrity and smear layer characteristics. Both 20% ferric chloride and 25% aluminum chloride produced surface alterations; however, ferric chloride showed more aggressive effects, including extensive smear layer removal, dentinal tubule exposure, and surface porosity.[5,9,10,11]

The extent of dentin alteration increased with duration of exposure. Samples treated for 2 minutes exhibited greater surface damage than those exposed for 30 seconds, indicating a time-dependent etching effect of acidic hemostatic agents.[5,9,12] This observation is in agreement with previous studies evaluating the effect of chemical agents on dentin morphology.[5,6,12]

The clinical implications of smear layer modification remain controversial.[7,8,13] Although smear layer removal may enhance bonding by facilitating hybrid layer formation, it can also increase dentinal permeability and postoperative sensitivity.[7,8] Therefore, the choice of hemostatic agent and its duration of application should be carefully controlled.

Within the limitations of this in vitro study, both the pH of the agent and the duration of exposure were critical determinants of dentin surface changes.[5,9,12] Shorter application times and less aggressive agents such as aluminum chloride may be preferable when preservation of dentin surface integrity is desired.[5,12]

## Limitations

This study was conducted under in vitro conditions and therefore does not fully reproduce the dynamic oral environment, where pH, saliva, temperature, and biological interactions may influence the behavior of hemostatic agents.

The study was a qualitative SEM observational study with limited sample size. The findings were based on qualitative SEM observations. Future studies with larger sample sizes and quantitative scoring or bond strength analysis may provide more clinically applicable evidence.

## Conclusion

All specimens prepared with rotary instruments exhibited a smear layer before chemical exposure.[7] Application of hemostatic agents resulted in varying degrees of smear layer alteration depending on the type of agent and duration of exposure. The 20% ferric chloride group exposed for 2 minutes showed the most pronounced surface changes, including significant smear layer removal and surface distortion. The 25% aluminum chloride group also produced surface changes, but to a lesser extent.

The degree of surface alteration followed the order: ferric chloride (2 minutes) > aluminum chloride (2 minutes) > ferric chloride (30 seconds) > aluminum chloride (30 seconds).

These findings indicate that both the pH of the hemostatic agent and duration of application play a critical role in dentin surface modification.[5,9,12]

## Clinical Implications

Hemostatic agents with a lower pH may produce greater abrasion and removal of the dentinal smear layer during gingival retraction procedures.[5,9,10]



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Selection of the hemostatic agent and control of contact time are important to minimize unwanted dentin surface alterations during fixed prosthodontic procedures.

**Future Scope**

Further studies may evaluate other hemostatic agents, different concentrations, and longer or shorter application times to better understand their influence on dentin surface morphology.

Future investigations may also correlate SEM findings with bond strength testing and clinical outcomes.

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