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Research Article

Comparative Evaluation of Manual and Ultrasonic Scaling and Root Planing (SRP) with and without Calculus Softening Agent Using Scanning Electron Microscope (SEM): An *In-vitro* Study

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Abstract

Background: Periodontal therapy often involves scaling and root planing (SRP) to remove plaque and calculus and mitigate periodontitis progression. While ultrasonic and manual methods are widely used, they vary in efficacy, particularly in terms of calculus removal and potential damage to tooth surfaces.

Objective: To compare the effectiveness of manual and ultrasonic SRP with and without a calculus softening agent, assessed through Scanning Electron Microscopy (SEM).

Methods: A total of 68 extracted human teeth were categorized into four treatment groups, each treated with a combination of SRP methods. SEM evaluated post-treatment calculus residue, cleanliness, and loss of tooth substance.

Results: Ultrasonic scaling with a softening agent significantly reduced remaining calculus while minimizing tooth surface damage, indicating a promising adjunctive strategy.

Conclusion: Incorporating a calculus softening agent in ultrasonic SRP may improve periodontal outcomes by enhancing calculus removal and preserving tooth structure.

Keywords: Calculus Softening Agent; Hand Scaling; Ultrasonic Scaling; Scanning Electron Microscope

Abbreviations

SRP: Scaling and Root Planing; SEM: Scanning Electron Microscope; DMI: Dimethyl Isosorbide; LTSI: Loss of Tooth Substance Index; RCI: Remaining Calculus Index; CI: Cleanliness Index

Introduction

Periodontitis is a chronic inflammatory disease affecting the tooth-supporting structures, which, if untreated, can lead to tooth loss. The main goals of periodontal therapy are to eradicate the microbial environment, control infection, and promote healing. SRP is considered the gold standard for non-surgical treatment, commonly performed using manual instruments (e.g., Gracey curettes) and ultrasonic devices [4].

Manual SRP can be effective but may result in significant loss of tooth structure due to aggressive instrumentation. In contrast, ultrasonic scaling, which vibrates at high frequencies, may be less invasive but might leave calculus or smear layers that can inhibit periodontal healing [3]. Chemical adjuncts, like calculus softening agents, have been introduced to improve the efficiency of SRP [3]. This study evaluates the comparative effectiveness of manual and ultrasonic SRP, with and without a softening agent, to determine the optimal approach for achieving thorough cleaning with minimal tooth surface damage.

Materials and Methods

Study design

This *in vitro* study included 68 extracted periodontally compromised human teeth. The study was conducted following ethical committee approval, ensuring compliance with research standards.

Sample preparation and grouping

The teeth were disinfected, mounted, and randomly assigned to one of four treatment groups.

- **Group 1a:** Manual SRP with Gracey curettes, without softening agent.
- **Group 1b:** Manual SRP with Gracey curettes and calculus softening agent.
- **Group 2a:** Ultrasonic SRP without softening agent.
- **Group 2b:** Ultrasonic SRP with calculus softening agent.

Figure 1: Armamentarium.

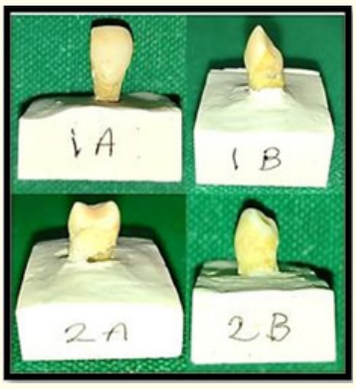

Figure 2: Sample grouping.

Scaling and root planing procedures

SRP was performed by an experienced operator, with hand and ultrasonic instruments, either with or without the calculus softening agent (according to the groups) on tooth surfaces presenting calculus, until a visibly clean and smooth surface was observed.

This was followed by SEM evaluation by a blinded examiner. Each root surface was prepared for SEM analysis by air drying, sputter-coating with gold, and examining with SEM at magnifications from 50x to 1000x.

The calculus softening agent included xylitol, dimethyl isosorbide (DMI), glycerin, xanthan gum, and methyl paraben, all components known to interact with biofilm and calculus.

Evaluation parameters

- **Loss of Tooth Substance Index (LTSI):** Assessed by observing the level of root substance loss, from no detectable loss to deep instrumental marks in the dentin.
- **Remaining Calculus Index (RCI**): Measured remaining calculus presence on the surface, ranging from no calculus to considerable deposits.
- **Cleanliness Index (CI):** Evaluated cleanliness and smear layer absence, indicating effective scaling.

Sem evaluation

- **400x Magnification**: Patches of calculus (hardened plaque) are still visible on the root surface, indicating incomplete removal despite curette treatment.
- **800x Magnification**: Scratches left by the curette are noticeable, showing the mechanical impact on the root surface. This suggests that while some calculus is removed, the instrument also leaves behind marks, raising questions about the thoroughness of the cleaning.
- **1000x Magnification**: At this high magnification, gouging of the cementum, the root's outer layer, becomes evident. This suggests that over-instrumentation may occur, with excessive force potentially harming the tooth's structure by removing too much tooth material.

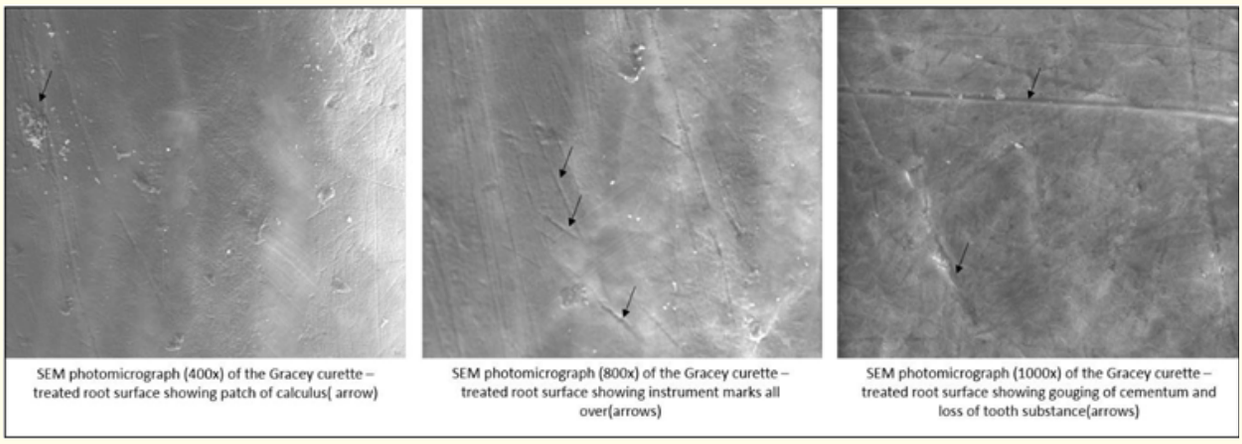

Image 1: Gracey Curette-Treated Root Surfaces.

- **400x Magnification**: The root surface appears much cleaner, with only minimal calculus remaining, suggesting that the softening agent enhances the effectiveness of the curette.
- **800x Magnification**: While the calculus is mostly removed, instrument marks are still visible on the root surface, indicating that the curette's mechanical effect is still present, though the surface remains largely clear of deposits.
- **1000x Magnification**: The curette grooves are shallower, with less tooth material loss, with no smear layer but also some exposure of dentin in few areas is observed. This indicates that the softening agent improves calculus removal using lesser pressure to minimize the risk of over- instrumentation, to preserve the tooth structure.

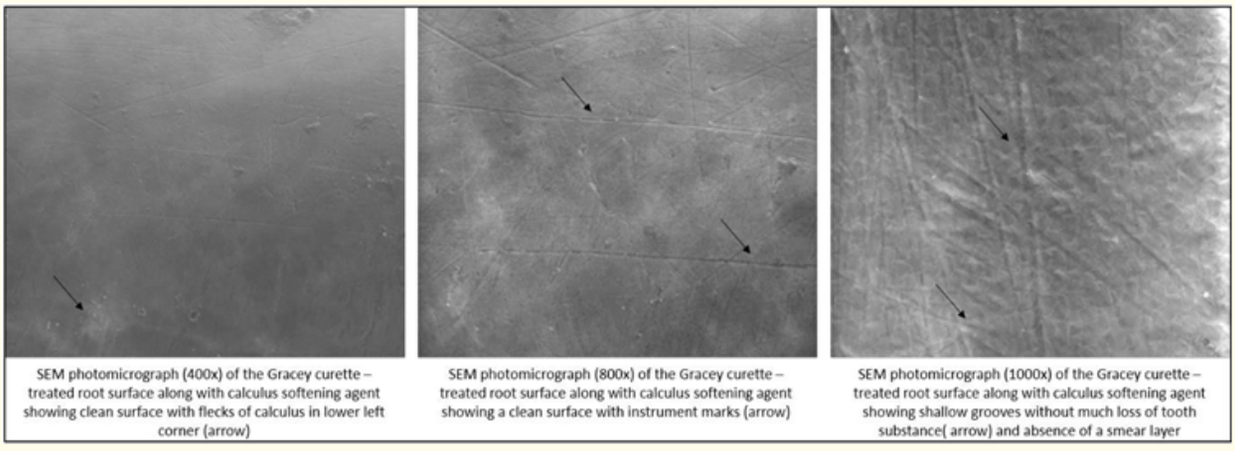

Image 2: Gracey Curette-Treated Root Surfaces with a Calculus Softening Agent.

- **400x Magnification**: Patches of calculus remain, indicating incomplete removal by the ultrasonic scaler. Arrows point to these areas where deposits persist.
- **800x Magnification**: Calculus is still present, and the root surface is covered by a smear layer, a byproduct of the scaling process. This layer can hinder gum healing and reattachment if not properly removed.
- **1000x Magnification**: Microcracks, debris, and the smear layer are visible. The microcracks suggest potential weakening of the root structure due to the ultrasonic scaler's high-frequency vibrations.

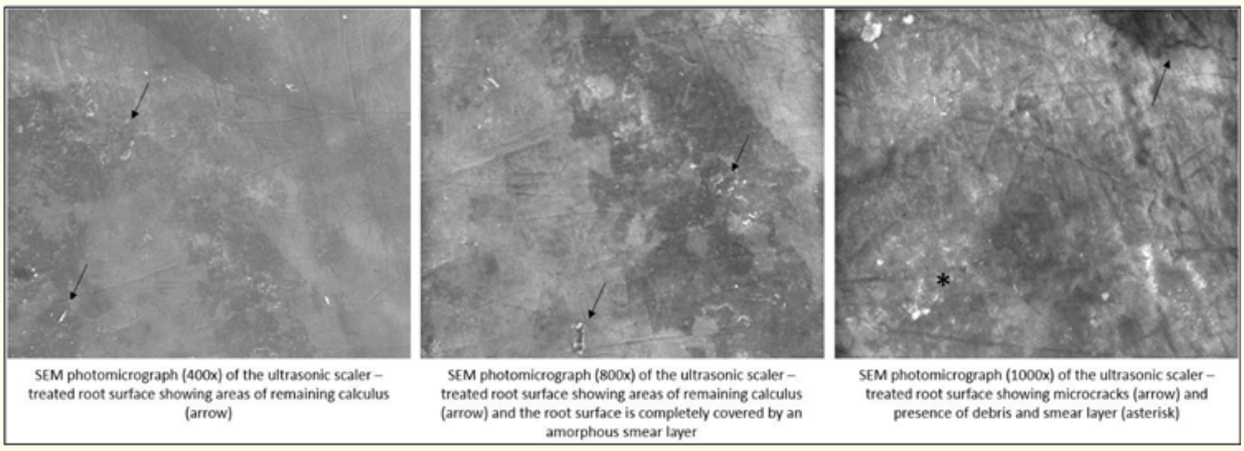

Image 3: Ultrasonic Scaler-Treated Root Surfaces.

- **400x Magnification**: The root surface appears clean and smooth, indicating that the softening agent allowed the ultrasonic scaler to remove calculus more effectively.
- **800x Magnification**: The surface remains clean with minimal tooth substance loss, suggesting that the softening agent makes the ultrasonic scaler gentler on the tooth.
- **1000x Magnification**: The root surface is free of debris and the smear layer, with only a small fleck of calculus left. Importantly, there is no evidence of tooth substance loss, which is beneficial for periodontal health.

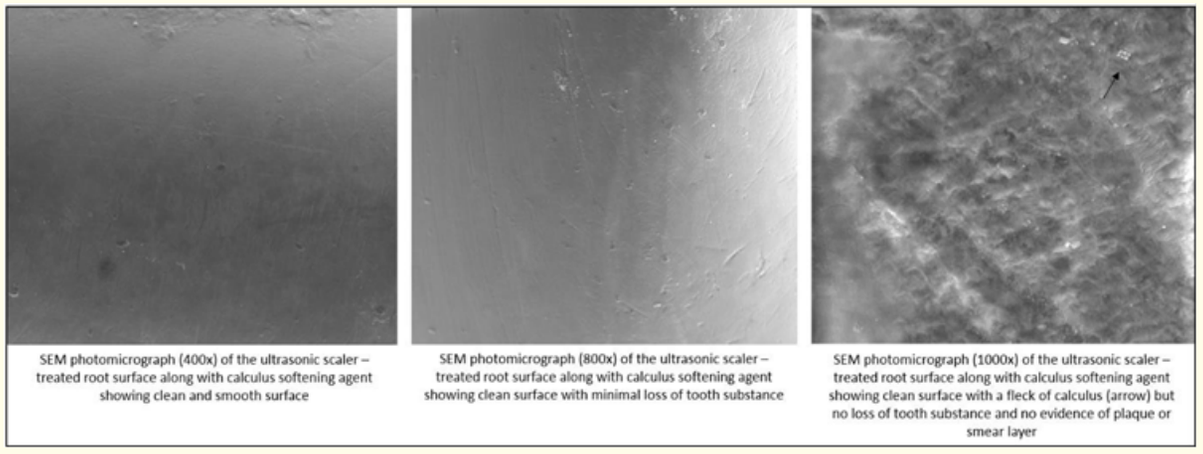

Image 4: Ultrasonic Scaler-Treated Root Surfaces with a Calculus Softening Agent.

Results and Discussion

Results

Loss of tooth substance Index (LTSI) * Group.

Loss of tooth substance index (LTSI)

Group 1a (manual SRP without softening agent) showed significant tooth loss, while Group 2b (ultrasonic SRP with softening agent) preserved more tooth structure.

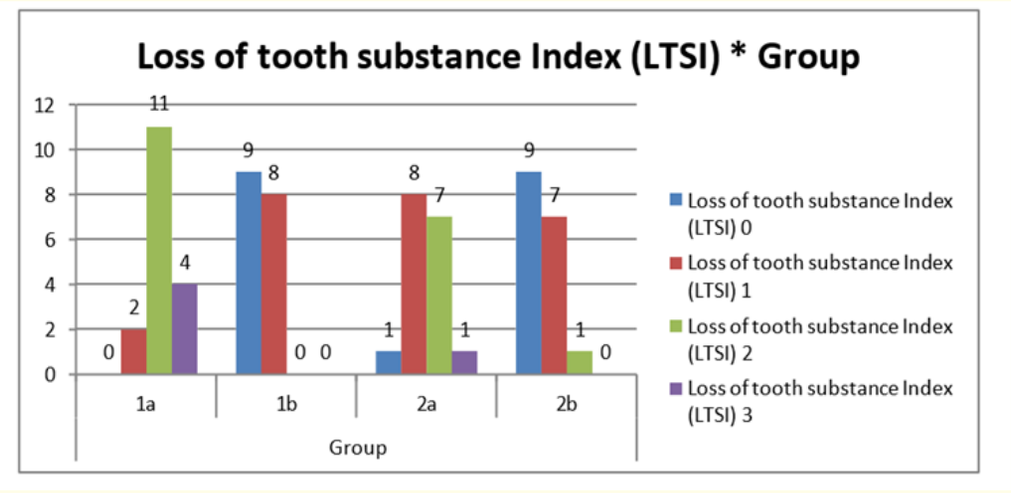

Figure 3

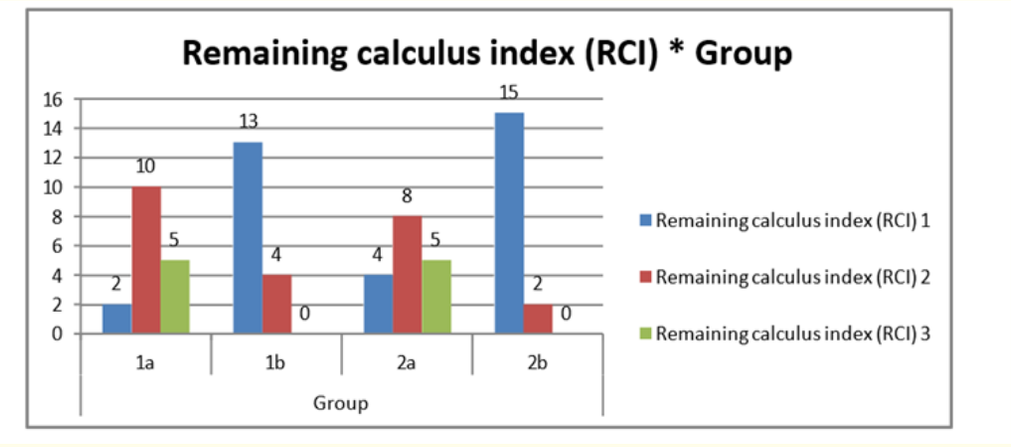

Figure 4

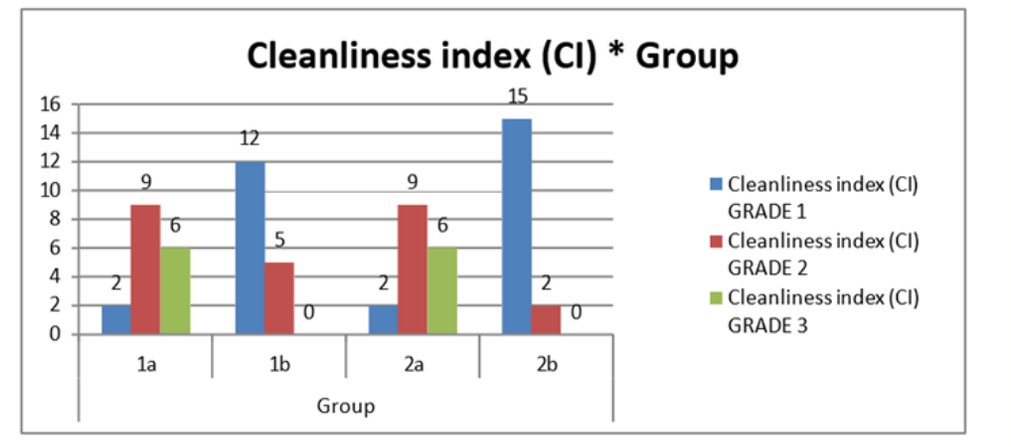

Figure 5

Remaining calculus index (RCI) * Group.

Remaining calculus index (RCI)

Group 2b had the fewest calculus remnants, as the softening agent improved ultrasonic cleaning effectiveness.

Cleanliness index (CI) * Group.

Cleanliness index (CI)

Group 2b scored highest for cleanliness, with smooth, debris-free root surfaces, unlike the less effective manual SRP in Group 1.

Discussion

The findings suggest that ultrasonic SRP, particularly when paired with a calculus softening agent, is more effective in calculus removal and root surface cleanliness than manual SRP alone. These findings are in line with previous studies conducted by Wilkinson., *et al*. (1973) indicating the limitations of manual instrumentation in removing calculus without causing considerable root surface damage [8]. Manual SRP, although effective, can leave deep scratches and result in cementum and dentin loss, potentially compromising long-term tooth integrity.

The addition of a calculus softening agent (primarily comprising xylitol and DMI) has several benefits. Xylitol disrupts biofilm formation, reducing bacterial adherence, while DMI acts as a solvent and penetration enhancer, allowing more effective calculus removal without excessive force. SEM images from this study showed that the softening agent aids in loosening calculus deposits, enabling ultrasonic scalers to achieve a cleaner, smoother root surface with fewer structural compromises.

Clinical implications

In clinical settings, this study suggests that combining ultrasonic SRP with a calculus softening agent may offer optimal outcomes for periodontal patients, balancing effective calculus removal with minimal risk to tooth integrity. This approach may benefit patients requiring repeated SRP procedures by preserving more of the tooth's natural structure over time.

Limitations and future research

The study's *in vitro* nature limits its ability to replicate complex oral conditions such as salivary flow and patient-related factors. Dentinal exposure can be eliminated by reducing the concentration of active ingredients of the solution and standardizing the magnitude of pressure of instrumentation. Future *in vivo* studies are necessary to validate these results in clinical settings. Further research should also examine the long-term effects of repeated ultrasonic SRP with softening agents on tooth and gum health, as well as determine the ideal concentration of softening agents for maximum efficacy and safety.

Conclusion

Ultrasonic scaling, especially when used in conjunction with a calculus softening agent, demonstrates significant advantages in terms of calculus removal and minimal tooth substance loss. The addition of softening agents not only enhances the cleaning efficiency but also mitigates the risk of over-instrumentation, preserving tooth structure. Adopting this method in clinical periodontal therapy could improve patient outcomes, providing a balance between effective cleaning and structural preservation. Future studies will help solidify these findings and potentially shape periodontal treatment protocols.

Conflict of Interest

No conflict of interest.

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