Profilometric Analysis of Root Surface Roughness Using 0.2% Chlorhexidine and 2% Povidone Iodine as An Ultrasonic Liquid Coolant

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Abstract:
Objective: This study was aimed to compare the effect of **0.2% Chlorhexidine, 2% Povidone iodine and Distilled water** as an ultrasonic liquid coolant on the roughness of root surface using profilometer after ultrasonic scaling.
Material and Method: This study utilized 40 extracted single-rooted teeth, including incisors, canines, and premolars. Ultrasonic scaling was performed in vitro using piezoelectric scalers. The teeth were randomly divided into control and experimental groups. Ultrasonic liquid coolants were procured directly from the market for the procedure.
Experimentation: Ultrasonic scaling was performed at a constant frequency using linear oscillations on the root surface, with movements maintained parallel to the long axis of each tooth. Each group was then subjected to profilometric analysis to evaluate root surface roughness.
Results: A significant difference was observed between the control and experimental groups ($P < 0.05$); however, no statistically significant difference was found among the experimental groups ($P > 0.05$).
Statistical Analysis: Intragroup surface roughness changes were analysed using **Post hoc analysis**, while intergroup comparisons were done with **one-way ANOVA**.
Conclusion: Neither 0.2% Chlorhexidine nor 2% Povidone Iodine can be regarded as reliable ultrasonic liquid coolants for minimizing root surface roughness during ultrasonic scaling.

Keywords: Profilometric analysis, Root surface roughness, Ultrasonic coolant, 0.2% Chlorhexidine, 2% Povidone iodine, Distilled water.

1. INTRODUCTION:

Chronic periodontitis is a microbial infection that causes inflammation of the tooth-supporting structures, leading to progressive loss of attachment and bone, and is marked by the development of periodontal pockets and/or gingival recession (1).
The primary aim of periodontal therapy is to remove bacterial biofilm and calculus from the root surfaces to restore and maintain healthy periodontal tissues. Scaling and Root Planning (SRP) plays a vital role in

preserving periodontal health and preventing disease recurrence. Therefore, the root surface should be carefully smoothened with minimal trauma [2].

However, SRP can lead to root surface irregularities, which may act as a nidus for plaque accumulation, potentially contributing to the recurrence of periodontitis. A normal dento-epithelial junction typically regenerates in regions where subgingival plaque and calculus have been removed [3]. Although tooth surface polishing is often done after oral prophylaxis to create a smooth surface, root surface polishing is not commonly performed after root planning [4].

During the use of ultrasonic scalers or air rotors, aerosols containing droplet nuclei are released, which can persist in the air for extended periods and may facilitate the spread of infectious diseases among patients and dental professionals [5].

Veksler et al. demonstrated that using a 0.12% chlorhexidine (CHX) gluconate rinse before dental procedures significantly decreases the aerobic and facultative microbial flora in the oral cavity [6]. When used as a pre-procedural rinse, povidone iodine (PVP) helps sustain the reduction of gingival surface microbes throughout the prophylaxis procedure [5].

At present, several polishing techniques are utilized, such as rotating rubber cups, nylon bristle brushes, polishing pastes, pumice, and air powder systems. Each of these methods in periodontal therapy has distinct benefits and drawbacks regarding the smoothness of enamel and root surfaces.

To the best of our knowledge, no English-language studies have assessed root surface roughness using different ultrasonic coolants within a single in vitro investigation.

The purpose of this research was to analyze the root surface roughness of extracted human teeth subjected to SRP with various ultrasonic coolants.

HYPOTHESIS:

1. Cavitation-Induced Microbubble Action

The use of 0.2% chlorhexidine as an ultrasonic coolant may promote enhanced cavitation, resulting in the generation of microbubbles during scaling. The rapid implosion of these microbubbles produces localized acoustic forces that assist in loosening and removing plaque and calculus deposits. This mechanism may reduce the dependency on direct scaler-to-tooth contact, thereby decreasing surface friction and helping to maintain a smoother root surface.

2. Electrostatic Binding and Surface Protection

Chlorhexidine possesses a positive charge due to its bisbiguanide structure, enabling it to adhere effectively to negatively charged surfaces such as root dentin and microbial cell walls. This ionic interaction facilitates the formation of a thin film over the root surface, which may serve as a protective barrier during instrumentation. As a result, this layer could buffer mechanical contact from the ultrasonic tip, minimizing microscopic abrasions and preserving root surface integrity.

3. Long-Term Binding and Smear Layer Preservation

One of chlorhexidine's key properties is its ability to bind strongly to oral surfaces, a phenomenon known as substantivity. This allows the agent to remain active for extended durations, even after the procedure. Its affinity for salivary proteins and dentin may contribute to the stabilization of the smear layer produced during ultrasonic scaling. By maintaining this layer, the underlying dentin is shielded from direct exposure, thus reducing the extent of surface roughness.

2. MATERIAL AND METHOD

The study utilized 40 extracted single-rooted teeth with closed apices, extracted for periodontal or orthodontic reasons. Teeth presenting with prosthetic restorations, fractures, external resorption, carious lesions, abrasion, or erosion were excluded from the sample. Ethical committee clearance was obtained.

Fig 1. Armamentarium

2.1 Sample Preparation and Grouping

2.2 All extracted teeth were thoroughly rinsed with distilled water and stored in saline to maintain hydration until the start of the experiment. Subsequently, the samples were randomly divided into four groups.

2.3 Inclusion criteria

1. Extracted single rooted teeth with closed apex
2. Teeth extracted for periodontal and orthodontic purposes.

2.4 Exclusion criteria

1. Teeth with root caries.
2. Teeth exhibiting cervical abrasions.
3. Teeth affected by pulpal or periapical pathologies.
4. Teeth restored with prostheses or showing fractures.
5. Teeth displaying signs of external root resorption.
6. Teeth with any form of caries, abrasion, or erosion.

2.5 Experimental groups

Group 1 (control group): Before SRP (10 teeth)
Group 2 (Test group): Ultrasonic scaling using 0.2% chlorhexidine (10 teeth)
Group 3 (Test group): Ultrasonic scaling using 2% povidone iodine (10 teeth)
Group 4 (Test group): Ultrasonic scaling using distilled water (10 teeth)

2.6 Working zone/ instrumentation zone determination

The mesial or distal cementoenamel junction (CEJ) of each tooth was identified using an explorer and marked accordingly. An area 2–3 mm apical to the CEJ was designated as the instrumentation or working zone.

2.7 Clinical procedure

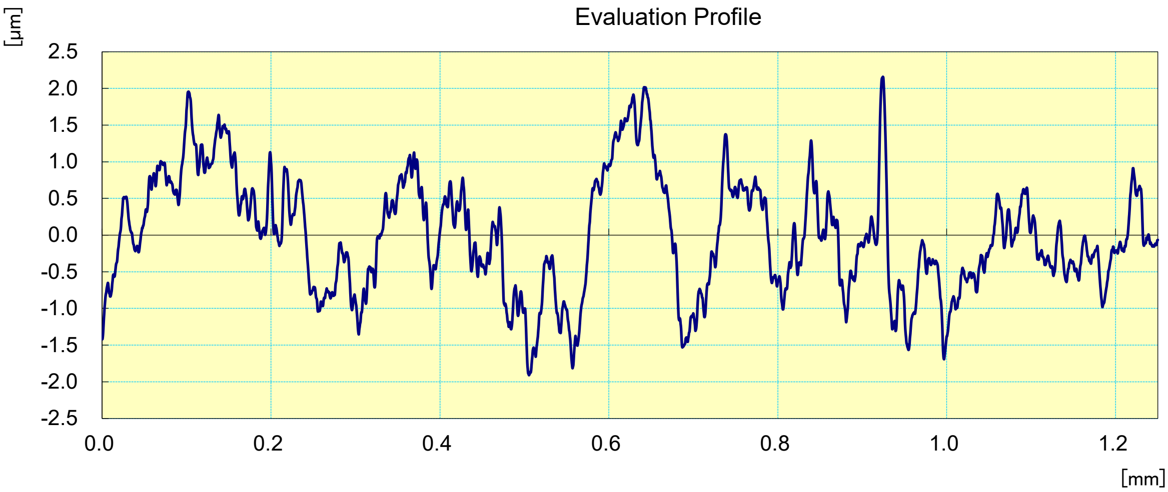
The ultrasonic coolant used for the treatment—0.2% chlorhexidine, 2% povidone iodine, and distilled water—was diluted in a 1:1 ratio. A total of 15 strokes of ultrasonic instrumentation was carried out on the root surface in an apical-to-coronal direction using linear oscillations at a frequency of 50 kHz. All movements were executed parallel to the tooth's long axis, with consistent angulation and controlled force maintained throughout the procedure. **Figure 2** illustrates the ultrasonic instrumentation using 0.2% chlorhexidine as the coolant, **Figure 3** shows the procedure with 2% povidone iodine, and **Figure 4** depicts the use of distilled water as the coolant.

2.8 Evaluation of root surface roughness

Root surface roughness in the specified instrumentation area was evaluated using a contact profilometer, with measurements taken at two different time intervals during the study.
Time period 1: Prior to SRP
Time period 2: Following SRP

2.9 Profilometric analysis

Surface roughness was measured using the Ra value, which indicates the average irregularity of the root surface.
Ra is defined as the mean difference between the peaks and valleys of the surface profile and is expressed in micrometres (µm).



Graphical representation of surface roughness using profilometer.

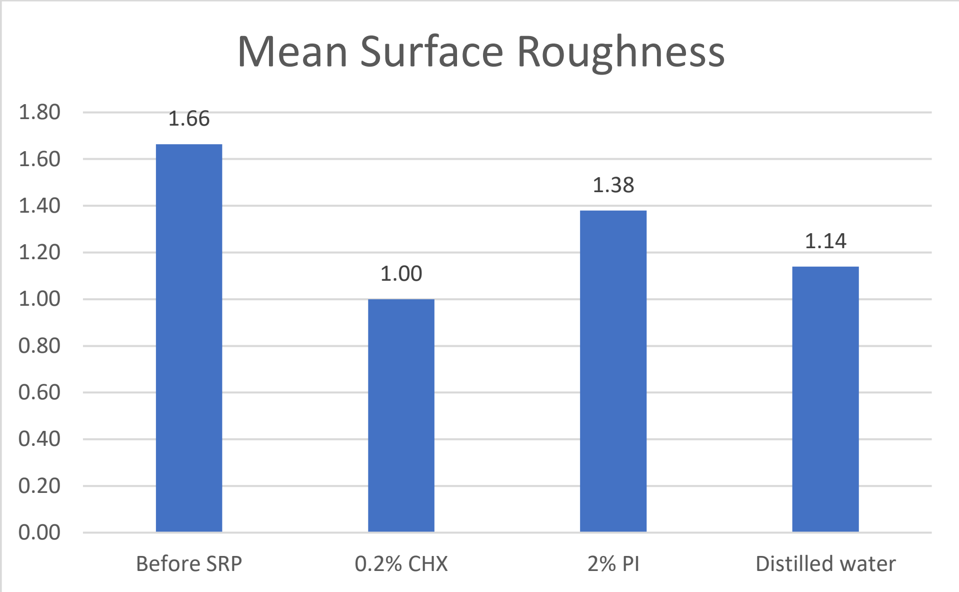
3. STATISTICAL ANALYSIS

The primary assumption was that all teeth exhibited uniform hardness and responded similarly to the treatments applied. Statistical analysis was performed using SPSS software, with data categorized based on the different treatment modalities. For determination of **intergroup analysis of root surface roughness, one way ANOVA** test was performed and for **intragroup analysis Post hoc test** was performed.

4. RESULTS

The current study was designed to assess the alterations in root surface roughness before and after scaling and root planning (SRP) in order to evaluate the effectiveness of different ultrasonic liquid coolants.
All teeth included in the experimental groups were treated using different ultrasonic coolants, applied in three distinct dimensions as detailed in the Materials and Methods section.
Post-instrumentation, surface topography was assessed through profilometric analysis, supplemented by representative photomicrographs for visual reference.

Evaluation of root surface roughness



Mean Ra value before SRP - 1.66 µm
Mean Ra value after SRP with 0.2% Chlorhexidine gluconate – 1.00 µm
Mean Ra value after SRP with 2% Povidone iodine – 1.38 µm
Mean Ra value after SRP with distilled water – 1.24 µm
Inter group analysis of post-instrumentation Ra values

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Before SRP	10	1.6641	0.53121	0.16798	1.2841	2.0441	0.86	2.49
Distilled water	10	1.1353	0.44371	0.14031	0.8179	1.4527	0.59	1.83
0.2%Chx	10	1.0001	0.39304	0.12429	0.7189	1.2813	0.63	1.71
Povidone-Iodine	10	1.3759	0.58215	0.18409	0.9595	1.7923	0.69	2.25
Total	40	1.2939	0.53838	0.08513	1.1217	1.4660	0.59	2.49

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.552	3	0.851	3.500	0.025
Within Groups	8.752	36	0.243		
Total	11.304	39			

P-value of 0.025<0.05 indicate that there is a significant difference between mean surface roughness between the study groups.

Post Hoc Tests - *Intra group analysis:*

(I) Groups		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Before SRP	Distilled water	0.52880	0.22050	0.096	-0.0651	1.1227
	0.2%Chx	.66400*	0.22050	0.023	0.0701	1.2579
	Povidone-Iodine	0.28820	0.22050	0.565	-0.3057	0.8821

p – Value of 0.096 <0.1 significant difference in Statistical reliability (SR) between groups Before SRP & Distilled water or vice-versa at 90% confidence level
p – Value of 0.023<0.05 significant difference in Statistical reliability (SR) between groups Before SRP & 0.2% Chlorhexidine or vice-versa at 95% confidence level.

5. DISCUSSION

Gingivitis and periodontitis are mainly driven by local factors, including plaque and calculus, as well as the host immune response to these irritants. Furthermore, systemic conditions like diabetes, lifestyle habits such as smoking, and other chronic diseases play a significant role in the initiation and progression of periodontal disorders [(7)].
Scaling and root planning (SRP) is carried out to remove plaque, calculus, and endotoxins adhered to the cementum, with the goal of creating a smooth root surface that discourages further plaque buildup. This procedure helps prevent additional bacterial colonization on the root surface. A key clinical indicator of effective subgingival debridement is a noticeable reduction in periodontal inflammation, such as bleeding on probing (BOP) [(8)].
An Ra value of 0.2 µm is considered the recommended standard for achieving optimal surface smoothness [(6)]. In a study by Kerry, root surfaces were treated using different methods—manual curettes alone, ultrasonic alone, manual curettes followed by ultrasonic, and ultrasonic followed by manual curettes [(9).] The findings revealed that the groups where instrumentation ended with manual curettes demonstrated significantly smoother surface roughness compared to those finished with ultrasonic treatment.
According to Pawan Kumar et al., the mean roughness value (Ra) was observed to be highest when SRP was performed with an ultrasonic scaler at a low power setting, compared to the medium power mode [(10)].
Prolonging instrumentation time can enhance the removal of calculus, resulting in a smoother root surface. However, excessive scaling may also lead to iatrogenic surface roughness. Nevertheless, the presence of residual subgingival calculus is likely to pose a greater risk to periodontal health than the roughness caused by instrumentation [(11)].
Variations in the application parameters of ultrasonic scalers can lead to notable differences in their effects on root surfaces. Both magneto-strictive and piezoelectric ultrasonic scalers produce comparable levels of wear and surface roughness when operated under similar conditions [(12)]. Nur Ayman Abdul Hayei et al.

reported that the use of a slim scaler tip design results in reduced tooth substance loss compared to a conventional wide tip design. Additionally, this clinical study observed that patients experienced less pain with the slim tip than with the conventional design [13].

Subgingival irrigation using a chemotherapeutic agent can serve as a valuable adjunct in periodontal therapy by reducing pathogenic microorganisms and enhancing clinical outcomes. Combining an ultrasonic device with a chemotherapeutic agent may further disrupt the subgingival microbial ecosystem, potentially increasing microbial exposure to the antimicrobial action of the irrigant [14].

Chlorhexidine is one of the most commonly used irrigant with antimicrobial property and also for pre procedural rinse in order to reduce the bacterial load before any surgical / non-surgical procedure The effectiveness of chlorhexidine is influenced not only by its antimicrobial properties but also by its ability to adhere to oral surfaces, which extends its antimicrobial activity [15]. Owing to its broad-spectrum efficacy and high substantivity, chlorhexidine is considered the gold standard for plaque control. Irrigation protocol using 2% CHX solution diluted in water has shown to preserve the mechanical properties of Ra (surface roughness) of the root dentin [16].

Elemental iodine and its derivatives, such as the polyvinylpyrrolidone-iodine complex (PVP-iodine), are regarded as some of the most powerful and broad-spectrum antiseptics available. Diluted PVP-iodine has been shown to effectively eliminate *Aggregatibacter actinomycetemcomitans*, *Porphyromonas gingivalis*, and other periodontal pathogens in vitro within 15 seconds of contact, while eradicating bacteria and yeasts in vivo within 5 minutes of exposure [17].

In a study by Rashmi Jawade et al, both Chlorhexidine gluconate and Povidone iodine showed better colony forming unit (CFU) reduction when used as an ultrasonic liquid coolant when compared to distilled water [4]. Chlorhexidine has been found to be more effective than povidone-iodine in 7 out of 8 cases for preventing overall, superficial, and deep surgical site infections (SSI) [18].

Kotsilkov et al. reported that subgingival irrigation with 10% povidone-iodine led to greater reductions in probing depth, enhanced clinical attachment gain, and improved gingival inflammation control compared to sites treated with SRP alone [19].

A variety of materials and techniques are employed in polishing procedures. Research has shown that polishing can effectively remove plaque, reduce bacterial accumulation, and smoothen the tooth surface following scaling. However, it may also lead to undesirable effects such as abrasion and dentin hypersensitivity. Additionally, polishing is time-consuming and must be performed as a separate step. This study was conducted to evaluate changes in root surface roughness after the application of different ultrasonic liquid coolants, aiming to assess their polishing effectiveness on root surfaces.

CONCLUSION:

The results of this study indicate a statistically significant reduction in surface roughness when comparing the control group with the experimental group, but when compared within the experimental group there is no significant reduction in mean Ra value. The reduction in surface roughness observed in this study does not match the smoothness achieved through a separate polishing procedure typically performed after SRP. This is because the coolants used during SRP only minimally decreased the root surface irregularities compared to conventional polishing agents.

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