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Root surface changes following manual and ultrasonic instrumentation - a scanning electron microscopic study

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Abstract. – OBJECTIVE: The aim of this study is to assess the efficacy of hand and ultrasonic scaling and to evaluate the surface roughness on the root surface of periodontally involved teeth using a scanning electron microscope.

PATIENTS AND METHODS: A sample of 90 single-rooted teeth with a hopeless prognosis was selected for the study and divided into three separate groups. Group I consist of no treatment. In Group II, hand scaling was done using Gracey curettes, and in Group III, ultrasonic scaling was done. The teeth were then extracted and fixed in 10% formaldehyde solution for 24-48 hours and subjected to scanning electron microscopic (SEM) evaluation.

RESULTS: The SEM analysis revealed that the remaining calculus index was found to be similar in the ultrasonic group and the hand scaling group, whereas the surface roughness was found to be the least in the ultrasonic group.

CONCLUSIONS: Hand instrumentation has resulted in more surface roughness as compared to ultrasonic instruments.

Key Words:
Hand instrumentation, Scanning electron microscope, Root surface, Ultrasonic instrumentation.

Introduction

Periodontal disease is widely recognized as one of the leading causes of tooth loss. Despite the fact that bacterial plaque and calculus are well-established etiological factors in the onset and progress of periodontal disease, a roughened root surface promotes their accumulation and attachment. The initial stage of periodontal therapy involves removing the primary etiological elements, from the tooth's surface in order to create a physiologically acceptable root surface. Therefore, oral hygiene instructions in conjunction with scaling and root planning are critical for both the treatment and the prevention of periodontal disease[1].

Complete elimination of dental calculus from root surfaces is regarded as a fundamental prerequisite for optimal periodontal therapy. Mechanical removal of these deposits from the root surface is required for establishing and maintaining periodontal health. Although hand instruments were the physicians' initial choice, they demanded a high level of manual dexterity for their effective operation. Furthermore, the inability to reach deep periodontal pockets, ambiguity about the sharpness of the instrument, and the duration of time required to attain is the principal constraints of manual instrumentation[2].

To overcome these challenges associated with the use of hand instruments, power-driven instruments have been developed. These are found to be more effective in deep and narrow infra bony pockets, and furcation areas and are more time efficient and less tiring to dental practitioners[3]. The mechanism of ultrasonic scalers includes the vibrations that aid in biofilm removal, the acoustic effects, and the mechanical chipping action of the oscillating scal-

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er probe assists in the removal of calculus deposit[4]. However, it has been reported that these power-driven scalers can also cause roughness of root surfaces[5,6]. Hence, the current study was undertaken to compare the efficacy of hand scaling and ultrasonic instrumentation on the root surface of periodontally involved teeth and to assess the root surface roughness using a scanning electron microscope.

Patients and Methods

The study was conducted among the patients who visited our institution's Department of Periodontology. Patients who were advised for extraction of periodontally affected teeth having grade III mobility with a hopeless prognosis were selected for the study. The Institutional Ethical Committee accepted the study's design (IEC). Before taking part in the trial, each patient gave their informed consent. All the procedures were followed in accordance with the Declaration of Helsinki and the Good Clinical Practice Guidelines.

Inclusion and Exclusion Criteria

The criteria for inclusion were i) systemically healthy patients with moderate to severe generalized chronic periodontitis, ii) patients with periodontally affected single-rooted teeth with poor prognosis indicated for extraction, iii) the teeth had pocket depth ≥ 6-7 mm following Phase-I therapy, and iv) extracted teeth with intact root surface. The exclusion criteria were i) patients who had undergone periodontal therapy in the past 6 months, ii) teeth with carious lesions or restorations on the root surface, iii) patients under any medications within a 6-month period, iv) patients using tobacco or tobacco related products, iv) patients with known systemic diseases, and v) patients with any known allergies.

Group Stratification

A sample of 90 single-rooted teeth was included in the study, which was grouped as Group I, including 30 extracted teeth in which no treatment was done. In Group II, 30 teeth were selected, and a notch with a small bur was made on the tooth surface to mark the free gingival margin and the lateral extent of the probing depths under evaluation. Treatment was done within the confines of the marking. Subgingival scaling and root planning were carried out by using Gracey curette #1-2 and #3-4 (Hu-Friedy, Chicago, IL, USA). These teeth were then extracted.

The root instrumentation was continued until the root felt smooth and hard when the explorer tip was passed over the treated surface. In Group III, 30 teeth were selected, and the treatment area was demarcated similarly to Group II. These teeth were treated using G6 piezo ultrasonic scaler tip (Satelec, San Diego, CA, USA) and subgingival scaling was carried out. The root instrumentation was performed with very light horizontal pressure, moving the instrument back and forth in a sweeping motion with only the lateral side of the insert in contact with the surface so that the pattern of vibration is parallel to the root surface. A piezo ultrasonic scaler (tip G6) was used with medium power setting under water irrigation. The teeth were rinsed in running tap water immediately after extraction and the soft tissue was removed. The teeth were then fixed in 10% formaldehyde solution for 24-48 hours and subjected to scanning electron microscopic evaluation (JEOL JSM-836QA at 130X). The specimen was affixed to SEM stubs, grounded with silver paint, coated with gold/palladium, and then examined under the scanning electron microscope.

The entire test surface of each specimen was scanned initially to obtain a general overview of the surface topography. Standardized photomicrographs of the selected sites were obtained. The data obtained were interpreted and subjected to statistical analysis. The efficacy of each treatment carried out with the two groups was assessed based on the amount of remaining calculus and roughness using the following indices:

Remaining Calculus Index (RCI)[7]:

1. No calculus remaining on the root surface.
2. Small patches of calculus confined to relatively small areas.
3. Definite patches of calculus are confined to relatively small areas.
4. Considerable amount of remaining calculus, appearing as one or a few voluminous patches or as several patches scattered on the treated surface.

Root surface roughness will be evaluated visually as under[2]:

1 = "Smooth" (glassy surface).
2 = "Slight" (slight irregularities).
3 = "Moderate" (moderate irregularities).
4 = "Rough" (definitive gouges, grooves and nicks).

Statistical Analysis

The values obtained after recording the Remaining calculus index and the Root surface roughness index using a scanning electron mi-

Table I. The mean scores of the remaining calculus index (RCI).

Groups	Mean	N	Std. Deviation
Group I	2.83	30	0.38
Group II	1.00	30	0.01
Group III	0.83	30	0.38

croscope were tabulated and then descriptive and inferential calculations were done using the computer software program SPSS version 21.0 [Statistical Package for Social Science, Version 21 (IBM Corp., Armonk, NY, USA)]. The means of all the values were calculated with standard deviation and are shown in Tables I for RCI (Remaining Calculus Index) and Table III for RSR (Root Surface Roughness Index) index, respectively. One-way ANOVA was used to calculate the comparison and *p*-value between different groups, which are shown in Table II and IV for RCI index and RSR index, respectively. In all the above statistical tools, the probability value $p \leq 0.05$ was considered significant.

Results

Root surfaces of the extracted teeth were examined using SEM to check for the remaining calculus and root surface roughness. The mean scores of the remaining calculus index (RCI) for Groups I, II, and III are 2.83 ± 0.38, 1.00 ± 0.01, and 0.83 ± 0.38, respectively (Table I), which show that hand instrumentation is less effective than ultrasonic instrumentation. The intergroup comparison using one-way ANOVA between the three groups revealed a statistically significant difference between Group I and Group II, and also Group III with a *p*-value of 0.01 (Table II). However, when group II was compared to Group III the *p*-value was 0.09, which was not statistically significant. This shows that both Group II and III were similarly effective in removing calculus.

Table III. The mean scores of the degree of surface roughness following SEM analysis.

Groups	Mean	N	Std. Deviation
Group I	3.70	30	.46609
Group II	2.83	30	.37905
Group III	1.16	30	.37905

The degree of surface roughness following SEM analysis in all three groups showed that mean scores were 3.70 ± 0.47 in Group I, 2.83 ± 0.38 in Group II, and 1.16 ± 0.38 in Group III (Table III). Comparison between Group I and Group II and III showed a *p*-value of 0.001 which was statistically significant. The difference between Group II and III showed a *p*-value of 0.005 which was also statistically significant (Table IV), implying that the ultrasonic scaler had the least roughness when compared with the untreated control and hand-instrumented groups.

Discussion

Periodontitis is a multifactorial disease, but the main risk factor is a microbial plaque that may remain attached to the supragingival or subgingival tooth surface by mineralizing and forming calculus. Therefore, the mechanical removal of this supragingival and subgingival plaque and calculus remains the most important objective in managing gingivitis and periodontitis.

Also, attaining a smooth topography of the root surface will render the teeth plaque-free. Partial removal of cementum was established as a therapeutic procedure over a century ago in the treatment of "Pyorrhea Alveolaris[8]". A number of studies[9] have identified Gram-negative bacteria as responsible for the periodontal disease but failed to disengage this finding from the subjective immunological response of patients. Mergenhagen et al[10] in 1961 were the first to demonstrate that plaque-related Gram-negative bacteria produced the complex li-

Table II. Intergroup comparison of the remaining calculus index (RCI).

(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower bound	Upper bound
Group I	Group II	1.83	0.07	0.001*	1.6428	2.0239
	Group III	2.00	0.07	0.001*	1.8095	2.1905
Group II	Group III	0.16	0.07	0.099	-0.0239	0.3572

*Statistically significant.

Table IV. Intergroup comparison of the degree of surface roughness following SEM analysis.

(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower bound	Upper bound
Group I	Group II	0.866	.10589	.001*	0.6142	1.1192
	Group III	2.533	.10589	.001*	2.2808	2.7858
Group II	Group III	1.666	0.105	.005*	1.4142	1.9192

*Statistically significant.

popolysaccharide endotoxins described by Bøe in 1941[11]. In 1975, Aleo et al[12] showed that the cementum of periodontally involved teeth contained endotoxins and also found that this lipopolysaccharide is toxic to *in vitro* cells. It has been shown that human gingival fibroblasts do not bind to the root surfaces of periodontally involved teeth. Hand, ultrasonic, and rotary tools are currently used in calculus removal. None of these have stood out as the most effective way to remove calculus in a reasonably short amount of time, even though they have all demonstrated substantial success. In the literature, different levels of remaining calculus, despite taking up to 45 minutes per tooth and hours per quadrant, were revealed.

Limitations in tactile sensitivity, uncertainty regarding the effectiveness and sharpness of the instruments, uncontrolled root damage, and the length of time required to complete the therapeutic goal are some of the challenges connected with calculus removal. The more recent diamond-coated ultrasonic tips may offer a more dependable, efficient, and effective way to remove calculus. Therefore, the present study was conducted to evaluate the efficacy of scaling and root planning using Gracey curettes and piezo ultrasonic scalar tips in a bid to establish the most effective technique.

All the teeth were then examined using a Scanning electron microscope (SEM) to ascertain the remaining calculus and recorded as the RCI. The surface roughness of the root was measured using SEM and recorded as the RSR index. The SEM images of Group I, II, and III are shown in Figures 1, 2, and 3, respectively. Intergroup comparison between Groups-I, II, and III showed a *p*-value of 0.001, which was statistically significant. A comparison of Group II and Group III gave a *p*-value of 0.09, which was not significant. These results are similar to those found by Mishra et al[13] in 2013, who stated that

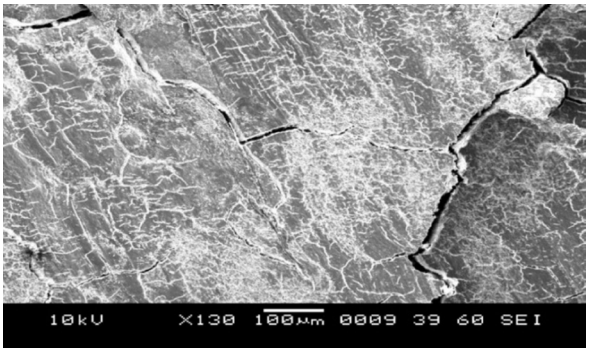

Figure 2. SEM image of Group II at 100x.

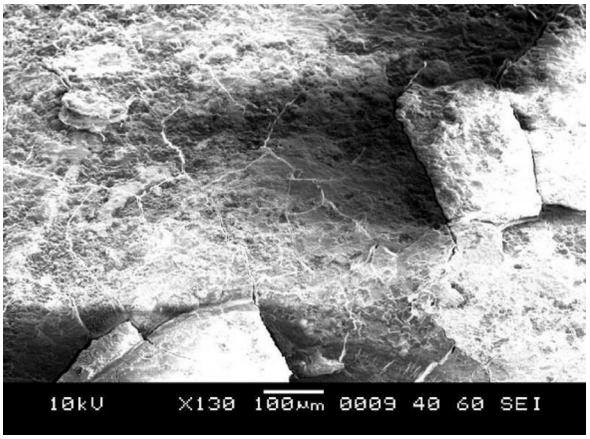

Figure 1. SEM image of Group I at 100x.

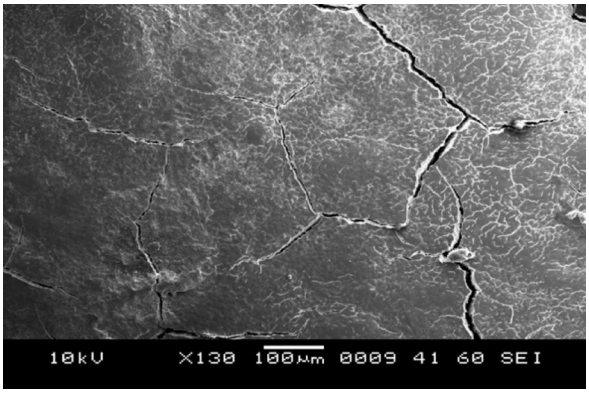

Figure 3. SEM image of Group III at 100x.

both methods were equally effective in the removal of calculus. However, it was in contrast to those of Marda et al[7], Checchi and Pelliccioni[8], Copulos et al[14], Garnick and Dent[15], who claimed that hand instrumentation was less effective.

Root surface roughness was compared in all three groups, and the mean difference was highly significant between the three groups, with *p*-value of 0.001 between Group I, Groups II, and III while it was 0.005 between Group II and III, implying that the ultrasonic scaler had the least roughness when compared with the untreated control and hand instrumented groups. These findings are similar to those by Al Ankily et al[16] in 2020, who revealed that the hand scaling method caused more increase in enamel roughness and more harmful changes to the enamel surface than the ultrasonic scaling method. This finding was, however, in contradiction with the findings by Garnick and Dent[15] in 1989 and Kumar et al[17] in 2015. Nonetheless, Zafar[18] in 2016 found that Gracey curettes and ultrasonic scalers are capable of significantly reducing the roughness following root planning. Although Gracey curettes produced smoother surfaces than ultrasonic scalers, there was no significant difference. Ultrasonic scalers have some drawbacks, such as poor tactile sensitivity, continuous emission of heat, tip size, and shape, any of which may hinder their successful functioning. The findings of this study were corroboration with studies by Marda et al[7], Lie and Meyer[19], and Khosravi et al[20].

Our study employed SEM as the basis for ascertaining the remaining calculus and root surface roughness which provides the variables for us to know which method can perform better. According to the current study, hand instrumentation and ultrasonic scaling both effectively remove calculus, with ultrasonic scaling being able to achieve a root surface that is smoother than hand instrumentation. However, because the sample size was so small, more research is required. A larger sample size should be used, and additional instruments can be added to the study to assess their impact on root surface roughness.

Conclusions

Various instruments have been compared in the literature, and root morphologic evaluations were performed using different methods. The literature ponders over the rigorous studies conducted in this context. It has been revealed that even the very basic treatment performed may cause damage. Since then, measures are constantly being taken to bring about the best possible result by developing and modifying the instruments and techniques. It has proved quite beneficial in increasing precision and skill. Within the limitation of the current study, it can be concluded that mechanical instrumentation, be it hand or powered, results in surface roughness of the root. Hand instrumentation has resulted in more surface roughness as compared to the ultrasonic instruments.

Ethics Approval

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of New Horizon Dental College & Research Institute, Bilaspur (NHDC&RI/2015/MDS/PERI/03-ECC dated 17-11-2015).

Informed Consent

Informed consent was obtained from all subjects involved in the study.

Data Availability

Not applicable.

Conflict of Interest

The authors declare that they have no competing interests.

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Authors' Contribution

Conceptualization: J. Asti, P.L. Ravishankar, K. Sunanda. Methodology: J. Wasti, A. Wasti, K. Sunanda. Software: P.L. Ravishankar, M.P.B. Rajula. Validation: P.L. Ravishankar, M.P.B. Rajula. Formal Analysis: J. Wasti, A. Wasti, K. Sunanda. Investigation: P.L. Ravishankar, A.M. Abulhamael, M.P.B. Rajula. Resources: J.Wasti, M.P.B. Rajula. Data Curation: J. Wasti, A. Wasti. Writing–Original Draft Preparation: J. Wasti, P.L. Ravishankar, A. Wasti, M.P.B. Rajula, K. Sunanda. Writing–Review and Editing: K.J. Alzahrani, K.F. Alsharif, I.F. Halawani, M. M. Alnfiai, F.M. Alzahrani, H.A. Baeshen, A. M. Abulhamael, S. Patil. Visualization: K.J. Alzahrani, I.F. Halawani, S.Patil. Supervision: K.F. Alsharif, A.M. Abulhamael, M.M. Alnfiai, H. A. Baeshen, S. Patil. Project Administration: K.J. Alzahrani, F.M. Alzahrani, H. A. Baeshen, M. M. Alnfiai. Funding Acquisition: K.F. Alsharif, I.F. Halawani, S. Patil. Final approval of the version to be published: All the authors have approved the final draft of the manuscript to be published.

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