Original Article

DOI: 10.17354/ijss/2015/563

Scaler Tip Design and Root Surface Roughness: An *In Vitro* Study

Pawan Kumar[1], Saindhya Tora Sonowal[2]

[1]Senior Resident, Department of Oral Health Sciences Center, Unit of Periodontics, Oral Health Science Centre, Post Graduate Institute of Medical Education and Research, Chandigarh, India, [2]Senior Lecturer, Department of Periodontics, Mansarovar Dental College, Bhopal, Madhya Pradesh, India

Abstract

Background: The most unfavorable alterations observed after instrumentation with ultrasonic scaler is root surface roughness. This study evaluates the influence of differently designed tips of ultrasonic scaler on root surfaces.

Materials and Methods: Both maxillary and mandibular premolars ($n = 20$), extracted for orthodontic purposes were used. Root surfaces were rinsed with water and stored in glutaraldehyde. Root planning was performed on the proximal root surfaces at the middle third. Three different tip designs (N1, N2, and N10X) were used. It was carried out on each sample in apicocoronal direction using 10 strokes at 0° angulation and with constant lateral pressure. After instrumentation, roughness was evaluated using 3D Optical Profilometer.

Results: The roughness produced after instrumentation was found to be consistent. The roughness produced with N10X was found to be highly significant in comparison to control, N1 and N2 ($P < 0.01$), while no difference was observed with N1 and N2 in comparison to the controls and in between them.

Conclusion: Roughness produced on the root surface after instrumentation is related to the surface area of ultrasonic tips and is inversely proportional.

Key words: 3D Optical profilometer, Glutaraldehyde, Mroot surface roughness, Root planning, Universal scaler tip

INTRODUCTION

The essential component of conventional periodontal therapy is the effective removal of plaque from the root surface, along with the calculus deposits, to create a biologically compatible root surface.[1] Mechanical debridement, i.e., scaling and root planning (SRP) is a fundamental part in periodontal treatment, and various instruments have been designed to achieve this goal.[2] Ultrasonic and sonic scalers and hand instruments are used for surgical and non-surgical periodontal therapy.

Access this article online

www.ijss-sn.com

Month of Submission : 10-2015
Month of Peer Review : 11-2015
Month of Acceptance : 12-2015
Month of Publishing : 12-2015

The use of ultrasonic and sonic scalers in periodontal therapy has been studied since the 1950s. These instruments have shown many advantages such as reduced instrumentation time spent per tooth and better accessibility in furcation defects.[3,4] However, complete removal of subgingival calculus with hand or machine instruments is difficult to achieve, even when a surgical approach is used.[5] To deal with this, recently, many tip designs for ultrasonic and sonic scalers have been modified to provide better access and instrumentation.[6,7]

The ideal goal of periodontal instrumentation is to effectively remove plaque and calculus without causing root surface damage. Studies evaluating differences in root surface alterations due to hand, sonic, and ultrasonic instruments are inconclusive.[8,9] Tooth substance removal by different ultrasonic devices has shown that magnetostrictive unit is more aggressive than the piezoelectric device.[10] Different surface alterations could be expected from different working tip designs since the tip geometry may significantly influence the displacement amplitude.[11]

Corresponding Author: Dr. Pawan Kumar, Oral Health Science Centre, Post Graduate Institute of Medical Education and Research, Chandigarh - 160 012, India. Phone: +91-7528936969. E-mail: drpkperio@gmail.com

Aims and Objectives

To evaluate the effects of different ultrasonic tip designs (N1, N2, and N10X) on root surface roughness post scaling.

MATERIALS AND METHODS

The present study was having two parts:

- Collection and preparation to the sample and,
- Visualization under profilometer.

The first part of the study was conducted in the Regional Dental College and Hospital, Guwahati and the second part in the Indian Institute of Technology, Guwahati.

Collection of Experimental Sample

20 mandibular and maxillary premolars extracted for orthodontic reasons were selected for this study. All teeth selected for the study were rinsed with running tap water for approximately 20 s to remove the surface debris or blood immediately after extraction. The teeth were then stored in 2% glutaraldehyde solution until use.

Tips used in this Study

Three different Piezo Electric Ultrasonic Scaler tips N1, N2, and N10X were used.

Selection Criteria

All teeth had to meet the following criteria:

Inclusion criteria

- Teeth extracted for orthodontic purpose
- Intact root surface
- Absence of caries
- No history of periodontal involvement
- Absence of gross hard and soft tissue debris
- Relatively flat surface.

Exclusion criteria

- Teeth with root concavities or convexities which impeded proper planning of root surfaces were excluded,
- Teeth extracted due to any other reasons other than orthodontic purpose.

Root planning was performed on the proximal root surfaces at the middle third. Three different tip designs (N1, N2, and N10X) were used. It was carried out on each sample in apicocoronal direction using 10 strokes at 0° angulation and with constant lateral pressure. After instrumentation, roughness was evaluated using 3D Optical Profilometer.

Mounting Procedure

After removal from the glutaraldehyde solution, the teeth were thoroughly washed with distilled water. Each tooth was then mounted in a plastic tube filled with acrylic resin, which is of 2 cm in height keeping either of the two proximal surfaces exposed without any visible surface irregularities (Figure 1). An area approximately of 5 mm which is 2 mm apical to the cementoenamel junction (CEJ) was selected for instrumentation. The samples were numbered from 1 to 20 and randomly divided into four groups as mentioned below:

- Group 1: Performed no instrumentation, regarded as control
- Group 2: Performed SRP using ultrasonic scaler tip N1
- Group 3: Performed SRP using ultrasonic scaler tip N2
- Group 4: Performed SRP using ultrasonic scaler tip N10X.

Root Scaling

Scaling was done by using piezoelectric ultrasonic scaler tips, i.e., N1, N2, and NX10 on the root surface of Groups 2, 3, and 4, respectively. 8-10 strokes in an apicocoronal direction with zero degree inclination between scaler tip and root surface of teeth was carried out by the same operator to avoid errors. Medium speed was used with water cooling according to the manufacturer's instructions (Figure 2).

Post Instrumentation Roughness Reading

The surface roughness after instrumentation was measured using non-contact based 3D Optical Profilometer (Talysurf 3D CCI Lite from Taylor Hobson, UK). 10 readings were made for each sample, from which mean was calculated. The surface roughness parameters used in this study are Ra and Rz. Ra is defined as the arithmetic mean of the absolute values of vertical deviation from the mean line through the profile. The mean line is the line such that the area between the profile and the mean line above the line is equal to that below the mean line. The Ra was calculated over the entire measured array and Rz is defined as ten points, i.e., the average absolute value of the five highest peak and the five lowest valleys over the evaluation length.

Statistical Analyses

The data collected were analyzed statistically. The following statistical methods were applied:

i. Standard deviation
ii. Analysis of variance
iii. Duncan multiple range test.

RESULTS

The observation was carried out in 05 numbers of specimens in each category. The root surface roughness produced after instrumentation with tips N1, N2, and N10X was found to be consistent. The roughness

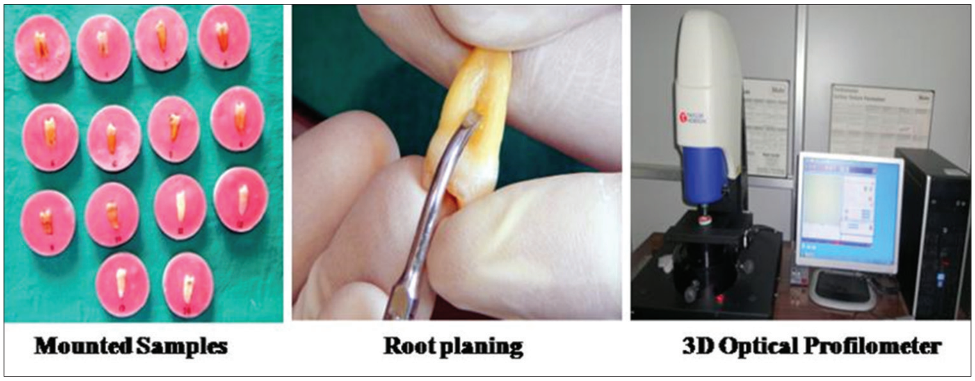

Figure 1: Mounted samples in a tube filled with acrylic resin, samples undergoing SRP and 3D Optical Profilometer used in the study

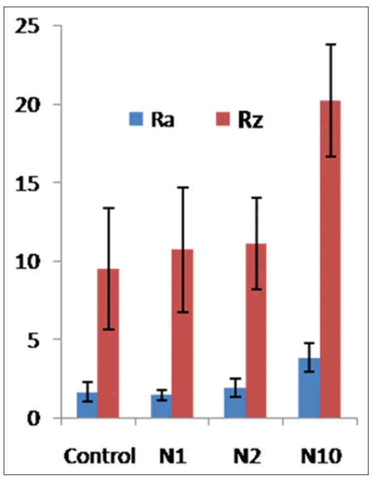

Figure 2: Mean roughness and extreme roughness values in different groups after instrumentation

produced with N10X was found to be highly significant in comparison to control, N1 and N2 ($P < 0.01$), while no difference was observed with N1 and N2 in comparison to the controls and in between them. Roughness values are measured as Ra and Rz; Ra is average of mean roughness and Rz is an average of extreme roughness values.

As shown in Table 1, the mean roughness value (R_a) was found to be the highest in Group 4 where SRP was performed using ultrasonic scaler tip N10X. The value was 3.82 ± 0.90 µm, which was followed by Groups 3 (SRP performed using ultrasonic scaler tip N2), Group 2 (SRP performed with ultrasonic scaler tip N1), and control (where no SRP was performed), the values being 1.91 ± 0.59, 1.63 ± 0.64, and 1.43 ± 0.33 µm, respectively. The lowest surface roughness was seen on the samples where SRP was not performed. These findings are graphically represented in Figure 2.

The mean roughness (Ra) observed in the various experimental groups were compared with the control group using parametric test (analysis of variance). While comparing with the control (Group 1), the roughness on

Table 1: Mean values of roughness and extreme roughness values with standard deviation in various groups

Group	R_a			R_z		
	Mean	SD	*P* value	Mean	SD	*P* value
Control	1.43	0.33		9.50	3.85	
N1	1.63	0.64	0.550	10.69	3.97	0.640
N2	1.91	0.59	0.480	11.10	2.93	0.470
N10X	3.82	0.90	0.002	20.20	3.54	0.001

SD: Standard deviation

the root surface in Group 4 was found to be statistically significant ($P < 0.05$).

Similar to the $R_{a,}$ mean of the extreme roughness values, referred to as $R_{z,}$ was found to be the highest in Group 4, where SRP was performed using ultrasonic scaler tip N10X. It was 20.20 ± 3.54 µm. As shown in Table 1, R_z in Groups 1, 2, and 3 was 9.50 ± 3.85, 10.69 ± 3.97, and 11.10 ± 2.93 µm, respectively.

These findings are graphically represented in Figure 1. The lowest R_z was observed in group 1, where SRP was not performed. Though the differences in R_z are observed among the Groups 2, 3, and 4, Group 4 was significant statistically ($P > 0.05$) (Table 1).

When the root surface roughness in terms of R_a and R_z was compared and assessed, it is observed that a similar trend of roughness was followed, i.e., the control group was found to be the smoothest with least roughness values, which was followed by Groups 2, 3, and 4 (Table 1 and Figure 3).

From the above results, it appears that maximum root surface roughness is produced in the specimens where SRP was performed with ultrasonic scaler tip N10X (Group 4), whereas the smoothest surface was observed in the specimens where no SRP was done (Group 1). Thus, the present study suggests that roughness produced on the root surface after instrumentation with differently designed

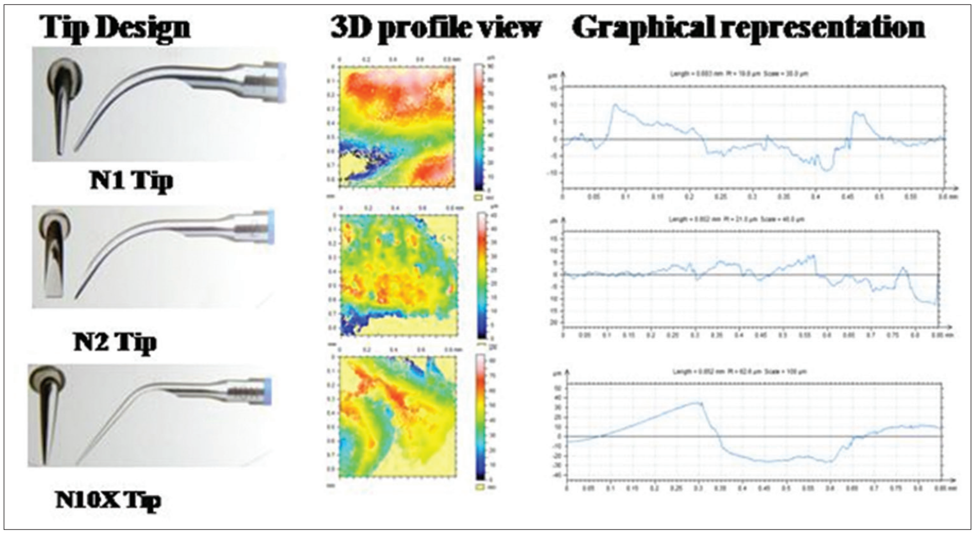

Figure 3: Tip design, with 3D profile view from Optical profilometer and graphical representation

ultrasonic tips is related to its surface area and is found to be inversely proportional.

Then, the surface appearance of one sample from each group was qualitatively assessed under 3D Optical Profilometer. The surface topography of the root surfaces was evaluated in the photographs obtained.

After instrumentation, difference in the surface topography was observed in each of the treated groups when compared to the control, untreated root surfaces. The instrumented surfaces showed surface gouges of varying depth and width along with cracks running in different directions.

Surfaces treated with the ultrasonic device varied greatly in appearance. As shown in Figure 2, the root surfaces after SRP conducted with different ultrasonic scaler tips showed multiple cracks running in various directions along with smooth surfaces in between. The smooth surface may indicate the loss of tooth substances. The variation on the root surfaces varied from relatively smooth to more irregular areas with gouges, fissures, and cracks of varying depths running in various directions over the area of instrumentation.

DISCUSSION

Ultrasonic scalers are becoming increasingly popular for subgingival debridement due to less strain for the operator and more comfort for the patients than hand instruments. It is easy to insert in narrow pockets than curettes.[12] In the present study, N1, N2, and N10X ultrasonic scaler tips were used for instrumentation. In the present study, we used 3D Optical Profilometer to find out the root surface changes after scaling. This instrument is the most sensitive device to analyze changes in the surface roughness. Ra is the most universally used roughness parameter for general quality control; this is easy to define, easy to measure, and gives a good general description of height variations. Rz is more sensitive to occasional high peaks or deep valleys than Ra.[13] According to the present study, the roughness reading showed that all treated groups presented a significant increase in roughness compared with the control group and demonstrated that the N10X ultrasonic tip caused increased roughness when compared to controls. Results were statistically significant with respect to Ra and Rz ($P < 0.05$) compared to the control group in Group 4 which was treated with an N10X type of tip.

Most of the studies have evaluated differences regarding the roughness produced by sonic, ultrasonic and hand instruments.[14] However, the angulations and design of instrument tip, sharpness of the working edge, the length of time the instrument is in contact with the root, and the cumulative numbers of strokes have an impact on the degree of root damage. Teeth extracted for the orthodontic purpose were selected for this study because premolars are most commonly extracted for while this treatment and cementum are healthy. In the case of diseased teeth, the cementum will be softened, and tips may remove the cementum more aggressively and it may give false results.[15]

Furthermore, the Roughness Loss of Tooth Substance Index has been used by some studies, but the loss of tooth substance of a specific instrument cannot be directly correlated with its produced roughness, and a separate evaluation of tooth substance loss and surface roughness produced is necessary.[7,14,16-18] Therefore, considering all these variables in previous studies, it is difficult to come to a conclusion regarding the method of instrumentation that causes the least amount of root surface alterations.

Numerous studies have demonstrated that the most important prerequisite for healing after periodontal treatment is a root surface free of plaque and calculus. Quirynen and Bollen (1995) have clarified that supragingival rough surfaces subsequent to professional instrumentation can promote plaque formation and contribute to bacterial adhesion.[19] Supragingival surface roughness and surface irregularities increase the surface area, promoting bacterial colonization, plaque formation and thereby compromising daily plaque removal.[20,21]

Leknes *et al*., (1996) demonstrated that roughness resulting from subgingival instrumentation significantly influenced the subgingival microbial colonization.[22] Then, a smooth root surface may be advantageous near the gingival margin since a smooth surface is less likely to accumulate plaque than a rough surface.

Japsen *et al*., (2004) did a similar study by using magnetostrictive and piezoelectric ultrasonic tips on the root surface, and concluded that significant increase in the aggressiveness to root dentin was seen for wide scaler tips as compared to narrow scaler tips. In contrast to that study, this study found root surface roughness is more aggressive by thinner scaler tip design than broader tip design.

Therefore, for clinical application, it can be assumed that a meticulous SRP procedure during initial cause-related therapy should be performed, and the long-term success of this treatment is dependent on the quality of the maintenance therapy.[18,23] It is important that caution should be taken while utilizing these instruments and that a higher standard of supragingival oral hygiene may be required for such patients. More studies are needed to clarify the influence of different ultrasonic tip design on the root surface roughness.

In the present study, differences in surface roughness have been found among different types of ultrasonic scaler tips, although it remains to be determined whether these differences are of clinical significance. To understand the issue of roughness created after debridement and the success of periodontal treatment, different aspects have to be distinguished: Supragingival or subgingival roughness and supragingival plaque control during healing.

Concerning subgingival roughness, some studies demonstrated that changes over subgingival root topography did not interfere with the response to periodontal treatment.[24] Rosenberg and Ash (1974) did not find that the different instruments had a significant effect on histologically assessed healing.[9] Khatiblou and Ghodossi (1983) have reported that periodontal healing following flap surgery occurs regardless of whether the subgingival root surface is rough or smooth.[25] These results were confirmed by Oberholzer and Rateitschak (1996), who have found no difference in pocket reduction and clinical attachment gain after creating rough or smooth surfaces during a flap operation.[26] This indicates that subgingival roughness does not interfere with healing if there is a good supragingival plaque control. In an animal experiment, subgingival roughness following surgery, without supragingival plaque control during healing, favored plaque retention and colonization.[27] Leknes *et al*. (1996) demonstrated that roughness resulting from subgingival instrumentation significantly influenced the subgingival microbial colonization.[22] Then, a smooth root surface may be advantageous near the gingival margin since a smooth surface is less likely to accumulate plaque than a rough surface.

CONCLUSION

In this study, root surface roughness was measured after scaling with N1, N2, and N10X scaler tips using a 3D Optical Profilometer. Within the limits of the present study, it can be concluded that large surface universal ultrasonic tips produce a more rough surface on the root surface than a thin probe type of tip. It means roughness on the root surface is inversely proportional to the surface area of the scaler tips.

ACKNOWLEDGMENT

Our special thanks to Staff of Mechanical Engineering and Central Instrument Facility of Indian Institute of Technology (IIT), Guwahati for their cooperation and constant support.

REFERENCES

1. Meissner G, Kocher T Calculus-detection technologies and their clinical application. Periodontol 2000 2011;55:189-204.
2. Lang NP. Indications and rationale for non-surgical periodontal therapy. Int Dent J 1983;33:127-36.
3. Copulos TA, Low SB, Walker CB, Trebilcock YY, Hefti AF. Comparative analysis between a modified ultrasonic tip and hand instruments on clinical parameters of periodontal disease. J Periodontol 1993;64:694-700.
4. Drisko CL, Cochran DL, Blieden T, Bouwsma OJ, Cohen RE, Damoulis P, *et al*. Position Paper: Sonic and ultrasonic scalers in periodontics. Research, Science and Therapy Committee of the American Academy of Periodontology. J Periodontol 2000;71:1792-801.
5. Caffesse RG, Sweeney PL, Smith BA. Scaling and root planing with and without periodontal flap surgery. J Clin Periodontol 1986;13:205-10.
6. Dragoo MR. A clinical evaluation of hand and ultrasonic instruments on subgingival debridement 1. With unmodified and modified ultrasonic inserts. Int J Periodontics Restorative Dent 1992;12:310-23.
7. Kocher T, Plagmann HC. The diamond-coated sonic scaler tip. Part II: Loss of substance and alteration of root surface texture after different scaling modalities. Int J Periodontics Restorative Dent 1997;17:484-93.
8. Lie T, Leknes KN. Evaluation of the effect on root surfaces of air turbine

scalers and ultrasonic instrumentation. J Periodontol 1985;56:522-31.
9. Rosenberg RM, Ash MM Jr. The effect of root roughness on plaque accumulation and gingival inflammation. J Periodontol 1974;45:146-50.
10. Flemmig TF, Petersilka GJ, Mehl A, Hickel R, Klaiber B. The effect of working parameters on root substance removal using a piezoelectric ultrasonic scaler *in vitro*. J Clin Periodontol 1998;25:158-63.
11. Gankerseer EJ, Walmsley AD. Preliminary investigation into the performance of a sonic scaler. J Periodontol 1987;58:780-4.
12. Nield-Gehrig JS. Ultrasonic and sonic instrumentation. Goucher J, Dietz KC, editors. Fundamentals of Periodontal Instrumentation and Advanced Root Instrumentation. 6th ed. Baltimore: Lippincott Williams & Wilkins; 2008. p. 535-82.
13. Gadelmawla ES, Koura MM. Roughness parameters. J Mater Process Technol 2002;123:133-45.
14. Jotikasthira NE, Lie T, Leknes KN. Comparative *in vitro* studies of sonic, ultrasonic and reciprocating scaling instruments. J Clin Periodontol 1992;19:560-9.
15. Carranza FA, Camarago PM. The periodontal pocket. Klokkevold PR, editor. Clinical Periodontology. 10th ed. Noida, U.P.: Elsevier Publishers; 2006. p. 434-51.
16. Kishida M, Sato S, Ito K. Effects of a new ultrasonic scaler on fibroblast attachment to root surfaces: A scanning electron microscopy analysis. J Periodontal Res 2004;39:111-9.
17. Kocher T, Fanghänel J, Sawaf H, Litz R. Substance loss caused by scaling with different sonic scaler inserts – An *in vitro* study. J Clin Periodontol 2001;28:9-15.
18. Schmidlin PR, Beuchat M, Busslinger A, Lehmann B, Lutz F. Tooth substance loss resulting from mechanical, sonic and ultrasonic root instrumentation assessed by liquid scintillation. J Clin Periodontol 2001;28:1058-66.
19. Quirynen M, Bollen CM. The influence of surface roughness and surface-free energy on supra- and subgingival plaque formation in man. A review of the literature. J Clin Periodontol 1995;22:1-14.
20. Leknes KN, Lie T. Influence of polishing procedures on sonic scaling root surface roughness. J Periodontol 1991;62:659-62.
21. Leknes KN, Lie T, Wikesjö UM, Bogle GC, Selvig KA. Influence of tooth instrumentation roughness on subgingival microbial colonization. J Periodontol 1994;65:303-8.
22. Leknes KN, Lie T, Wikesjö UM, Böe OE, Selvig KA Influence of tooth instrumentation roughness on gingival tissue reactions. J Periodontol 1996;67:197-204.
23. Axelsson P, Lindhe J. The significance of maintenance care in the treatment of periodontal disease. J Clin Periodontol 1981;8:281-94.
24. Chapple IL, Walmsley AD, Saxby MS, Moscrop H. Effect of instrument power setting during ultrasonic scaling upon treatment outcome. J Periodontol 1995;66:756-60.
25. Khatiblou FA, Ghodssi A. Root surface smoothness or roughness in periodontal treatment. A clinical study. J Periodontol 1983;54:365-7.
26. Oberholzer R, Rateitschak KH. Root cleaning or root smoothing. An *in vivo* study. J Clin Periodontol 1996;23:326-30.
27. Leknes KN, Lie T, Böe OE, Selvig KA. A correlation study of inflammatory cell mobilization in response to subgingival microbial colonization. J Periodontol 1997;68:67-72.

How to cite this article: Kumar P, Sonowal ST. Scaler Tip Design and Root Surface Roughness: An *In Vitro* Study. Int J Sci Stud 2015;3(9):96-101.

Source of Support: Nil, **Conflict of Interest:** None declared.