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Surface roughness of enamel and root surface after scaling, root planning and polishing procedures: An in-vitro study

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ABSTRACT

Objectives: The aim of this study was to evaluate enamel and root surface roughness on exracted human teeth by using different tecniques (ultrasonic scaler, hand instruments, polishing paste, pumice and air powder system).
Materials and methods: A total of 200 samples were divided into two groups (enamel and root) randomly with 100 samples for each enamel and root groups. The groups were divided into 5 subgroups: Group I: ultrasonic scaler, group II: hand instruments, group III: polishing paste, group IV: pumice, group V: air-powder. Surface roughness (Ra) was assessed with Mitutoyo SJ-410 device. The one-way analysis of variance (ANOVA) test along with the Tukey test was used for statistical analysis. P values less than 0.05 were considered statistically significant.
Results: The use of ultrasonic scalers caused the highest roughness increase on the enamel surface (0.935 ± 0.010), whereas the use of pumice was the least (0.896 ± 0.018) ($p < 0.05$). There was a significant difference between ultrasonic scalers and all the groups (hand instruments, polishing paste, pumice and air powder system) on enamel surface ($p < 0.05$). Maximum surface roughness increase was observed in the ultrasonic scalers on root surface. There was a significant difference between ultrasonic scalers and polishing paste, pumice and air powder on root surface, respectively ($p < 0.05$).
Conclusion: The use of ultrasonic scalers cause more rough enamel and root surfaces than hand instrumentation and polishing tecniques.
Clinical relevance: Uneven surfaces adversely affect the intended periodontal healing by creating a retention area of microbial dental plaque.

1. Introduction

Chronic periodontitis is an inflammatory disease of the structures supporting the teeth and periodontium. It occurs as a result of interactions between the microbial dental plaque layer colonized and the non-specific/specific host responses at the gingival side.[1,2] The purpose of periodontal treatment is to remove bacterial deposits and calculus from the root surface and obtain healthy periodontal tissues.[3]

Ideally, the external tooth coloration, plaque, calculus, and bacterial components should be removed during the scaling and root planing (SRP). The teeth surface should be smoothened with minimal damage.[4] SRP procedure, plays an important role in maintaining periodontal health and preventing recurrence of the disease.[5,6] For this purpose, hand instruments were commonly used in the past. Nowadays, sonic and ultrasonic devices are often used in addition to hand instruments in periodontal treatment.[7,8]

The roughness of the residual root surface as a result of instrumentation, is another important consideration in periodontal therapy.[9,10] The main objective of polishing is to obtain the most smooth surface possible by removing stains and bacterial plaque. Polishing can be considered as the final stage of periodontal treatment after SRP.[10,11] Today, different polishing tecniques is used such as the rotating rubber cup, the nylon bristle brush, polishing paste, pumice and air powder system.[7,9]

All of these tecniques used in periodontal treatment have different advantages and disadvantages related to the roughness of the enamel and root surface. However, to best of our knowledge, no studies in English language evaluated different SRP techniques and polishing methods in the same in vitro research.

The aim of this study was to evaluate enamel and root surface roughness on exracted human teeth by using different tecniques

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(ultrasonic scaler, hand instruments, polishing paste, pumice and air powder system).

2. Material and method

Two hundred extracted human maxillary central and premolar teeth which were lost due to periodontal and orthodontic reasons, were used. Teeth with prosthesis, fracture, showing signs of external resorption, caries, abrasion, and erosion were excluded. Institutional Review Board Approval was obtained (14.12.2017/17/24).

2.1. Sample preparation and group divisions

All teeth were washed with distilled water and stored in saline solution to maintain hydration until the experiment was performed.[4] Teeth were randomly divided into two groups as enamel surface and root surface. The surface properties of enamel were standardized by carbide papers where three different abrasive particle size on buccal surface were used. Each carbon paper was applied in 10 stroke 1200A, 1000A and 800A, respectively. The expected area for root group was 5 mm apical from cemento-enamel junction (CEJ). For enamel surface group, it was the one third of the middle crown. Both enamel and root groups were divided into five subgroups.

Group I (n=40): The ultrasonic instrumentation (FI-21601, Planmeca, Parainen, Finland) was used with 15 strokes from apical to coronal direction using linear oscillations at a frequency of 30 kHz on enamel and root surfaces. Movements were made parallel to the axis of each tooth with standard angle and force applications.[9]
Group II (n=40): Gracey curettes (1/2 and 5/6 Gracey Curettes, Hu-Friedy, Chicago, IL, USA) were used to make 15 vertical strokes in apical-coronal direction for each enamel and root surface.[12] Movements were made parallel to the axis of the tooth with standard curettes with angle and force applications.
Group III (n=40): Samples from each of enamel and root surface were polished for 15 s with rubber cup (905.C.100, Kenda, Liechtenstein) and polishing paste (grain size 58 μm, Kerr Cleanic, CA, USA) with low-speed contra-angle handpiece in a circular motion.[13]
Group IV (n=40): Samples from each of enamel and root surface were polished for 15 s with rubber cup and polishing pumice (grain size 50 μm, 0948, Imicryl, Konya, Turkey) by using a low-speed contra-angle handpiece in a circular motion.[13]
Group V (n=40): Samples from each of enamel and root surface were polished for 15 s with air polisher using sodium bicarbonate powder (grain size 62 μm, Air-Flow Classic, Ems Sa, Nyon, Switzerland).[13]

One operator (T.T.Y.) performed all scaling, root planing and polishing procedures. A second blinded operator (F.O.) evaluated the samples with Mitutoyo SJ-410 (Mitutoyo Sul Americana Ltda, Santo Amaro, SP, Brazil).

2.2. Determination of surface roughness

Average surface roughness (Ra; μm) of all samples were evaluated before and after SRP and polishing procedures with profilometer (Surftest SJ-410, Mitutoyo Sul Americana Ltda, Santo Amaro, SP, Brazil) with an accuracy of 0.01 μm. Three measurements were performed for each region of each sample at different sites within a predetermined and similar area. For each reading, the device needle ran 1.5 mm in a single direction with a cutoff of 0.8 mm. The arithmetic mean of the 3 measurements was used as a reference value for the roughness of each evaluated area.[7] The difference between the two measurements was recorded.

2.3. Statistical analysis

The mean values and standard deviations for surface roughness were calculated for groups at baseline and after instrumentation. The difference between the two measurements was recorded. The normality test indicated that the data were normally distributed ($p > 0.05$). The one-way analysis of variance (ANOVA) test along with the Tukey test was used for the comparison between the different measurements of groups. P values less than 0.05 were considered as statistically significant. All analyzes were performed by using SPSS version 23.0 (SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Evaluation of enamel surface roughness

The baseline mean ± standard deviation (SD) roughness values for subgroups I, II, III, IV and V were 0.466 ± 0.459 ± μm, 0.483 ± 0.915 μm, 0.491 ± 0.101 μm, 0.482 ± 0.062 μm, 0.473 ± 0.074 μm, respectively. After instrumentation, mean ± SD roughness values for subgroups I, II, III, IV and V were 7.320 ± 1.067 μm, 5.865 ± 1.046 μm, 6.269 ± 1.312 μm, 4.740 ± 0.635 μm, 5.555 ± 1.154 μm, respectively (Table 1). The overall results showed that polishing and SRP with different tecniques increased the surface roughness on enamel surface. Table 2 shows the increase of surface roughness as a result of different instrumentation on enamel group. The use of ultrasonic scalers caused the highest roughness increase on the enamel surface, whereas the use of pumice has the least roughness increase. There is no significant difference between pumice and air flow when evaluated in terms of surface roughness change ($p > 0.05$). However, there is a significant difference between ultrasonic scalers and all other groups ($p < 0.05$) (Table 2).

3.2. Evaluation of root surface roughness

The baseline mean ± SD roughness values for subgroups I, II, III, IV and V were 4.973 ± 0.922 μm, 5.348 ± 1.198 μm, 4.999 ± 0.984 μm, 3.623 ± 1.275 μm, 3.984 ± 1.039 μm, respectively. After instrumentation, mean ± SD roughness values for subgroups I, II, III, IV and V were 6.425 ± 1.799 μm, 6.512 ± 1.904 μm, 6.709 ± 1.479 μm, 6.899 ± 1.344 μm, 6.907 ± 0.998 μm, respectively (Table 3). The surface roughness on root surface was increased in all groups after instrumentation. Maximum surface roughness increase was observed in the ultrasonic scalers group. There is a significant difference between ultrasonic scalers and pumice, polishing paste and air powder, respectively ($p < 0.05$) (Table 2). There is no significant difference between pumice, polishing paste and air powder when evaluated in terms of surface roughness change ($p > 0.05$).

4. Discussion

The first stage of periodontal treatment involves the removal of bacterial deposits and calculus from the root surface. The treatment includes the protection of healthy tissues, where a biologically acceptable root surface can be obtained. The main purpose of polishing is to remove plaque, biofilm and stains on the enamel and root surfaces to provide the smoothest surface possible.[14,15] One of the aims of periodontal treatment

Table 1
Mean values of surface roughness (Ra) and standard deviations (SD) in enamel group at baseline and after instrumentation.

Enamel Group	Baseline	After instrumentation
Group I	0.466 ± 0.459	7.320 ± 1.067
Group II	0.483 ± 0.915	5.865 ± 1.046
Group III	0.491 ± 0.101	6.269 ± 1.312
Group IV	0.482 ± 0.062	4.740 ± 0.635
Group V	0.473 ± 0.074	5.555 ± 1.154

Table 2
Evaluation of the intergroup roughness change on enamel and root surface.

Enamel Group		Root Group
Group I	$0.935 \pm 0.010^{a,b,c,d}$	$0.442 \pm 0.552^{g,h,ı}$
Group II	$0.916 \pm 0.012^{a,e}$	0.351 ± 0.210
Group III	$0.918 \pm 0.024^{b,f}$	0.236 ± 0.148^{g}
Group IV	$0.896 \pm 0.018^{c,e,f}$	0.267 ± 0.123^{h}
Group V	0.911 ± 0.020^{d}	0.224 ± 0.145^{ı}

$p < 0.05$ represents statistical significance.
*Within the same measurement category, values with the same lower letter are statistically different by Tukey's post hoc analysis.

Table 3
Mean values of surface roughness (Ra) and standard deviations (SD) in root group at baseline and after instrumentation.

Root Group	Baseline	After instrumentation
Group I	4.973 ± 0.922	6.425 ± 1.799
Group II	5.348 ± 1.198	6.512 ± 1.904
Group III	4.999 ± 0.984	6.709 ± 1.479
Group IV	3.623 ± 1.275	6.899 ± 1.344
Group V	3.984 ± 1.039	6.907 ± 0.998

is to reduce the accumulation of bacteria and plaque by minimizing the roughness of enamel and root surfaces. Creating a smooth surface after mechanical debridement facilitates the reattachment of gingival fibrous tissues.[16,17] In addition to physiological tissue healing, surface features are also important for tissue regeneration.[16,18]

The present in vitro study compared the effect of different SRP (ultrasonic scaler and hand instruments) and polishing tecniques (polishing paste, pumice and air powder) on enamel and root surfaces. Before the instrumentation procedures, the enamel surface was standardized by carbide papers. Standardization of experimental conditions is always important in studies concerned with the evaluation of instrumentation and their effects on the enamel surface as well as elimination of the environmental factors.[19]

The results of the present study demostrated that the surface roughness of the ultrasonic scaler was higher than hand instrumentation on enamel surface. This may be due to the fact that gracey curettes facilitate better tactile proprioception and controlled movement to the operator. The ultrasonic instruments work on the principle of vibrational forces that may introduce new surface features following root planing.[20,21] Similar to the result of this study, Aspriello et al. reported that after ultrasonic instrumentation, the surfaces appeared irregular, and had grooves compared to hand instrumentation.[22] Only one study reported about higher Ra values after using a hand instrument in comparison to an ultrasonic system.[23] In addition, previous in vitro investigations showed that ultrasonic scalers produced a rougher surface than hand instrumentation.[24,25]

Previous research presented that scalers, curettes, and ultrasonic instruments were effective in removing subgingival plaque and calculus. However they did not produce smooth tooth surface.[13,26] For these reasons, polishing was very important to obtain smootless surface. The present study, when polishing techniques were considered, pumice (4.740 ± 0.635 μm) was found to have a minimum surface roughness on enamel than polishing paste (6.269 ± 1.312 μm) and air power (5.555 ± 1.154 μm). However, there is a statistically significant difference between polishing paste and pumice ($p < 0.05$). Zoya et al. demonstrated that polishing with rubber cup was more effective when compared to air powder for the enamel and root surface roughness.[13] Several authors reported that air powder increased the surface roughness as well as the debris on both crown and root surfaces.[27,28] In the present study, polishing paste (6.269 ± 1.312 μm) caused more surface roughness than pumice (4.740 ± 0.635 μm), where polishing was affected by the hardness, shape, and size of the abrasive particles as well as the speed of the rotary handpiece.[19,29] These results may be related to the grain size in the polishing paste which are larger than pumice.

During initial periodontal treatment, practitioners want the procedure to be completed quickly. Ultrasonic tool usage shortens the duration of SRP procedures. However, patients usually worry about root abrasion and sensitivity after treatment. It is very important for the patients to determine the least abrasive effect on the root surface during SRP and polishing procedures. In the present study, the authors may suggest that ultrasonic scalers (0.442 ± 0.552 μm) produced more roughness on the root surfaces than the hand instruments (0.351 ± 0.210 μm). Green and Ramfjord found similar results with the present study.[30] Previous researchers presented that hand instrument produced smooth surfaces than ultrasonic devices.[31,32]

A wide variety of materials and methods may be used during the implementation of the polishing processes.[27,33,34] Studies concluded that polishing removed plaque, reduced bacterial accumulation, and smoothened the tooth surface after scaling.[13,35] As a result of polishing, adverse effects, including abrasion and dentin hypersensitivity may still occur.[4,36] The results of the present study showed that all dental applications (SRP and polishing tecniques) were increased the root surface roughness. Moreover, there is a significant difference between the ultrasonic device and other polishing tecniques. There is no difference between any of the polishing tecniques on the root surface. The results of this study also demostrated that polishing procedures made less surface roughness compared to SRP procedures. Therefore, polishing was recommended after SRP operations. Similar results for root surface were seen in the previous studies,[34,37] where they demonstrated that polishing with air powder reduced surface roughness on both enamel and root surfaces.

5. Conclusions

The results of the present in vitro study may suggest that use of ultrasonic scalers may cause more roughness enamel and root surface than hand instrumentation. These uneven surfaces adversely affect the intended periodontal healing by creating a retention area for the microbial dental plaque.

Author contribution

TTY contributed to conception and design, analysis and interpretation, and drafted the manuscript. FO contributed to evaluated the samples, analysis and interpretation of data. EK contributed to design study, evaluated the samples. MDT contributed to drafting the article or revising it critically for important intellectual content.

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Ethical approval

The ethical approval was released by Institutional Review Board Approval of Firat University (14.12.2017/17/24).

Informed consent

For this type of study, formal consent is not required.

Declaration of competing interest

T. Talo Yildirim declares that she has no conflict of interest. F. Öztekin declares that he has no conflict of interest. E.Keklik declares that she has no conflict of interest. M.D. Tozum declares that she has no conflict of interest.

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