Journal of Cardiovascular Disease Research
ISSN: 0975-3583, 0976-2833 VOL12, ISSUE 03, 2021

Comparison of root surface roughness resulting from the two conventional root-planing procedures applied on human teeth: an in-vitro AFM study

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Abstract

Purpose: Any instrumentation on the root surface for calculus removal will cause some amount of roughness on the surface. Hence this in-vitro AFM study was proposed to investigate the effect of root planing on the human tooth root using the two conventional methods i.e. root planing using hand instruments and ultrasonic root planing tips.

Materials and Methods: Twenty tooth samples were prepared from extracted maxillary first pre-molars and were divided randomly into two groups of 10 samples each. Group I: root planing with ultrasonic root planing tip, and Group II: root planing using hand curettes. The amount of roughness produced on the surface of each samples in the two groups were evaluated using the atomic force microscopy (AFM) and statistically analyzed using ANOVA and Wilcoxon tests.

Results: Results suggested that the surface roughness produced on root after root planing using hand instrument is lower than that of ultrasonic unit. However, there is no enough evidence to conclude a significant difference (P=0.13) between root planing using hand instrument and ultrasonic root planing tip.

Conclusion: From the present study, authors concluded that root planing using ultrasonic unit causes more tooth surface roughness as compared to hand instruments. However, there is no statistically significant difference between the surface-roughness of root-cementum produced due to the root planing in both the groups.

Clinical significance of the study: Because they provide locations for microbial dental plaque to accumulate, teeth surfaces that are rough or uneven have a negative effect on the periodontium's expected recovery.

Keywords: calculus, curettes, root surface roughness, ultrasonic unit, atomic force microscopy

Introduction

Periodontal diseases are inflammatory conditions that commence with gingivitis and progresses to periodontitis, and, if left untreated, may result in unalterable damage of tooth-supporting tissues. Periodontal therapy aids to maintain a healthy periodontium and may also help to control related diseases. Obtaining a root surface that is acceptable to biology is the primary objective of periodontal therapy. This goal can be achieved by the mechanical removal of supra & subgingival biofilm and calculus, which are the most prominent causes of periodontal disease. For this function, the most popular and recommended tool is an ultrasonic scaler. Changes to the tooth's surface can have a significant impact on the condition of the periodontium because bacterial plaque gathers more readily on uneven surfaces.[1] Studies have shown that ultrasonic scalers result in less tissue loss but a rougher root surface when compared to hand instruments.[2,3] Conversely, no significant differences have been reported between the roughness parameters associated with hand instruments and ultrasonic piezoelectric scalers in a study analyzing the

root surfaces of extracted teeth.[4] Yousefimanesh et al[5] and Flemmig et al[6] through their respective studies stated that piezoelectric scalers left smoother root surfaces than magnetostrictive scalers under the same forces. Differing results have also been obtained in studies comparing the effects of sonic and ultrasonic scalers[7,8] Graetz et al[7] established that the ultrasonic scaler created a smoother surface than the sonic scaler or hand instruments, whereas Ribeiro et al[8] demonstrated that a sonic scaler with a diamond-coated tip and an ultrasonic scaler produced similar root-surface roughness, which was higher than that created with hand instruments. However, Busslinger et al[9] reported that, after instrumentation, a piezoelectric device left a rougher root surface than a magnetostrictive device. In contrast to the previously mentioned investigations, Singh et al[10] results showed that both magnetostrictive and piezoelectric ultrasonic tools produced surface-roughness values that were identical, and they were similarly capable of creating a physiologically harmonious surface. These contradictory findings emphasize the need for additional research on this topic.

Therefore, the purpose of this study was to assess, using Atomic Force Microscopy (AFM), the root surface roughness created during the root planing method by hand and ultrasonic instruments.

Materials and methods

20 tooth sections of 2x4x1mm dimensions were obtained from root portions of freshly extracted intact maxillary first pre-molars and were randomly divided into two groups of ten samples each.
Group I: 10 samples of root-cementum treated with ultrasonic root planing tips
Group II: 10 samples of root cementum treated with universal curettes

Machine induced root planing was done on the samples of Group I using ultrasonic unit (Woodpecker UDS-J) with its recommended root planing tip with medium (level-4) power setting and maximum water coolant level as mentioned in the product manual. Group II samples underwent root planing using Hu-Friedy's 5/6 Gracey curette. Root planing was carried out by turning on the corresponding device at a working angle of between 60 and 70^0 and using 20 overlapping root planing strokes. Following root planing, atomic force microscopy (AMF) was employed on all the samples to assess the surface roughness brought on by each treatment and to record the tooth surface photographs (Figure 1). One investigator carried out the entire process, from sample preparation to root planing, in order to minimize operator-induced procedural bias. Following the acquisition of the necessary data and images from the AFM, a statistical analysis of the surface roughness difference in each group was conducted using Anova, and Wilcoxon tests. A p-value of 0.05 or less was regarded as statistically significant. Data was recorded and analyzed using R-project and Minitab software.

Observation and Results

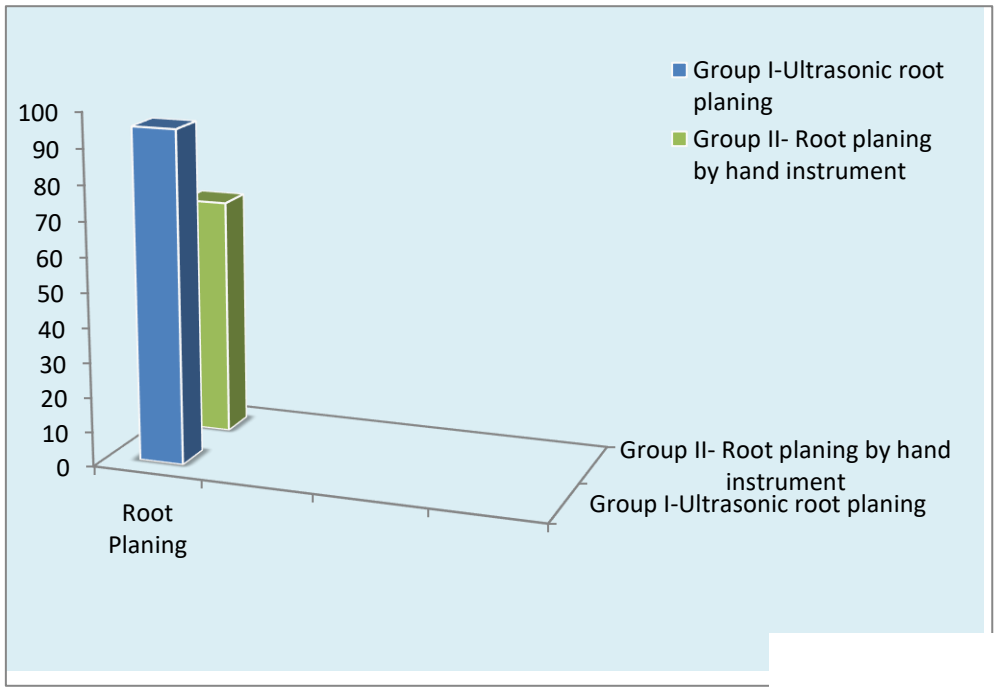
Evaluation of root-cementum surface roughness: The average surface roughness values observed in Group I (ultrasonic root planing) is 95.053 ± 36.247nm and in Group II (hand instruments) is 68.064±39.801nm stating that ultrasonic root planing causes more surface roughness as compared to handheld curettes. However, the p-value of 0.130 (which is larger than 0.05) indicates that there is no statistically significant difference between the two groups for root planing (Table 1 & 2 and Graph 1)

Groups	***Count***	***Sum***	***Average***	***Variance***	***Standard deviation***
Group I-Ultrasonic root planing	10	950.5	95.05	1313.9	36.3
Group II- Root planing by hand instrument	10	680.6	68.06	1584.10	39.8

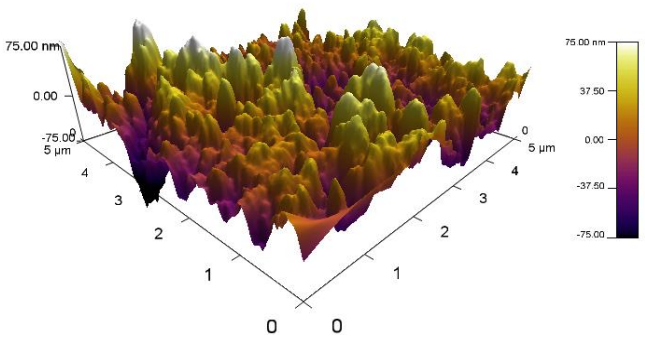
Table 1: showing the amount of surface roughness (in nm) produced in each group

Source of Variation	**SS**	**F**	**F crit**	**P-value (ANOVA)**	**P- value (Wilcoxon)**
Between Groups	3642.004	2.513	4.414	0.1302	0.1431
Within Groups	26081.73				
Total	29723.74				

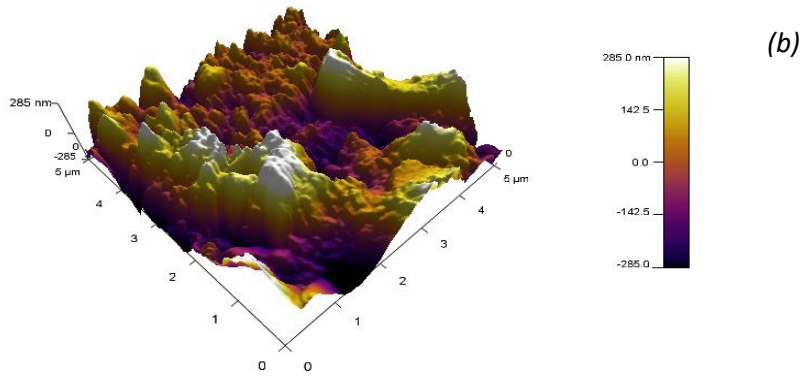
Table 2: Statistical analysis of surface roughness of Root using ANOVA one way and Wilcoxon (SS: sum of squares, df: Degree of Freedom, MS: Mean sum of squares, F: Anova Coefficient)



Graph 1: Graph showing the amount of root surface roughness produced in the two groups after root planing by ultrasonic unit and hand instrument



(a)



(b)

Figure 1: showing AFM images of the surface roughness produced in the two groups after root planing by (a) ultrasonic unit and (b) hand instrument

Discussion

Reduction or removal of subgingival local irritants including dental calculus along with a decline in inflammatory level of the disease is the main key feature of root planing and curettage in a periodontal therapy. Even though scaling-root planing should ideally remove calculus, plaque, stains of external origin, and bacterial components, multiple in vitro studies have demonstrated iatrogenic effects following instrumentation.[11] These surface abnormalities and lesions increase the tooth's surface area, which encourages bacterial colonisation and plaque production and jeopardises the patients' ability to remove plaque on a daily basis.[12] The angulation of the hand instrument or the scaling tip, shape of the instrument used, type of prophylactic method used, lateral pressure and the number of treatments underwent till date etc all affect this surface roughness. Despite a great deal of research, the crucial roughness level of hard tooth tissues has not yet been established. Nonetheless, it is commonly acknowledged that 0.2 µm (200 nm) is the threshold surface roughness required for plaque retention.[13,14]

The micro-roughness of natural tooth cementum should ideally remain confined to 3-7µm layer of endotoxin invasion in addition to the biofilm, a range obtained from various studies. It is well recognized that the cemental thickness varies with patient age, root location, and tooth type.[15] Cementum is often thought to have a thickness of 250µm under normal healthy conditions. These numbers make it clear that overuse of instruments can rapidly thin or eliminate the cementum layer, which will promote poor healing. Excess cementum removal may expose dentinal tubules, resulting in root sensitivity.[16] Based on various studies it is predicted that ultrasonic scaler causes 6.3-55.9µm and curettes 100µm of root surface roughness after root planing.[3] There is still disagreement in the literature regarding how different instrumentation

affects a tooth's crown and root surfaces. While some investigations suggested that excessive root surface removal was caused by manual instrumentation, other researchers demonstrated that ultrasonic scalers had the same detrimental effect.[17] Ultrasonic systems are favoured over hand instruments by practitioners and patients who desire faster treatment methods because it shortens the interval of scaling and root planing (SRP). Nonetheless, given that some patients are concerned about tooth sensitivity and abrasion following oral prophylaxis, it is imperative that the patient and dentist determine which course of therapy would result in the least amount of surface roughness during SRP.

The present in vitro study compared the surface roughness produced by ultrasonic unit and hand instrument on root-cementum surface. The topographic study of the AFM showed that ultrasonic root planing tip produced slightly higher surface roughness than hand instruments, as shown in the AFM-microphotographs (figure 1) although it was not statistically significant. The results were in contrast to various previous studies done by different researchers such as Aspriello et al who observed uneven, roughened tooth surfaces and grooves post ultrasonic instrumentation compared to hand instrumentation.[18] and Yildirim et al who concluded that surface roughness produced by ultrasonic scaler on the enamel and cementum surface was higher than manual instruments. Yildirim suggested that hand instruments such as Gracey curettes aided enhanced instrument control and tactile proprioception during instrumentation whereas the decreased tactile sensation and vibrational forces of the ultrasonic unit induced more surface roughness following root planing. Kerry too in her study on extracted teeth stated that ultrasonic instrumentation created significantly rougher root surfaces in comparison to hand curettes.[19] Meyer et al in his in-vitro study on surface roughness using SEM stated that hand curette formed least roughness, followed by the Roto-Pro instrument, whilst the ultrasonic curette and the diamond produced the most irregular surfaces.[20]

There are certain limitations to our study, but they can be addressed in further studies. The investigation employed a solitary method for assessing surface roughness on a limited sample size. The investigation can be conducted with bigger samples and a variety of techniques, including histological analysis and confocal microscopy, to assess surface roughness. Furthermore, patient-centered research would be more appropriate to validate our findings and apply them to a clinical setting.

Conclusions

The results of this study concluded that although root planing by ultrasonic unit produces slightly more surface roughness in comparison to hand instrumentation, the results were not statistically significant.

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