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ORIGINAL ARTICLE

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Evaluation of root roughness after using diamond tips, ultrasound tips, and hand curettes in human teeth, in vitro study

Avaliação da rugosidade radicular utilizando pontas diamantadas, pontas ultrassônicas e curetas manuais em dentes humanos, estudo in vitro

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ABSTRACT

Objective: This *in vitro* study aimed to compare the degree of root roughness in human teeth treated after using hand curettes, stainless steel, and diamond ultrasound tips. **Material and Methods:** The scaling was performed on the root surface of 36 human teeth previously standardized and randomly divided into three groups (n=12). The roughness degree was measured with the aid of a rugosimeter, before and after the scaling, through readings perpendicular and parallel to the scaling direction. The statistical analysis comprised *Wilcoxon* and *Kruskal-Wallis* tests ($p<0.05$). The qualitative and visual complementation of the results was performed by scanning electronic microscopy. **Results:** The scaling executed with hand curettes increased root roughness (before - Ra median=0.1583μm; after =0.7783μm; before - Rz median =1.667 μm; after=7.350μm). The degree of root roughness also increased when stainless steel ultrasound (before - Ra median= 0.1483 μm; after=0.3933 μm; before- Rz median=1.567 μm; after=4.333 μm) and diamond tips were used (before - Ra median=0.1800 μm; after=2.457 μm; before - Rz median=1.850 μm; after=18.58 μm). **Conclusion:** The superficial roughness significantly increased in all groups. The scaling with diamond tips promoted the greatest root roughness than hand curettes and ultrasound tips.

KEYWORDS

Dental biofilm; Dental scaling; Periodontics; Superficial roughness.

RESUMO

Objetivo: O objetivo deste estudo in vitro foi avaliar e comparar o grau de rugosidade radicular em dentes humanos tratados com curetas manuais, pontas ultrassônicas de aço-inox e pontas diamantadas. **Materiais e Métodos:** A instrumentação foi realizada sobre a superfície radicular de 36 dentes humanos previamente padronizados e divididos aleatoriamente em três grupos (n = 12). O grau de rugosidade foi mensurado, em rugosímetro, antes a após a instrumentação, através de leituras perpendiculares e paralelas ao sentido da instrumentação. Na análise estatística foram utilizados os Testes de Wilcoxon e Kruskal-Wallis ($p < 0,05$). Para avaliação qualitativa e complementação visual dos resultados foi realizada microscopia eletrônica de varredura. **Resultados:** A instrumentação realizada com curetas manuais provocou aumento da rugosidade radicular (mediana de Ra antes = 0,1583 μm/depois = 0,7783 μm; mediana de Rz antes = 1,667 μm/depois = 7,350 μm). O grau de rugosidade radicular também aumentou quando se utilizou pontas ultrassônicas de aço-inox (mediana de Ra antes= 0.1483 μm/depois = 0,3933 μm; mediana de Rz antes = 1,567 μm/depois = 4,333 μm) e pontas diamantadas (mediana de Ra antes = 0,1800 μm/depois = 2,457 μm; mediana de Rz antes = 1,850 μm/depois = 18,58 μm). **Conclusão:** Houve aumento significativo da rugosidade superficial em todos os grupos. A instrumentação realizada com pontas diamantadas provocou maior aumento da rugosidade radicular quando comparada com o uso de curetas manuais e pontas ultrassônicas.

PALAVRAS-CHAVE

Biofilme dentário; Raspagem dentária; Periodontia; Rugosidade superficial.

INTRODUCTION

Theperiodontal disease (PD) is an infection of bacterial origin and dental biofilm is the main etiologic agent. Periodontal disease is a destructive inflammatory process due to the action of bacteria and their byproducts and PD may lead to tooth loss. PD signs and symptoms manifest as the interaction between the causative agent and the host's immune and inflammatory responses. PD beginning and progression is associated to genetic and modifying factors as smoking, diabetes, nutrition, and drug use [1].

Periodontal therapy aims to stablish an acceptable biologically surface through the mechanical removal of toxins, biofilm, pathogens, and tooth calculus. Root scaling and planning using hand curettes is the gold standard to treat chronic periodontitis [1]. Root debridement with hand instruments traumatizes the root surface leading to loss of tooth substance [2]. The necessity of removing the defects of tooth surface aiming to achieve greater smoothness, and consequently making difficult plaque retention is not a consensus because although smoother surface leads to smaller adhesion of periodontal pathogens, the superficial smoothness also prevents the adhesion of fibroblasts which initiates the process of tissue regeneration [3-5].

The root scaling with ultrasound devices started with Zinnerem in the mid-50s, alternatively to hand debridement and currently is largely used in periodontal therapy. The ultrasound instruments are effective in eliminating the bacterial toxins and removing less tooth substances than hand curettes [6]. According to current literature [7], the use of both ultrasound and hand curettes promotes a significant reduction of root roughness with similar results. In addition to hand curettes and stainless steel ultrasound tips, diamond ultrasound tips have been alternatively proposed to treat periodontal disease [8-14].

The original superficial roughness is associated to the neoformation of dental biofilm and microbial recolonization of subgingival tissue due to the presence of retentive areas on the root. Thus, a smoother root surface, free of roughness, is an important aspect to be considered in PD treatment because a rougher surface enables greater biofilm accumulation [15,16]. Because the literature lacks consensus on the superficial roughness produced by root scaling, this study aimed to evaluate and compare the degree of root roughness on root surfaces treated by hand curettes, stainless steel and diamond ultrasound tips.

MATERIAL AND METHODS

This study was submitted and approved to the Institutional Review Board regarding ethical aspects under protocol no. CAAE 39526414.0.0000.0077.

Tooth obtainment

Thirty-six single-rooted teeth were extracted due to periodontal reasons in the Surgery Clinics of the Institute of Science and Technology of São José dos Campos, UNESP. All patients donated the teeth by reading and signing a free and clarified consent form. The teeth were immediately stored in 0.9% saline solution and frozen until their use.

Preparation and standardization of the samples

The tooth crowns were sectioned with flexible diamond disc (KG Sorensen, Brazil) and discarded so that only the root portion remained. The root was embedded in self-polymerizable resin (Jet Clássico, Brasil) in PVC tubes (Tigre, Brazil). Next, the specimens were planned with the aid of a polishing machine (EcoMet™/ AutoMet™ 250 & 300 Grinder-Polisher/Power Head, USA) and 150-, 180-, 240-, 320-, 400-, 600-, and 1200-grit sandpaper (Norton Saint Gobain, Brazil), at speed of 450 rpm. Then felt discs (Polifix TDV, Brasil) and polishing paste (EnamelizeCosmedent, USA) were used. An area

of 9 mm2 was delimited on the root surface, on which the scaling and rugosimeter reading was executed. At that moment, the scaling direction was defined: apical-crown direction (Figure 1). The samples were identified by numbers from #1 to #36. Following, the samples were randomly divided into three different groups (n = 12): G1 (scaling through hand curettes), G2 (scaling through stainless steel ultrasound tips), and G3 (scaling through diamond ultrasound tips).

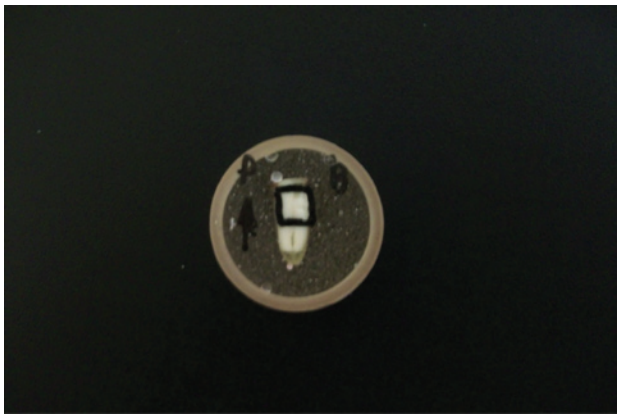

Figure 1 - Standardized sample: root portion embedded in acrylic resin inside PVC tube. Observe the marked area to be analyzed and the apical-crown direction of the scaling.

Roughness readings

Before the scaling, the area previously demarcated on the root surface was submitted to a first reading using a rugosimeter (Mitutoyo SJ 400, Brazil) (Figure 2). The first reading conditions are listed: ISO 1997 Range 800 Gauss, measuring speed 1 mm/s, covering the distance of 3 mm. The parameters Ra and Rz (μm) were used to measure the superficial roughness of the samples. Ra value is the arithmetic mean between the lowest (valleys) and highest points (peaks). Rz value is the mean value of the area obtained from the absolute height of the five lowest valleys and five highest peaks. We executed two readings at parallel direction and one reading at perpendicular direction to the scaling. After the scaling, each sample was submitted to a second reading, with the conditions aforementioned described.

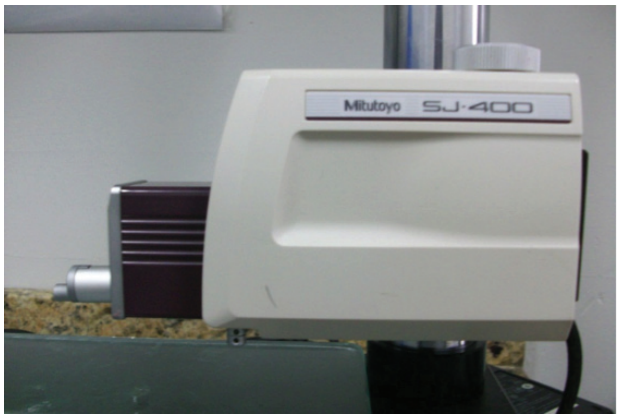

Figure 2 - Rugosimeter used to measure the roughness degree of the root surfaces.

Root scaling

Root scaling in all groups was performed at apical-crown direction through 15 movements each [17], by a single operator.

In group G1 (scaling using hand curettes), we employed *Gracey* curettes no. 5/6 (Millenium-Golgan, Brazil) (Figure 3). The curettes were sharpened at every 10 scaling movements.

In group G2 (scaling with ultrasound tips), we used stainless steel ultrasound tips (T1-S, CVDentus, CVDVale, Brazil) (Figure 3), coupled in ultrasound device (DVDent 1000 - CVDVale, Brazil). According to the manufacturer's recommendations, only the lateral surface of the tip was used at a power of 40%.

In group G3 (scaling with ultrasound diamond tips), a tip with extra-fine grit diamond (T1U-E *CVDentus*, CVDVale, Brazil) (Figure 3) was used coupled to ultrasound device (DVDent 1000 - CVDVale, Brazil), at power of 30% and cooling by dripping, according to the manufacturer's recommendations. Similarly to G2, only the lateral surface of the tip was used during the scaling.

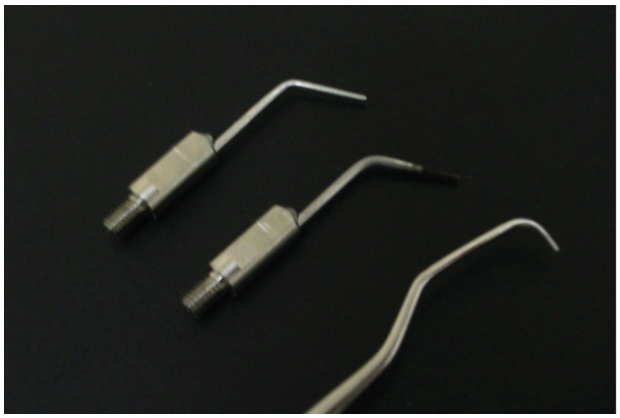

Figure 3 - Instrumentals used: ultrasound point, diamond point and hand curette, from top to bottom.

Scanning electronic microscopy (SEM)

One specimen from each group was analyzed through SEM for visual complementation of the results. The samples were first removed from the acrylic resin inside the PVC tube, through heater plate (Quimis, Brasil) at 320 ºC. Next, the samples were placed into an ultrasound appliance (Cristófoli, Brasil) for 30 minutes to remove the remnants. Then, the samples were dehydrated in 70%, 80% and 90% alcohol, successively, and maintained for 15 min inside each alcoholic concentration. Elapsed that period, the samples were immersed in absolute alcohol for 1 h. The specimens were placed inside an incubator at 37 ºC for 24 h to dry completely. Following, the specimens were places inside aluminum *stubs* and conductive carbon tape sputtered with gold for 90 seconds at 12k mA vacuum (SputterCoater EMICTECH SC7620). After the metallization, the root surfaces were examined and photographed in SEM (Inspect S50 – FEI, Czech Republic), at high vacuum with secondary electron detector ETD, operating at 25 kV, spot 5. SEM was carried out in the Dental Materials and Prosthesis of the Institute of Science and Technology of the São Paulo State University (ICT - UNESP).

Statistical Analysis

Ra and Rz data were submitted to statistical analysis. *Wilcoxon* test ($p < 0.05$) was applied to analyze the range in roughness degree of the samples within the same group and *Kruskal-Wallis* test compared the roughness alteration among different groups. The statistical analysis was executed through *GraphPadPrismversion* 6.00 for Windows and *Minitab*® 17.1.0 © 2013.

RESULTS

The intragroup analysis compared the roughness degree before and after scaling and showed that for all groups the second roughness reading (after scaling) was significantly higher than the first reading ($p < 0.05$). We analyzed the parallel and perpendicular directions separately. Total roughness is the arithmetic mean of the values of the perpendicular and parallel directions (Tables 1 and 2).

Table 1 - Median values regarding parallel, perpendicular, and total roughness using Ra parameter

Mean values obtained in Ra (µm), before and after scaling				
Root scaling		**Parallel**	**Perpendicular**	**Total**
Hand curettes	Before	0.1625	0.1450	0.1583
	After	0.6600	0.8950	0.7783
Ultrasound tips	Before	0.1350	0.1950	0.1483
	After	0.3650	0.3300	0.3933
Apical	Before	0.1625	0.1800	0.1800
	After	2.770	1.635	2.457

Table 2 - Median values regarding parallel, perpendicular, and total roughness using Rz parameter

Mean values obtained in Rz (µm), before and after scaling				
Root scaling		**Parallel**	**Perpendicular**	**Total**
Hand curettes	Before	1.750	1.750	1.667
	After	7.100	8.500	7.350
Ultrasound tips	Before	1.275	1.900	1.567
	After	3.900	3.550	4.333
Diamond tips	Before	1.825	2.050	1.850
	After	19.08	16.95	18.58

Kruskal-Wallis test compared the values of three groups and found that diamond tips promoted the greatest increase of root roughness than that of ultrasound tips and hand curettes, which were statistically similar between each other. Figures 4 and 5 presented Ra and Rz results.

The analysis of the images obtained through SEM, at x1000 magnification, suggested considerable differences in the root surface of the samples treated with diamond tips, stainless steel ultrasound tips, and hand curettes. The diamond tips promoted the greatest superficial roughness alterations (Figure 6). Figure 7 shows the image regarding the root surface area treated by the ultrasound tip. We observed that the root curettes caused a more uniform, smoother surface (Figure 8).

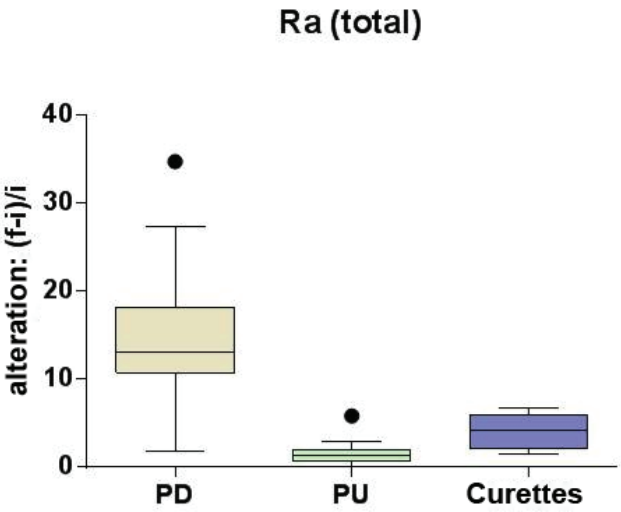

Figure 4 - Graph of total root roughness alteration (parallel and perpendicular) using Ra, after comparing the three groups (diamond tips, ultrasound tips, and hand curettes). PD – diamond tip; PU – Ultrasound tips.

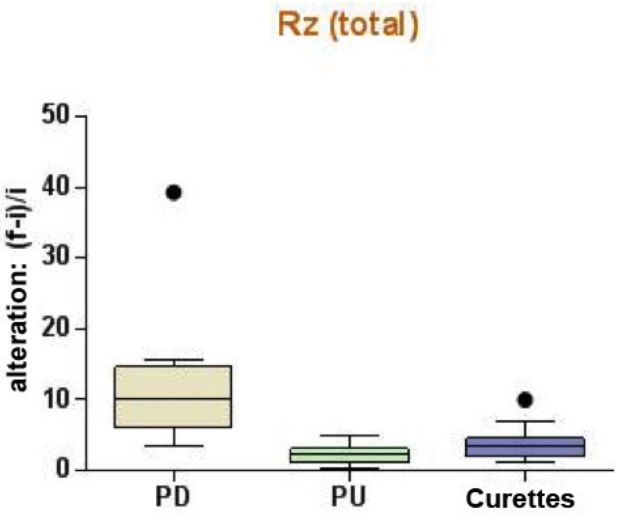

Figure 5 - Graph of total root roughness alteration (parallel and perpendicular) using Rz, after comparing the three groups (diamond tips, ultrasound tips, and hand curettes). PD – diamond tip; PU – Ultrasound tips.

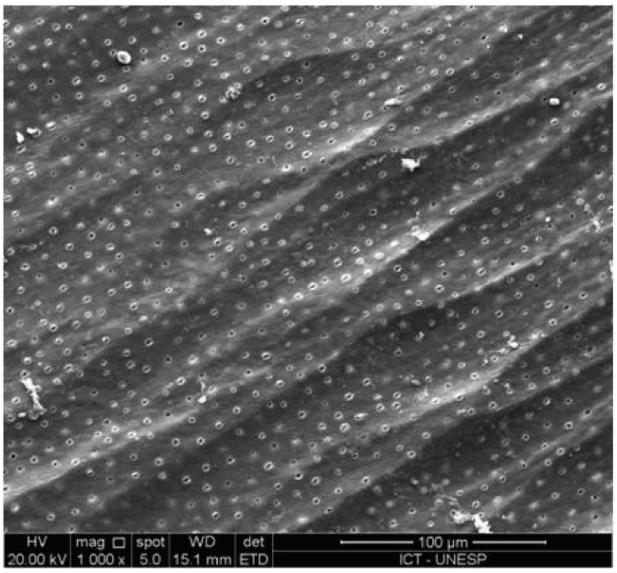

Figure 6 - Root surface of a sample submitted to scaling with diamond tip, showing the superficial roughness (SEM x 1000 magnification).

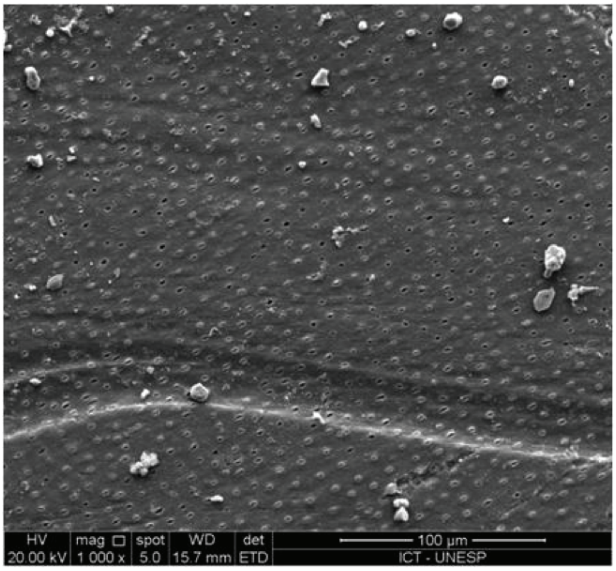

Figure 7 - Root surface of a sample submitted to scaling with ultrasound tip, showing the roughness leaved by the tip (SEM x 1000 magnification).

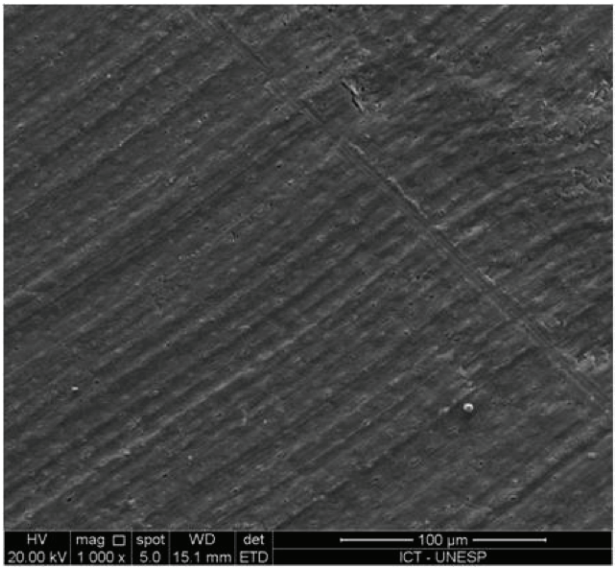

Figure 8 - Root surface of a sample submitted to scaling with hand curette, showing a more uniform superficial roughness and the presence of "smear layer" obliterating the dentinal tubules (SEM x 1000 magnification).

DISCUSSION

The most important therapy for PD is the removal of biofilm and dental calculus through either hand or ultrasound scaling, which promotes alterations on the root surface, resulting in roughness. This study compared the degree of root roughness among three different instruments: ultrasound tips, diamond tips, and hand curettes, demonstrating a significant increasing of root roughness in all groups, which is in agreement with the literature [2,4,8,10].

In the comparison performed among the different groups, the diamond tips promoted the greatest increasing of the root roughness than that of ultrasound tips and hand curettes, which were statistically similar between each other. These findings corroborates the studies of Silva Filho et al. [2], Vastardis S [10], and Solis Moreno C et al. [18].

The results of Silva Filho et al. [2] showed that diamond tips produced a rougher surface than hand curettes and ultrasound tips, which presented similar roughness degrees.

Martins et al. [4] employed a methodology similar to that of this present study and analyzed the superficial roughness of hand curettes, conventional ultrasound tips, and extra-fine diamond flame-shaped tips, mounted in high-speed handpiece and concluded that extra-fine diamond tips resulted in the smallest degree of residual roughness, followed by hand curettes and ultrasound tips. Only considering the hand curettes and ultrasound tips, the results of Martins et al were different from that of this study.

Ribeiro FV et al. [8] conducted an *in vitro* study comparing the root roughness after scaling with diamond tips, ultrasound tips, and hand curettes. The results revealed that the diamond and ultrasound tips were similar and resulted in a higher root roughness than that of hand curettes, which promoted a smoother surface. These aforementioned results differed from those of this present study finding that diamond tips caused a greater roughness on root surface than ultrasound tips.

The study of Vastardis S. [10] shows that diamond tips are more effective during root planning and can be used in periodontal therapy.

Also, the authors affirmed that the diamond tips promoted greater tooth structure and left a rougher surface than stainless steel tips and hand curettes, which were statistically similar. The study of Solis Moreno C et al. [18] compared the root surface of samples treated with hand curettes, diamond tips, and ultrasound tips and concluded that diamond tips caused a rougher surface than the other instruments tested. The information presented by the two latter authors corroborates the findings of this present study.

Freitas NM et al. [17] showed that the scaling executed with conventional ultrasound tips is effective in removing the bacterial endotoxins and causes smaller loss of tooth substance than hand curettes. Kochcr T et al. [22] affirmed that the loss of tooth substance was greater when ultrasound tips were employed, unlikely the use of hand curettes. The results showed by these authors exhibit positive association with the results of this present study because there is correlation between the loss of tooth substance and root roughness caused by scaling.

The study of Yukna RA et al. [23] affirmed that hand curettes, ultrasound tips, and diamond tips are effective in removing tooth calculus. The ultrasound tips require less time than does ultrasound tips. The scaling performed with diamond tips require less time than does ultrasound tips. The diamond tip was much more effective in removing calculus than ultrasound tips and hand curettes. The root surface texture showed significant differences among all instruments tested. Root surface treated with hand curettes was more regular than that of ultrasound and diamond tips.

In relation to methodology, in this study, it was not possible to standardize the force intensity applied during scaling, as executed by Lara et al. [16], but the amount of movements was standardized in 15. According to the findings of this same author, the greater the force applied the greater is the amount of calculus and cementum removed. Also, more than 15 repetitions of scaling did not provide further benefits regarding calculus and cementum removal.

CONCLUSION

Based on the limits and results of this present study, there was a significant increasing of superficial roughness in all groups after root scaling. The scaling performed with diamond tips promoted greater root roughness than that of hand curettes and ultrasound tips, which were statistically similar between each other.

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