Original Article

Root Surface Roughness After Scaling and Root Planing with Er:YAG Laser Compared to Hand and Ultrasonic Instruments by Profilometry

Jaber Yaghini[1], Narges Naghsh[2], Elaheh Attaei[3], Reza Birang[4], Ehsan Birang[5]

[1]Associate Professor, Torabinejad Dental Research Center, Department of Periodontology, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
[2]Assistant Professor, Torabinejad Dental Research Center, Department of Periodontology, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
[3]Dentist, Tehran, Iran
[4]Professor, Torabinejad Dental Research Center, Department of Periodontology, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
[5]Postgraduate Student, Department of Periodontology, School of Dentistry, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran

Abstract

Objectives: Scaling and root planing (SRP) is one of the most commonly used procedures during periodontal treatment. The aim of this study was to evaluate the root surface roughness after SRP with erbium: yttrium aluminum garnet (Er:YAG) laser compared to ultrasonic and hand instruments.

Materials and Methods: In this experimental study, 56 extracted sound single-rooted teeth with moderate level of calculus were selected and randomly divided into four groups: SRP was performed with Er:YAG laser (100 mJ pulse, 1W, 10Hz, VSP and contact mode, with 50% water and air) in group one, hand instrument in group two and ultrasonic tool in group three. Group four was considered as the control group. After SRP, all samples were cut by Servocut cutting machine into pieces with 3×3×2mm dimensions. The samples were mounted in acrylic resin. The surface roughness of the samples was evaluated with profilometry, and the data were analyzed using one-way ANOVA and Tukey's test in SPSS software.

Results: Surface roughness was higher in laser and lower in ultrasonic group compared to other groups. There was a significant difference in surface roughness between laser and ultrasonic groups (P=0.043), but there was no significant difference in surface roughness among other groups (P>0.05).

Conclusion: The results of this study showed that surface roughness after SRP with Er:YAG laser was not higher than that after manual SRP, but the former value was higher than that after SRP with ultrasonic instrument.

Keywords: Dental Cementum; Lasers, Solid-State; Root Planing

Journal of Dentistry, Tehran University of Medical Sciences, Tehran, Iran (2015; Vol. 12, No. 12)

Corresponding author:
E. Birang, Department of Periodontology, School of Dentistry, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran

nn_2005_d@yahoo.com

Received: 23 June 2015
Accepted: 27 November 2015

INTRODUCTION

Bacterial plaque is the primary etiology of gingivitis and periodontitis. Bacterial plaque is converted to calculus after mineralization and can be formed on natural teeth or dental prostheses. Calculus plays a major role in development and progression of periodontal disease due to its contact with periodontal tissues. Therefore, removing the calculus and the collected bacterial plaque from the tooth surface is among the most important interventions for treatment of periodontal

disease. Scaling and root planing is performed to remove calculus and plaque [1]. The goal of SRP is to smooth the root surface [2]. Various methods such as hand instruments, ultrasonic scalers, and recently erbium family of lasers have been used for SRP [3-5]. Hand instruments have some advantages such as better control over the instrument, sense of touch to recognize the roughness of the surface, and obtaining a smooth surface. There are also some disadvantages such as being time consuming, the need for high level of physical force to remove calculus, bleeding, which limits vision and access, pain, lack of access to distant areas such as furcations and fissures and the resultant roughness of root surface. In addition, the efficacy of treatment with hand instruments depends on the operator's skills [6,7].

In comparison with hand instruments, ultrasonic tools leave more contaminated cementum on the surface of the teeth after treatment, and are valuable adjuncts to hand instruments for tooth surface debridement [8,9]. When ultrasonic tools are appropriately used, the discomfort after the operation decreases; thus, they are suitable for primary debridement of root surfaces in patients with acute necrotizing ulcerative gingivitis [10]. There are also disadvantages like production and release of contaminating aerosols, potential injury to tooth structure, formation of micro-cracks in dental enamel and porcelain crown surfaces, roughening the surface, risk of interference in patients with cardiac pacemakers and leaving a smear layer [11,12]. With regard to the aforementioned disadvantages for hand instruments and ultrasonic tools, replacing them with more appropriate and efficient methods has always been considered and therefore, various researchers recommend the application of Er:YAG laser with different wavelengths to remove deposits on root surfaces [13]. Various types of lasers such as carbon dioxide (CO_2), neodymium yttrium aluminum garnet (Nd:YAG), Er:YAG and erbium chromium: yttrium scandium gallium garnet (Er,Cr:YSGG) have been used for SRP, but Er:YAG is more appropriate due to its absorption by H2O and hydroxyapatite, which is the highest in comparison with other wavelengths [14]. Evidence shows that laser yields clinical and microbiological results comparable to those of hand instruments and sonic and ultrasonic tools [15,16]. Therefore, the question is whether the application of laser for SRP would result in a smoother surface compared to other methods. The goal of this study was to assess the surface roughness following SRP with Er:YAG laser compared to ultrasonic and hand instruments using profilometry.

MATERIALS AND METHODS

In this experimental study, 42 extracted sound single rooted teeth covered with calculus and 14 sound teeth with no calculus were collected and immersed in sodium azide solution (pH=7.05, 0.2%). Mesial and distal surfaces of the teeth below cementoenamel junction (CEJ) with calculus were considered as areas for SRP. In case of any decay, breakage, congenital anomaly or concavity in these areas, the tooth was excluded and replaced with another tooth. The samples were randomly divided into four equal groups.

In group one, the samples were subjected to SRP with Er:YAG laser at a wavelength of 2940 nm (Fotona, Fidelisplus, Ljubljana, Slovenia), energy of 100 mJ pulse, 1W, frequency of 10Hz, VSP mode, power density of 15.38 W/cm^2, water/ air of 50% and hand piece of R 14 with a chisel tip until a smooth surface was achieved [17-20] (Fig. 1). The contact angle of the device tip relative to the tooth surface was fixed as 20-30° visually, and laser was used with a strong scrubbing motion from the apex towards the CEJ in all groups. Then, root planing movements were performed more smoothly with a higher range and lower side force.

Fig. 1. Laser handpiece (R14) with chisel tip

Scaling and root planing was continued until calculus was completely removed based on the clinician's judgment leaving a smooth and flat surface. Finally, explorers No. 17 and 23 were used for further examination of the surface roughness and to confirm its smoothness. The samples in group two were scaled by a hand instrument. Scaling was conducted by Gracey curette No. 3-4 (Medesy SRL, Maniago, Italy) with its heavy shank grasped in hand in modified pen grasp position with short and strong movements from apex toward the CEJ. Root planing was performed after scaling. In group three, scaling was conducted by an ultrasonic device (Micropiezo S, Mectron, Carasco, Italy) with a universal tip. In a previous study done by Casarin et al, [21] it was demonstrated that the power setting of the ultrasonic scaler did not influence the defect depth on root surface; therefore we used the ultrasonic device in moderate power under high water irrigation. The contact angle between the tip of the device and the tooth was fixed a little less than 90˚

during the process and the process was continued until a smooth surface was achieved. Group four was the control group with no calculus. No intervention on the mesial or distal surfaces of the teeth was performed. After finishing SRP, the samples were cut by Servocut M300P (Metkon instrument LTD, Bursa, Turkey) into pieces measuring 2×3×3mm in such a way that the scaled surfaces remained intact.

The cut samples were mounted in glass blocks containing acrylic resin within holes made inside the acrylic with a diameter of 25mm and depth of 6mm so that the scaled surfaces were at the level of the cold cure acrylic resin surface (Acropars, Marlic Medical Co., Karaj, Iran). Then, two pairs of parallel lines distanced 1mm from each other were perpendicularly drawn on the blocks obtained from mounting to guide the direction of profilometer movement. Next, the mounted samples were analyzed by a profilometer (Marsurf PS1, Mahr Co., Gottingen, Germany) to determine the level of surface roughness. Finally, the obtained results were analyzed by one-way ANOVA and Tukey's tests using SPSS version 16 (SPSS Inc., Chicago, IL, USA).

RESULTS

The P-value of Levene's test for homogeneity of variances was 0.179 indicating existence of homogeneity among the groups. The mean surface roughness scores were compared by one-way ANOVA and it was revealed that the lowest mean score of surface roughness was noted in the group treated with ultrasonic method (1.08 µm).

The scores were 1.1 µm in the control, 1.21 µm in the hand instrument and 1.2 in the laser group, respectively (P=0.03) (Table 1). One-way ANOVA was followed by Tukey's test for pairwise comparison of the groups. The results showed a significant difference between the two groups of laser and ultrasonic tool (P=0.043). Meanwhile, the results showed no significant difference among other groups including the control group and ultrasonic tool group (P>0.05, Table 2).

DISCUSSION

The obtained results of the current study showed that among the three methods of SRP namely laser, ultrasonic and hand instruments, the smoothest surface was obtained by ultrasonic instrument while the roughest surface after SRP was obtained by laser.

Table 1. Comparison of the mean and standard deviation of surface roughness (µm) in the four groups

Value / Groups	Mean	Standard deviation	Minimum	Maximum	P-value
Laser	1.50	0.47	0.82	2.83	0.03
Hand instrument	1.21	0.33	0.86	1.99	
Ultrasonic	1.08	0.24	0.66	1.44	
Control	1.10	0.56	0.07	2.29	

Table 2. P-values for the pairwise comparison of the groups with Tukey's post hoc test

Groups	Laser	Hand instrument	Ultrasonic	Control
Laser	--	0.268	0.043	0.064
Hand Instrument	0.268	---	0.832	0.893
Ultrasonic	0.043	0.832	---	0.999
Control	0.893	0.893	0.999	---

These findings are consistent with the results of former studies reporting the smoothest surface after SRP with ultrasonic method [22-27]. However, Crespi et al, [3] and Schwarz et al. [28] showed that surface roughness after SRP with laser was lower than that in other methods. Their findings were not in line with those of the current study. De Mendonca et al, [25] and Folwaczny et al. [29] reported that the roughness following laser therapy was almost similar to that following SRP with hand or ultrasonic instruments. Ota-Tsuzuki et al. [24] compared three methods of hand instrument, ultrasonic instrument and Er:YAG laser and stated that the roughest surface was obtained by hand instrument, while the smoothest surface was obtained with ultrasonic method. The surface roughness following SRP with laser ranked between the two abovementioned methods. There was no significant difference between ultrasonic and control groups. Hakki et al. investigated the effect of hand instrumentation and Er,Cr:YSGG laser irradiation on the roughness of root surfaces. They observed greater roughness in laser group than in group treated with hand instruments and showed the ability of laser to do SRP in treatment of periodontitis [30]. In another study, Er:Cr:YSGG laser and hand instrumentation were compared in terms of their effect on attachment of periodontal ligament fibroblasts to periodontally diseased root surfaces and it was shown that short-pulse laser was more promising with regard to the attachment of periodontal ligament cells [31].

Marda et al. compared the roughness of root surfaces after root planing with Gracey curettes, ultrasonic instrument and rotary bur and concluded that ultrasonic instrument caused the lowest mean roughness, which was comparable to our results [32].

However, the findings of the current study showed that application of laser for SRP results in higher roughness compared to other methods. These results are more reliable due to the precise method of profilometry adopted in the current study compared to some other studies [22-27].

Although the method of laser application and the selected parameters can affect the results, the difference in standards, surface roughness measurement methods, application of various tools with different sharpness and tip size, tip contact with the root surface, operator's skills and force applied during SRP may be responsible for the controversial results in various studies [22,23]. Ota-Tsuzuki et al, [24] and Quirynen et al. [33,34] emphasized that increased root surface roughness can enhance bacterial accumulation and biofilm formation and lead to gingivitis. Schwarz et al. [35] compared two groups of laser and hand instrument and showed an increase in the bond of cocci and rods and a decrease in the bond of spirochetes to the treated surfaces in both groups. They reported no significant difference in clinical attachment level between the two groups. Etemadi et al, [36] in a recent study compared Er:YAG and Er,Cr:YSGG lasers for scaling of root surfaces and concluded that there were no significant differences in their efficacy for calculus removal. Although based on the results of the afore-mentioned studies, the effect of laser method with regard to causing surface roughness after SRP is controversial to some extent, there are studies emphasizing on optimal efficacy of laser for SRP. Laser can be applied as an adjunct to conventional methods of SRP due to an increase in adhesion of fibroblasts and periodontal ligament to tooth surface as the result of causing higher roughness in addition to its antimicrobial effects on the microorganisms responsible for periodontitis [37,38]. Considering all the above, it can be concluded that surface roughness may be somehow favorable in root dentin since it is adjacent to the periodontal ligament, but in coronal dentin exposed to oral environment, surface roughness must be minimized. Further studies in this field particularly controlled clinical trials are required. Also, use of more precise tools for measurement of surface roughness is suggested.

CONCLUSION

The results of the current study showed that application of Er:YAG laser for SRP was not different from the hand instrument in terms of surface roughness, but led to higher surface roughness compared to the ultrasonic method.

ACKNOWLEDGMENTS

The authors like to express their gratitude to the Laser Institute of Torabinejad Dental Research Center for their financial support of this study.

REFERENCES

1- Badersten A, Nilveus R, Egelberg J. Effect of nonsurgical periodontal therapy. II. Severely advanced periodontitis. J Clin Periodontol. 1984 Jan;11(1):63-76.

2- Research, Science and Therapy Committee of the American Academy of Periodontology. Treatment of plaque-induced gingivitis, chronic periodontitis, and other clinical conditions. J Periodontol. 2001 Dec;72(12): 1790-800.

3- Crespi R, Barone A, Covani U. Effect of Er:YAG laser on diseased root surfaces: an in vivo study. J Periodontol. 2005 Aug;76(8): 1386-90.

4- Yukna RA, Scott JB, Aichelmann-Reidy ME, LeBlanc DM, Mayer ET. Clinical evaluation of the speed and effectiveness of subgingival calculus removal on single-rooted teeth with diamond-coated ultrasonic tips. J Periodontol. 1997 May;68(5):436-42.

5- Crespi R, Capparè P, Toscanelli I, Gherlone E, Romanos GE. Effects of Er:YAG laser compared to ultrasonic scaler in periodontal treatment: a 2-year follow-up split-mouth clinical study. J Periodontol. 2007 Jul;78(7): 1195-200.

6- Moghare Abed A, Tawakkoli M, Dehchenari MA, Gutknecht N, Mir M. A comparative SEM study between hand instrument and Er:YAG laser scaling and root planing. Lasers Med Sci. 2007 Mar;22(1):25-9.

7- Oda S, Nitta H, Setoguchi T, Izumi Y, Ishikawa I. Current concepts and advances in

manual and power-driven instrumentation. Periodontol 2000. 2004;36:45-58.
8- Kawashima H, Sato S, Kishida M, Ito K. A comparison of root surface instrumentation using two piezoelectric ultrasonic scalers and a hand scaler in vivo. J Periodontal Res. 2007 Feb;42(1):90-5.
9- Chen SK, Vesley D, Brosseau LM, Vincent JH. Evaluation of single-use masks and respirators for protection of health care workers against mycobacterial aerosols. Am J Infect Control. 1994 Apr;22(2):65-74.
10- Wilson JR. The use of ultrasonics in periodontal treatment. J Prosthet Dent. 1958 Jan;8(1):161-6.
11- Dibart S, Capri D, Casavecchia P, Nunn M, Skobe Z. Comparison of the effectiveness scaling and root planning in vivo using hand vs rotary instruments. Int J Periodontics Restorative Dent. 2004 Aug;24(4):370-7.
12- Lie T, Meyer K. Calculus removal and loss of tooth substance in response to different periodontal instruments. A scanning electron microscope study. J Clin Periodontol. 1977 Nov;4(4):250-62.
13- Morlock BJ, Pippin DJ, Cobb CM, Killoy WJ, Rapley JW. The effect of Nd:YAG laser exposure on root surfaces when used as an adjunct to root planing: an in vitro study. J Periodontol. 1992 Jul;63(7):637-41.
14- Hakki SS, Berk G, Dundar N, Saglam M, Berk N. Effects of root planing procedures with hand instrument or erbium, chromium: yttrium–scandium–gallium–garnet laser irradiation on the root surfaces: a comparative scanning electron microscopy study. Lasers Med Sci 2010 May;25(3):345-53.
15- Derdilopoulou FV, Nonhoff J, Neumann K, Kielbassa AM. Microbiological findings after periodontal therapy using curettes, Er: YAG laser, sonic, and ultrasonic scalers. J Clin Periodontol. 2007 Jul;34(7):588-98.
16- Lopes BM, Marcantonio RA, Thompson GM, Neves LH, Theodoro LH. Short-term clinical and immunologic effects of scaling and root planing with Er:YAG laser in chronic periodontitis. J Periodontol. 2008 Jul;79(7): 1158-67.
17- Crespi R, Barone A, Covani U. Er:YAG laser scaling of diseased root surfaces: a histologic study. J Periodontol. 2006 Feb;77 (2):218-22.
18- Yaneva B, Firkova E, Karaslavova E. Early Clinical Effectiveness of Er:Yag Laser in Association with the Red Complex of Bacteria in the Initial Treatment of Moderate Chronic Periodontitis. Acta Med Bulg 2014; 41(1):37–44.
19- Stock K, Hibst R, Keller U. Er: YAG removal of subgingival calculi: efficiency, temperature, and surface quality. InBiOS Europe'96 1996 Dec;2922:98-106.
20- Araki AT, Ibraki Y, Kawakami T, Lage-Marques JL. Er:YAG laser irradiation of the microbiological apical biofilm. Braz Dent J. 2006;17(4):296-9.
21- Casarin RC, Ribeiro FV, Sallum AW, Sallum EA, Nociti-Jr FH, Casati MZ. Root surface defect produced by hand instruments and ultrasonic scaler with different power settings: an in vitro study. Braz Dent J. 2009; 20(1):58-63.
22- Aoki A, Miura M, Akiyama F, Nakagawa N, Tanaka J, Oda S, et al. In vitro evaluation of Er:YAG laser scaling of subgingival calculus in comparison with ultrasonic scaling. J Periodontal Res. 2000 Oct;35(5):266-77.
23- Crespi R, Romanos GE, Cassinelli C, Gherlone E. Effects of Er:YAG laser and ultrasonic treatment on fibroblast attachment to root surfaces: An in vitro study. J Periodontol. 2006 Jul;77(7):1217-22.
24- Ota-Tsuzuki C, Martins FL, Giorgetti AP, de Freitas PM, Duarte PM. In vitro adhesion of Streptococcus sanguinis to dentine root surface after treatment with Er:YAG laser, ultrasonic system, or manual curette. Photomed Laser Surg. 2009 Oct;27(5):735-41.
25- de Mendonça AC, Máximo MB, Rodrigues JA, Arrais CA, de Freitas PM, Duarte PM. Er:YAG laser, ultrasonic system, and curette produce different profiles on dentine root

surfaces: an in vitro study. Photomed Laser Surg. 2008 Apr;26(2):91-7
26- Frentzen M, Braun A, Aniol D. Er:YAG laser scaling of diseased root surfaces. J Periodontol. 2002 May;73(5):524-30.
27- Solís Moreno C, Santos A, Nart J, Levi P, Velásquez A, Sanz Moliner J. Evaluation of root surface microtopography following the use of four instrumentation systems by confocal microscopy and scanning electron microscopy: an in vitro study. J Periodontal Res. 2012 Oct;47(5):608-15.
28- Schwarz F, Pütz N, Georg T, Reich E. Effect of an Er:YAG laser on periodontally involved root surfaces: an in vivo and in vitro SEM comparison. Lasers Surg Med. 2001;29(4):328-35.
29- Folwaczny M, Mehl A, Aggstaller H, Hickel R. Antimicrobial effects of 2.94 microm Er:YAG laser radiation on root surfaces: an in vitro study. J Clin Periodontol. 2002 Jan;29 (1):73-8.
30- Hakki SS, Berk G, Dundar N, Saglam M, Berk N. Effects of root planing procedures with hand instrument or erbium, chromium:yttrium-scandium-gallium-garnet laser irradiation on the root surfaces: a comparative scanning electron microscopy study. Lasers Med Sci. 2010 May;25(3):345-53.
31- Hakki SS, Korkusuz P, Berk G, Dundar N, Saglam M, Bozkurt B, et al. Comparison of Er,Cr:YSGG laser and hand instrumentation on the attachment of periodontal ligament fibroblasts to periodontally diseased root surfaces: an in vitro study. J Periodontol. 2010 Aug;81(8):1216-25.
32- Marda P, Prakash S, Devaraj CG, Vastardis S. A comparison of root surface instrumentation using manual, ultrasonic and rotary instruments: An in vitro study using scanning electron microscopy. Indian J Dent Res. 2012 Mar-Apr;23(2):164-70.
33- Quirynen M, van der Mei HC, Bollen CM, Schotte A, Marechal M, Doornbusch GI, et al. An in vivo study of the influence of the surface roughness of implants on the microbiology of supra-and subgingival plaque. J Dent Res. 1993 Sep;72(9):1304-9.
34- Quirynen M, Marechal M, Busscher HJ, Weerkamp AH, Darius PL, van Steenberghe D. The influence of surface free energy and surface roughness on early plaque formation. J Clin Periodontol. 1990 Mar;17(3):138-44.
35- Schwarz F, Sculean A, Berakdar M, Georg T, Reich E, Becker J. Periodontal treatment with an Er:YAG laser or scaling and root planing. A 2-year follow-up split-mouth study. J Periodontol. 2003 May;74(5):590-6.
36- Etemadi A, Sadeghi M, Abbas FM, Razavi F, Aoki A, Azad RF, et al. Comparing efficiency and root surface morphology after scaling with Er:YAG and Er,Cr:YSGG lasers. Int J Periodontics Restorative Dent. 2013 Nov-Dec;33(6):e140-4.
37- Schwarz F, Aoki A, Sculean A, Georg T, Scherbaum W, Becker J. In vivo effects of an Er:YAG laser, an ultrasonic system and scaling and root planing on the biocompatibility of periodontally diseased root surfaces in cultures of human PDL fibroblasts. Lasers Surg Med. 2003;33(2):140-7.
38- Lopes BM, Theodoro LH, Melo RF, Thompson GM, Marcantonio RA. Clinical and microbiologic follow up evaluation after non-surgical periodontal treatment with Erbium:YAG laser and scaling and root planning. J Periodontol. 2010 May;81(5):682-91.