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Research Article

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Periimplantitis Surface Decontamination and Integrity Following Use of Co2 Laser or Water Irrigation and Mechanical Therapy: A Comparison Study

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ABSTRACT

Objective: The primary aim of this study was to evaluate and compare the effects of Carbon dioxide (Co2) laser or mechanical therapy and water irrigation on dislodgement of surface deposits, surface decontamination and surface integrity of bacterially contaminated implant surfaces.

Background: Currently, there is a lack of evidence about optimal surface decontamination for implants affected with peri-implantitis. This study compares these two methods of surface decontamination on two implants which were explanted due to bone loss caused by periimplantitis.

Method: This in-vitro comparison study was performed on two failed dental implants that were affected by advanced levels of peri-implantitis and required explanation. Two periimplantitis affected implants were removed with one treated with mechanical cleaning and saline irrigation and the other with high-power laser irradiation using a 1.0mm spot size, 60% cutting speed and energy output of 13.9 watt (w) 100% mist for one minute. Post treatment, both implants were dehydrated, mounted on aluminum studs and gold plated for surface topography and surface disinfection level Scanning electron microscope (SEM) evaluation.

Results: High power laser treatment for one minute showed no deposits attached to the implant surface. The entire surface appeared intact with no surface scratches and no adherent bacterial colonies. The mechanical and water treated implants showed deposits still adherent to the implant surface with multiple areas of implant surface scratches and surface distortion.

Conclusions: A 9.3-micron Co2 laser setting used with a high-power setting of 1.0mm spot size, 60% cutting speed, 100% mist and an energy output of 13.9w for one minute could be a safe effective setting providing maximum antiplaque effect with minimum to no effects on implant surface integrity. Mechanical hand cleaning with saline irrigation was not effective in removing all biofilm and left scratches on the implant surface.

Keywords: Peri-Implantitis, Implant Decontamination, Co2 Laser

Introduction

The fundamental concept of peri-implantitis treatment is to restore the biocompatibility of implant surfaces affected with

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peri implant disease and encourage proximal bone and soft tissue to re-adhere to the implant surface. Peri-implant inflammatory reactions, when exposed to bacteria contained within the oral biofilm, appear more severe and require a longer healing phase after removal of biofilm compared to that of natural teeth [1]. In addition, implant surface decontamination of a dental implant is more challenging compared to a natural tooth root. Consequently, the use of adjunctive therapies appears to be more essential for superior outcomes when comparing debridement of dental implants to tooth root surfaces [2]. The challenge of an exposed implant surface decontamination procedure, an essential step in peri-implantitis therapy, is to remove causative bacteria from the implant surface without altering the implant surface structure. Several treatment protocols for peri-implantitis management have been proposed including non-surgical or surgical treatment with or without regenerative/resective approaches [3]. Decontamination options including mechanical, chemical, and/or laser assisted protocols have been attempted to restore peri-implantitis affected surface biocompatibility without inducing surface damage [4].

Mechanical debridement with or without adjunctive antibiotics, systemic or local antibiotics and antimicrobial photodynamic therapy (aPDT) have been proposed with variable outcomes. Mechanical therapy demonstrated diminished effectiveness in removing pathogens and has the most potential to damage or alter implant surfaces. Surface damage can induce a chemical oxide layer that increases the possibility of implant surface corrosion, surface roughness, and enhances biofilm re-growth on treated surfaces [5-8]. Systemic and local antibiotics have been used in conjunction with mechanical debridement to enhance efficacy with mixed reviews in the literature. A recent systematic review reported a threefold increase in treatment success when using antibiotics with mechanical debridement as compared with mechanical debridement alone [9]. Jepsen et al. 2015, reported that adjunctive measures such as local and systemic antibiotics, antiseptics, and air abrasive devices could not significantly enhance the reduction of inflammation around dental implants compared to mechanical debridement alone [10]. A consensus report in 2019 on periodontitis and peri-implant disease reported that there is currently no sufficient evidence for the use of antimicrobials for treatment of peri-implant mucositis [5]. Regenerative studies around peri-implant bony lesions also report a limited outcome when surgical treatments used mechanical debridement and antibiotics as compared with mechanical debridement alone. The authors concluded that effective surface decontamination appears to be the more important determinant of treatment success as compared with what type of regenerative material was used [11].

Concern exists around both antibiotic resistance and sensitivity/allergic reactions when using systemic antibiotic as adjunctive therapies. Subgingival peri-implant pathogens were reported to be resistant in vitro to certain concentrations of clindamycin, amoxicillin, doxycycline, or metronidazole in 71.7% of the cases [12].

Laser assisted implant surface decontamination has been investigated as a possible method capable of implant surface decontamination without negative surface alteration. Laser decontamination has also been shown to be an effective debridement method without the need for adjunctive antibiotic use [13]. Combining the ability to debride inaccessible areas without damage to implant surface topography has given lasers the ability to induce new bone formation around implants with bone loss [14]. Various laser systems, such as diodes, neodymium: yttrium-aluminum-garnet (Nd:YAG), erbium: yttrium-aluminum-garnet (Er:YAG), and carbon dioxide (CO_2), have been used for the treatment of peri-implantitis [15]. Both 9,300 nm and 10,600 nm CO_2 lasers have been used for the decontamination of the implant surface [16]. However, the 10.6-micron wavelength has been studied more extensively and has been recommended for soft-tissue incision, ablation, de-epithelialization, periodontal, and implant surgery due to its minimal tissue penetration of 0.03 - 0.1 mm [17]. Effects of laser decontamination of peri-implantitis affected implants using a 10.6-micron Co2 laser have also been studied with mixed success [18].

Currently, there is a lack of evidence about the optimal treatment protocol of implants affected with peri-implantitis. The main objective of this study was to compare the effect of high-power laser irradiation for one minute with mechanical hand instruments and saline irrigation for one minute on dislodgement of surface deposits, surface decontamination and surface integrity of bacterially contaminated implant surfaces.

Material and Methods

This in vitro SEM study was performed on 2 samples of failed dental implants from the same manufacturer (Nobel Biocare) that were affected by advanced levels of peri-implantitis and required explantation. Two implants were obtained from patients with severe peri-implant disease with over 50% bone loss around the dental implants that were explanted. Implants were carefully extracted by the same study investigator with the implant driver being inserted into the platform and removed in reverse torque fashion. No implant was manipulated in order to preclude any surface damage from occurring. The removed implants were then treated immediately. Both received surface decontamination. All the implants were handheld during testing with the implant driver mount. Once completed, implants were labeled and kept in 10% formalin solution until SEM processing. Both samples were dehydrated in a vacuum oven (Jelotech, OV-11, Korea), mounted on aluminum studs and gold plated for surface topography and surface disinfection level SEM evaluation. Implants were placed in the sample room of scanning electron microscope (LEO Field Emission SEM Model: Leo Supra 55 Specification: Ultra high resolution at low KV: 1 nanometer(nm) @ 15 kilo volt (KV), 1.7 nm @ 1 KV, 4 nm @ 0.1 KV. Magnification 20 x to 900,000 x Electron gun: thermal field emission type) and sites in each were evaluated from the first to the most apical implant threads at different magnifications. The surface showing the deepest probing depths on each implant was the one treated and studied. The presence or absence of gross hard deposits were recorded as yes or no. All samples were evaluated first at low magnification (30-50x) to explore surface deposits. Bacterial contamination and surface structure were evaluated at 500x, and magnification increased to confirm the findings at different levels. One implant was treated with mechanical hand instrumentation (with graphite curettes) followed by mechanical therapy and one minute of saline irrigation and the other treated with high power laser irradiation using a 1.0 mm spot size, 60% cutting speed and energy output of 13.9w followed by 100% saline mist irrigation for one minute.

Results

The implant treated with mechanical debridement (graphite curettes) and saline irrigation showed deposits within the implant grooves which appeared partially dislodged from the implant surface. Most of the surfaces were covered by a heavy biofilm layer with multiple discrete colonies on top. (Figure. 1) Some discrete areas of a clean implant surface appeared with full exposure of the implant surface surrounded by a biofilm layer. The hand instrumentation combined with saline irrigation treated samples showed various levels of bacterial deposits still adherent to the implant surface. Most of the surfaces appeared with a partial smear layer coverage with many adsorbed bacterial aggregates on top of exposed implant surface (Figure. 2). Multiple areas of implant surface scratches and surface distortions were apparent. (Figure. 3).

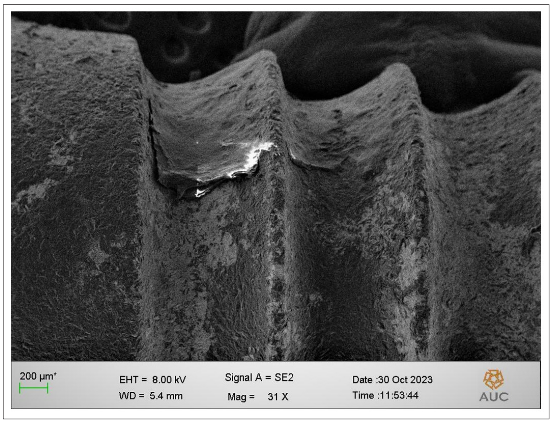

Figure 1: Hand instruments and saline irrigation treated control sample showing partial cleaning of the implant surface with evident calcareous deposits still adherent to the surface

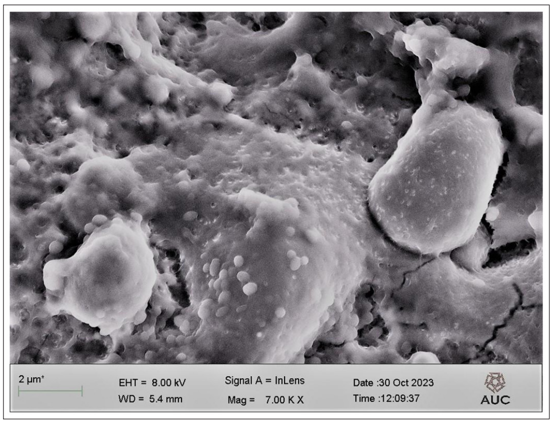

Figure 2: Hand instrument and saline treated sample showing implant surface covered with bacterial colonies on an exposed implant surface

The implant treated with the high13.9w laser setting 60% cutting speed and 100%w for one minute showed no deposits attached to the implant surface. The entire surface appeared intact with no surface scratches and no presence of bacterial colonies (Figure. 4,5).

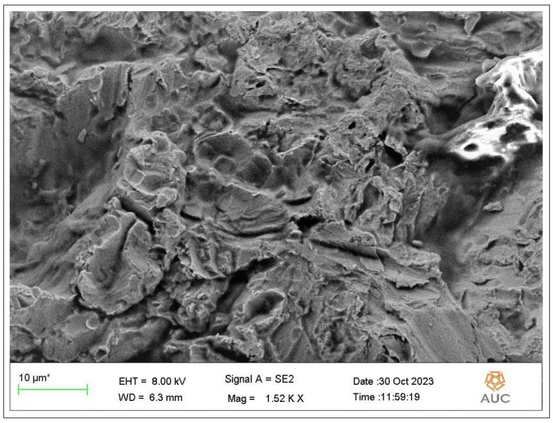

Figure 3: Hand instrument and saline treated sample showing some areas of implant surface scratches and surface distortion with some bacterial contaminants

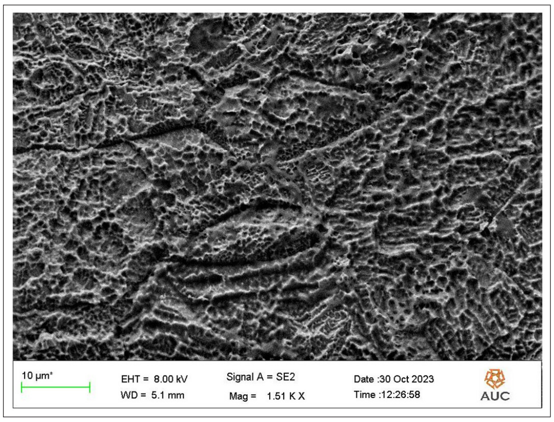

Figure 4: High power laser treated surface for one minute with the implant surface totally clean with no deposits and free from bacterial contamination

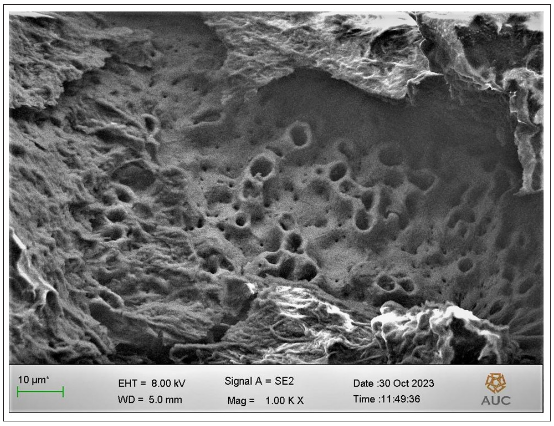

Figure 5: High power laser treated surface showing no surface scratches or alterations

Discussion

Although many implant decontamination strategies have been proposed in the literature, no single peri-implantitis treatment protocol is considered the gold standard One of the most important factors that remains a challenge is thorough surface decontamination of an implant contaminated with bacteria prior to regenerative therapy [19,20]. Laser therapy is a promising, minimally invasive approach that could reach areas not accessible by manual debridement. The 9,300 nm wavelength of Co2 laser is well absorbed by water with an excellent power to coagulate biofilm structure and has a shallow depth of penetration into soft tissue. This shallow penetration depth makes it not absorbed by metallic surfaces keeping the metallic implant structure and any surrounding tissues intact while avoiding temperature related tissue necrosis [21]. The 9.3- micron Co2 wavelength has the highest absorption in hydroxyapatite of any dental laser, about 1000 times greater than erbium [22]. Therefore, these lasers have the potential to have an efficacious removal of calcareous deposits on the implant surface. The problem is that the exact settings and protocols when using these lasers remain unclear. By using appropriate setting parameters, the laser radiation can be absorbed by adjacent peri-implant tissues, promoting bio-stimulation and anti-phlogistic effects without overheating adjacent tissues. This study was designed to compare Co2 high power laser setting on cleaning the implant surface deposits, achieving surface decontamination, and maintaining surface integrity of peri-implantitis affected rough exposed fixture parts.

Water irrigation devices do not seem to effectively treat peri-implantitis with lack of disease resolution [23]. In the present study the implant treated with manual instrumentation combined with saline irrigation of the implant surface showed partial surface removal of surface deposits but failure to completely disinfect bacterial colonies. In addition, manual instrumentation led to implant surface alterations and scratches. These findings again are supported by clinical studies that show continued inflammation with bleeding upon probing and a failure to achieve complete disease resolution when using manual instrumentation to treat peri-implantitis affected implants [24,25].

High power laser treatment, 1.0 spot size 60% cutting speed 13.9w 100% mist, for one minute showed no gross surface deposits on the implant surface. The entire surface appeared intact and free of any biofilm deposits or bacterial colonies (Figure. 4). No surface alteration or scratches were present. (Figure. 5)

Different Co2 laser settings for safe implant surface disinfection have been reported in the literature. Froum et al 2019 analyzed the ability of a 9.3-micron Co2 laser to irradiate implants invitro while not inducing surface damage or raising soft and hard proximal tissues above the 44 degrees Celsius [26]. The authors concluded that laser irradiation of titanium implant surfaces using a 9.3- micrometer (μm) carbon dioxide laser with an average power of 0.7w showed no increase in thermal temperature of the implant body and tissue temperatures as well as no evidence of implant surface damage. This study did not evaluate the efficacy of implant surface decontamination. Stubinger et al. 2010 stated that a 10.6-micron Co2 laser irradiation with a spot size of 0.4 millimeter (mm) at 4w continuous wave mode for 10 seconds without external cooling did not cause any surface alteration of implant surfaces [27]. Tosun et al 2012 reported that 10.6-micron Co2 laser eliminated 100% of the bacteria at 6w, 20 hertz (Hz), and a 10-milliseconds (ms) exposure time/pulse with a 10-second application period (0.8-mm spot size) but did not report on surface alteration. The present study evaluated both the efficacy of implant surface decontamination and alteration of implant surface topography while using a 9.3-micron Co2 laser [28].

Similar to natural tooth root surface chemical or laser disinfection outcomes, many studies report that the additional diode or Co2 laser application does not significantly affect bleeding on probing (BOP) and probing depth (PD) changes compared to the mechanical treatment alone [29,30]. The value of implant surface disinfection is enhanced however when not used as a monotherapy but combined with regenerative therapies. Gamal et al reported that ethylenediaminetetraacetic acid (EDTA) root surface treatment could enhance Chlorhexidine (CHX) availability for 48 hours and could improve graft material adhesion to the root surface reducing clot blended graft shrinkage away from the root surface [31,32]. For that reason, examining the effect of Co2 laser implant surface disinfection in combination with bone grafts, biologics and/or other regenerative materials should be clinically evaluated.

Within the limitations of this study, we can conclude that a 9.3-micron Co2 laser setting used with a high-power setting of 1.0 mm spot size, 60% cutting speed, 100% mist and an energy output of 13.9w for one minute showed the best results including dislodgement of surface deposits, surface decontamination, and surface integrity. Water irrigation with mechanical therapy appeared unreliable for implant surface cleaning and decontamination. However, the current comparison study of two different methods of surface decontamination only treated two implants. More studies with other mechanical cleaning methods and use of CO2 lasers with other settings are needed to verify the results obtained in the current comparison study.

Declarations

Consent to Participate Declaration: Every human participant has provided their consent to participate in this study.

Funding Declaration: There is no funding source.

Human Ethics Declaration: Not applicable

Data Availability Declaration: The authors declare that the data supporting the findings of this study are available within the paper, derived data supporting the findings of this study are available from the corresponding author [Scott H. Froum] on request.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. Salvi GE, Aglietta M, Eick S, Sculean A, Lang NP, et al. Reversibility of experimental peri-implant mucositis compared with experimental gingivitis in humans. Clinical Oral Implants Research. 2012. 23: 182-190.
2. Wong R, Hiyari S, Yaghsezian A, Davar M, Lin YL, et al. Comparing the healing potential of late-stage periodontitis and Peri-Implantitis. J Oral Implantol. 2017. 43: 437-445.
3. Froum SJ, Froum SH, Rosen PS. A Regenerative Approach to the Successful Treatment of Peri-implantitis: A Consecutive Series of 170 Implants in 100 Patients with 2- to 10-Year Follow-up. Int J Periodontics Restorative Dent. 2015. 35: 857-863.

4. Barootchi S, Wang H. Peri-implant diseases: Current understanding and management. Int J Oral Implantol (Berl). 2021. 14: 263-282.
5. Renvert S, Lessem J, Dahlen G, Renvert H, Lindahl C. Mechanical and repeated antimicrobial therapy using a local drug delivery system in the treatment of peri implantitis: A randomized clinical trial. J Periodontol. 2008. 79: 836-844.
6. Blanco C, Pico A, Dopico J, Gándara P, Blanco J, et al. Adjunctive benefits of systemic metronidazole on non-surgical treatment of peri-implantitis. A randomized placebo-controlled clinical trial. J Clin Periodontol. 2022. 49: 15-27.
7. Romanos G, Nentwig G. Regenerative therapy of deep peri-implant infrabony defects after CO2 laser implant surface decontamination. Int J Periodontics Restorative Dent. 2008. 28: 245-255.
8. Souza JGS, Bertolini MM, Costa RC, Nagay BE, Dongari-Bagtzoglou A, et al. Targeting implant-associated infections: titanium surface loaded with antimicrobial. iScience. 2021. 24: 102008.
9. Barbato L, Cavalcanti R, Rupe C, Scartabelli D, Serni L, et al. Clinical efficacy of adjunctive methods for the non-surgical treatment of peri-implantitis: a systematic review and meta-analysis. BMC Oral Health. 2023. 23: 375.
10. Jepsen S, Berglundh T, Genco R, Aass AM, Demirel K, et al. Primary prevention of peri-implantitis: Managing peri-implant mucositis. Journal of Clinical Periodontology. 2015. 42: S152-S157.
11. Lehmann B, Brägger U, Hämmerle CHF, Foumousis I, Lang NP. Treatment of an early implant failure according to the principles of guided tissue regeneration (GTR). Clin. Oral Implants Res. 1992. 3: 42-48.
12. Rams T, Degener J, van WA. Antibiotic resistance in human peri-implantitis microbiota. Clin Oral Implants Res. 2014. 25: 82-90.
13. Ting M, Alluri LSC, Sulewski JG, Suzuki JB, Paes Batista da Silva A. Laser Treatment of Peri-Implantitis: A Systematic Review of Radiographic Outcomes. Dent J (Basel). 2022. 10: 20.
14. Mizutani K, Aoki A, Coluzzi D, Yukna R, Wang CY, et al. Lasers in Minimally Invasive Periodontal and Peri-Implant Therapy. Periodontology 2000. 2016. 71: 185-212.
15. Ishikawa I, Aoki A, Takasaki AA, Mizutani K, Sasaki KM, et al. Application of Lasers in Periodontics: True Innovation or Myth? Periodontology 2000. 2009. 50: 90-126.
16. Romanos GE, Everts H, Nentwig GH. Effects of Diode and Nd:YAG Laser Irradiation on Titanium Discs: A Scanning Electron Microscope Examination. J. Periodontol. 2000. 71: 810-815.
17. Dang AB, Rallan NS. Role of Lasers in Periodontology: A Review. Annals of Dental Specialty. 2013. 1: 8-12.
18. Oyster DK, Parker WB, Gher ME. CO2 lasers and temperature changes of titanium implants. J Periodontol. 1995. 66: 1017-1024.
19. Froum Stuart J. "Treatment of advanced peri-implantitis with regenerative therapy: a review of the rationale, technique, and outcomes." Frontiers of Oral and Maxillofacial Medicine 4 .2022.
20. Gamal Ahmed Y, Abdel-Ghaffar KA, El-Mofty M, Al Destawy MT, FroumD SH. Influence of Different Decontamination Approaches on Bone Substitute Adhesion to Peri-Implantitis Affected Implant Surfaces: An SEM Proof of Principle Study. 2020. 38-48.
21. Xue VW, Zhao IS, Yin IX, Niu JY, Lo ECM, et al. Effects of 9,300 nm Carbon Dioxide Laser on Dental Hard Tissue: A Concise Review. Clin Cosmet Investig Dent. 2021. 13: 155-161.
22. Pogrel MA, Muff DF, Marshall GW. Structural changes in dental enamel induced by high energy continuous wave carbon dioxide laser. Lasers Surg Med. 1993. 13: 89-96.
23. Hentenaar DFM, De Waal YCM, Van Winkelhoff AJ, Meijer HJA, Raghoebar GM. Non-surgical peri-implantitis treatment using a pocket irrigator device; clinical, microbiological, radiographical and patient-centred outcomes-A pilot study. International Journal of Dental Hygiene. 2020. 18: 403-412.
24. Nart J, Pons R, Valles C, Esmatges A, Sanz-Martín I. Non-surgical therapeutic outcomes of peri-implantitis: 12-month results. Clin Oral Investig. 2020. 24: 675-682.
25. Scarano A, Khater AGA, Gehrke SA, Serra P, Francesco I, et al. Current Status of Peri-Implant Diseases: A Clinical Review for Evidence-Based Decision Making. J Funct Biomater. 2023. 14: 210.
26. Froum SH, Cantor-Balan R, Kerbage C, Froum SJ. Thermal Testing of Titanium Implants and the Surrounding Ex-Vivo Tissue Irradiated With 9.3um CO2 Laser. Implant Dent. 2019. 28: 463-471.
27. Stubinger S, Etter C, Miskiewicz M, Homann F, Saldamli B, et al. Surface alterations of polished and sandblasted and acid-etched titanium implants after Er:YAG, carbon dioxide, and diode laser irradiation. Int J Oral Maxillofac Implants. 2010. 25:104-11.
28. Tosun E, Tasar F, Strauss R, Kıvanc DG, Ungor C. Comparative evaluation of antimicrobial effects of Er:YAG, diode, and CO_2 lasers on titanium discs: an experimental study. J Oral Maxillofac Surg. 2012. 70:1064-1069.
29. Aimetti M, Mariani GM, Ferrarotti F, Ercoli E, Liu CC, et al. Adjunctive efficacy of diode laser in the treatment of peri-implant mucositis with mechanical therapy: a randomized clinical trial. Clin Oral Implants Res. 2019. 30: 429-438.
30. Mariani GM, Ercoli E, Guzzi N, Bongiovanni L, Bianco L, et al. One-year clinical outcomes following non-surgical treatment of peri-implant mucositis with adjunctive diode laser application. Minerva Stomatol. 2020. 69: 269-277.
31. Gamal AY. Enhanced β-Tricalcium Phosphate Blended Clot Adhesion to EDTA Biomodulated Periodontally Affected Root Surfaces: In Vivo Scanning Electron Microscopy Evaluation J of Periodontology. 2011. 82: 1587-1595
32. Gamal AY, Abdel Ghaffar KA, Zouair MG, Salama MH, El Destawy MT. Dimensional evaluation of blood clot gap distances within intrabony defects following grafting and EDTA root surface treatment-experimental study in dogs. J Periodontol. 2018. 89: 691-698.