ER, CR:YSGG LAZERLERİN OSSEOİNTEGRASYON ÜZERİNE ETKİLERİNİN BELİRLENMESİ

DETERMINING THE EFFECTS OF ER, CR:YSGG LASERS ON OSSEOINTEGRATION

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Özet

Erbiyum, Krom: Yittriyum-Selenyum-Galyum-Garnet (Er, Cr:YSGG) lazerler dental kliniklerde kullanımı gittikçe artmaktadır. Çalışmamızın amacı konvansiyonel yöntemler ile açılmış implant kavitelerine Er, Cr:YSGG lazer uygulanmasının implant stabilite (ISQ) değeri üzerine etkisini karşılaştırılmasıdır.

Çalışmaya dahil edilen 16 bireyin her birine iki adet implant yerleştirilmiştir. Her bireydeki iki implantin birine konvansiyonel yöntemler ile implant kavitesi açılarak implant yerleştirilmiş (I-1), ikincisine ise yine konvansiyonel yöntemler ile implant yerleştirildikten sonra implant kavitesine Er, Cr:YSGG lazer uygulanmasını takiben implant yerleştirilmiştir (I-2). Ossseointegrasyon süreci tamamlandıktan sonra ISQ değeri tekrar ölçülerek arasındaki fark alınıp karşılaştırılmıştır.

Operasyon sonrası ISQ değerler ile osteointegrasyon süreçleri tamamlandıktan sonraki ISQ değerlerin farkları alındığında I-1 grubunun ISQ değer değişimi 11,18 olurken I-2 grubunda ortalama ISQ değer değişimi ise 17,5 olarak bulunmuştur. ISQ değişim değerleri I-2 grubunda, I-1 grubundan istatistiksel olarak anlamlı şekilde yüksek olduğu belirlenmiştir

Er, Cr:YSGG lazer uygulanması kavite içerisindeki osseointegrasyonu geciktiren ya da önleyen bakterileri yok ederek osseointegrasyonun tam oluşmasını sağlıyor olabilir. Diğer bir açıdan düşünüldüğünde ise Er,Cr:YSGG laser kemik yüzeyine uygulandığında kemik rezenerasyonu hızlandırmakta ve collajen fibril oluşumun artırabilmektedir.

Anahtar Kelimeler: Er, Cr:YSGG lazer, osseointegration, implant, implant stabilite değeri.

Abstract

The usage of Erbium chrome: yttrium-selenium-gallium-Garnet (Er, Cr:YSGG) lasers in dental clinics have increased in time. The aim of these invention is to compare the effect of Er, Cr:YSGG laser applications carried out on implant cavities that have been opened using conventional methods, to the implant stability quotient (ISQ) values.

Two implants have been implanted for each of the 16 subjects which have been included in the study. One of the implants have been implanted by opening an implant cavity through conventional methods (I-1) and the other again has been implanted by opening a cavity through conventional methods but said second implant has been inserted following the application of Er, Cr:YSGG laser to the implant cavity (I-2). After the completion of the osseointegration process, ISQ values were again measured and the differences between the initial values have been compared.

When the difference between the ISQ values following operation, and the ISQ values following the completion of osseointegration processes were taken, it has been determined that the average ISQ value variance was 11,18 in the I-1 groups, and the average ISQ value variance was 17,5 in the I-2 group. It has been found out that the ISQ variance values in the I-2 group wherein was statistically meaningfully higher to the ISQ variance values in I-1 group.

The Er, Cr:YSGG laser application could ensure the full formation of osseintegration by preventing bacteria that delays osseointegration in the implant cavities. If taken into consideration from another aspect, when Er, Cr:YSGG laser is applied on a bone surface the bone regeneration is accelerated and compromised collagen fibres to re-grow before osteogenesis can begin.

Key words: Er, Cr:YSGG laser, osseointegration, implant, implant stability quotient.

INTRODUCTION

Laser in periodontal treatment is basically non surgical, surgical, and is considered to be safe with its usage and correct parameters in antimicrobial treatment in addition to periodontal treatment. Laser treatment is also used in controlling bleeding postoperatively, and is used to benefit from its effects to decrease the severity of pain and inflammation. Following all mechanical procedures, it can also be used in maintenance treatment as antimicrobial support.[1-3] Many studies have been carried out to increase the success of periodontal treatment nowadays and various types of laser have been applied. CO2 laser was used as defocus and it has been defined that the smear layer on the root surface was lifted, decontamination was obtained and fibroblast adhesion was provided.[4] In studies carried out with Nd:YAG laser, it has been reported that Nd:YAG laser provided decontamination and endotoxine inactivation on

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unhealthy root surfaces and provided bactericidal effect.[4,5] It has been put forward that clinical applications of diode laser, had a bactericidal effect on the bacteria found in the environment.[4] It has been mentioned in many studies that the usage of Er:YAG lasers showed high bactericidal effects on periodontopathogenic bacteria in low energy levels and that it removed toxins such as lippolysaccharides that have been diffused on the root surface.[6] In order to decrease the thermal side effects that can be formed during periodontal tissue applications and to increase the cutting efficiency of the system, different types of lasers have been developed. One of these systems are the Er, Cr:YSGG lasers. Er, Cr:YSGG lasers have 2.78 µm wave lengths, and comprise together the YSGG laser energy and air-water cooling system which removes enamel and dentine efficiently. The air-water spray is attached to the device, and while a light beam is exuded air-water flow is established towards the sapphire tip. The laser energy at this wave length is absorbed at a maximum degree by water molecules.[7] Laser treatment is successfully applied in dental implant applications. The most important rule in oral implantology is to ensure the primary stabilization of the implant and to protect stabilization following overload, or in other words to ensure the development of osseointegration.[8-11] In order to evaluate the primary stabilization of implants and the osseointegration degree, methods such as histology, histomorphometry, extraction torque analysis, pushing and pulling tests, and radiological methods have been used. However as some of these methods are invasive and not trustworthy enough, they are deemed to be unsuitable for long term clinical evaluations.[12] A non invasive Periotest (Siemens AG, Bensheim, Germany) device has been used in order to overcome such problems and to measure the implant stabilization.[11,12] However this device does have disadvantages as it is low resolution, it has insufficient precision and is sensitive to the physician using the device. By starting off from these necessities, a resonance frequency analysis (RFA) method has been developed which evaluates the status between the implant and bone without damaging the implant and which provides reliable results.[13-16] RFA is a method which measures osseointegration and stabilization without causing any kind of damage to the implant.[15,16] In order to carry out these measurements an Osstell device (Integration Diagnostics AB, Gothenburg, Sweden) has been used. The transducer which connected to the device in order to take the necessary measurements is screwed on tightly to the implant and oscillation is carried out with the effect of piezo elements.[14,15] The device records the resonance frequency established between the ranges of implant-bone. This value is shown with a graphic and numerical value that varies between 0-100. The numerical value that is established as a result of the oscillation of the implant-transducer elements is called the implant stabilization rate (ISQ).[16] The higher the ISQ value of the implant, the more that implant is stabilized.[13,16] It is possible to monitor the implants during their insertion (primary stabilization), during the healing process and after overload by means of this device used for diagnosis. An implant which shows decrease in its stabilization due to excessive overload can be early diagnosed and can be saved before the implant is unsuccessful. The implant stability of laser treatments or in other words studies which investigate the effects of laser treatment on osseointegration are scarce in literature. The aim of the invention, is to compare the changes of the ISQ values following the osseointegration processes of implants, between implants which have been implanted following the application of Er, Cr:YSGG laser into the implant cavities that has been formed with conventional methods during dental implant treatment and which have been implanted without the application of Er, Cr:YSGG laser into the implant cavities.

MATERIAL AND METHODS

Subjects participating in the study:

16 subjects have been included in our study who had applied to Yüzüncü Yıl University Faculty of Dentistry, Periodontology Department Clinics in the year 2012, who were found to have at least two teeth missing as a result of clinical and radiographic analysis and were planned to receive two implants as treatment. Attention was paid to the subjects to be included in the study so that they did not have any kind of systemic diseases in their anamnesis, that they were not menopausal, pregnant, or lactating, that they had not used

any kind of medicine which was effective on their immune system or that they did not use antibiotics in the last six months, and that they are non smokers. The subjects involved in the study were told about the aim and content of the study, and they signed an approval form stating that they voluntarily participated in the survey. Each subject read the Helsinki Declaration before getting involved in the study. Consent for the study from the Human Ethics Research Committee of Konya University Medical Faculty (KU-120312) has been obtained.

Applying the implants:

At least two implant treatments have been carried out on each of the 16 subjects who have participated in the study. Each implant applied to each subject has been opened by using conventional surgical methods, and the implant cavities have been filled in accordance with the methods suggested to be applied by the implant company. An additional method was not applied to the first one of the cavities and an implant was inserted. Er, Cr:YSGG laser (1.5 W power setting and 20 Hz/sec pulse repetition with 35% water and 45% air spray) has been applied to the other implant cavity and then said implanted were inserted. Irradiation was performed with a sapphire tip (8.5 mm, 0.6 mmΦ, MG6; BIOLASE) in noncontact and focusing modes. Each patient was rehabilitated with two endosseous osseointegrated implants (10 mm in length and 3.7 mm in diameter, Implant-Direct Screwplant). All of the implants included in the study were implanted in the mandible. All measurements were made by the same dentist. Finally 32 implants were used in 16 patients in the present study. Said 32 implants were divided into two groups;

I-1 Group: Is the group where the implant is inserted into the cavity opened with conventional methods without an application of Er, Cr:YSGG laser treatment.

I-2 Grubu: Is the group where the implant is inserted into the cavity opened with conventional methods following the application of Er, Cr:YSGG laser treatment.

The ISQ values of implants following their insertions have been measured and it has been waited for the osseointegration process to be completed. After the completion of the osseointegration processes of the implants (100 day), the ISQ values of the implants belonging to the subjects participating to the study have been re-measured and the changes between the ISQ values have been recorded.

Data Analysis:

Each implant has been accepted to be a statistical unit in this study and the analysis have been carried out with a SPSS 15 packet program. Defining statistics such as arithmetic means, standard deviation are used in the presentation and evaluation of data. The intra group comparisons of the ISQ values before the osseointegration process was completed and after the osseointegration process was completed were carried out with a Wilcoxon Test. The statistical significance of the results were evaluated at $p<0.05$ level.

RESULTS

16 subjects, 7 of which were women and 9 of which were men were included in the study. 32 implants were implanted in total, as two implants each for all 16 subjects. The average ages of the subjects participating in the study was calculated to be 40.32 (Table-1).

Patients Gender/Age	Implants Locations	Groups	ISQ Values After Surgery	ISQ Values After Completion Of The Process Of Osseointegration	ISQ Volues Differences
Male/33	36	I-1	52	65	13
	46	I-2	59	73	14
Male/40	36	I-1	55	70	15
	47	I-2	52	76	24
Male/38	37	I-1	60	68	8
	44	I-2	58	75	17
Male/44	46	I-1	61	70	9
	36	I-2	59	73	14
Male/42	37	I-1	50	65	15
	46	I-2	54	71	17
Male/41	47	I-1	52	62	10
	36	I-2	53	69	16
Male/39	45	I-1	56	61	5
	35	I-2	59	71	12
Male/44	37	I-1	52	63	11
	46	I-2	51	68	17
Male/31	46	I-1	58	68	10
	36	I-2	48	67	19
Female/29	35	I-1	53	68	15
	46	I-2	51	79	28
Female/41	46	I-1	59	72	13
	36	I-2	54	73	19
Female/33	36	I-1	61	70	9
	47	I-2	54	72	18
Female/34	46	I-1	63	69	6
	37	I-2	59	68	9
Female/40	37	I-1	51	72	21
	46	I-2	52	78	26
Female/36	45	I-1	61	69	8
	36	I-2	53	75	22
Female/38	46	I-1	60	71	11
	34	I-2	59	67	8

Table-1: Shows the implant stability quotient (ISQ) values following the operation and after completion of the osseointegration process of groups wherein Cr:YSGG was not applied to the implant cavity (I-1) and wherein Cr:YSGG was applied to the implant cavity (I-2).

The ISQ values calculated following surgical operation of all implants and the ISQ values following the completion of the osseointegration process have been presented in Table 1.

When the results were evaluated, the average ISQ values following operation in the I-1 group have been determined to be 56,5. And the average ISQ values following operation in the I-2 group have been determined to be 54,6. When the results were evaluated, the average ISQ values following completion of the osseointegration processes in the I-1 group have been determined to be 67,6. And the average ISQ values following completion of the osseointegration processes in the I-2 group have been determined to be 72,1. When the difference between the ISQ values following operation and following the completion of the osseointegration process are taken, it has been determined that the average ISQ value variance was 17,5 in the I-2 group and the average ISQ value variance was 11,18 in the I-1 group. It has been found out that the ISQ variance values in I-2 group were statistically meaningfully higher in comparison to the I-1 group ($p<0,05$).

DISCUSSION

There are some proven techniques for opening implant cavities and inserting implants. These techniques are based on the principle for establishing healing such that it will not prevent the relationship between the implant and the bone. When this healing process is examined, there are some conditions which need to occur. Blood clots fill the extraction site, provisional connective tissue matrix replaces the blood clot, woven bone fills in most of the provisional matrix, cortical bone grows over the woven bone, and bone marrow fills the inside of the lamellar bone.[17] When healing processes continue without any problems, the osseointegration between the bone and the implant is formed without any problems. With this study it has been examined to see if dental lasers are effective in the implant bone healing process. Conventional drills and different laser types have been used in opening implant cavities in literature and these drills and laser types have been compared with each other. However a study like our one, which compares the osseointegration levels of both implants with RFA, wherein one of the implants are inserted into an implant cavity which has been opened with conventional methods following the application of Er,Cr:YSGG laser and the other implant is inserted into an implant cavity which has been opened with conventional methods without the application of Er,Cr:YSGG laser, is not present in literature. When studies wherein implant cavities are opened only using a laser are evaluated; it was found that the Er:YAG laser showed faster bone healing and better osseointegration than that achieved after conventional techniques using a drill.[18] In these study, although a cavity is not opened completely using a laser, it was found that the ISQ variance values in the group wherein Er,Cr:YSGG laser was applied to the implant cavity like in other studies, were higher in comparison to the group where Er,Cr:YSGG laser was not applied. In this case it is shown that the implants where Er,Cr:YSGG laser is applied were better osseointegrated. The reason for this situation could be that even though an implant cavity is sterile, it could be contaminated with bacteria. It has been determined in literature, in many studies that, the level of bacteria decreased in areas which were treated with laser.[19] The laser treatment could be eliminating the bacteria that delay the osseointegration within a cavity and ensuring that osseointegration is fully established.[20] If taken into consideration from another point of view, it could be said that when Er,Cr:YSGG laser is applied on a bone surface, bone regeneration could be accelerated and could compromise collagen fibres to re-grow before osteogenesis can begin.[21] Moreover there are studies which show that preparing the implant cavity with different lasers stimulate the growth factors and increase healing.[22,23] In another study, the difference between the implant cavity in dogs where the cavities were opened with conventional methods, and where the cavities were opened with Er:YAG laser have been examined and it has been found that the primary stability of implants inserted into the cavity opened by using Er:YAG laser device was better in comparison to the ones opened with conventional drills.[22]

Extensive heat through thermal destruction of cells, reduced blood flow, a denaturation of alkaline phosphatase and

change in the hydroxyapatite mineral lattice structure are some of the factors that affect the self treating of the bone following the preparation of a dental implant cavity.[24,25] Not only in implant surgery but also in surgical procedures, irrevocable damages could occur in the bone depending on mechanical and thermal effects.[26-28] In order to decrease this damage, laser treatments are frequently used. Thermal surgical trauma and mechanical trauma caused by the manipulation of the osseous tissue during implant cavity preparation substantially affects the progress of osseointegration and bone healing.[28-30] As it can be understood from the results of our study, it has been found out that the ISQ variance values were higher when Er,Cr:YSGG laser is applied during surgical operation into the implant cavities opened using conventional drilling. This situation can conclude that osseointegration was better when Er,Cr:YSGG laser was used.

CONCLUSION

The bone tissue regeneration being effected due to thermal and mechanical trauma occurring during the opening of implant cavities could have gone back to its prior state with the application of Er,Cr:YSGG laser. Therefore, further studies could help us understand better the effect of laser treatment on implant osseointegration. Many more studies need to be carried out in order to understand the level of effect of the interaction on the bone implant surface of laser treatment applied in addition to conventional implant cavity opening methods. Within the limits of the present study, it was concluded that Er,Cr:YSGG laser may represent a promising tool for suitable osseointegration.

References

1. Payne JT, Peavy GM, Reinisch L, Van Sickle DC. Cortical bone healing following laser osteotomy using 6.1 micron wavelength. Lasers Surg Med 2001; 29: 38-43.
2. Buchelt M, et al. Erb:YAG and Hol:YAG laser osteotomy: the effect of laser ablation on bone healing. Lasers Surg Med 1994; 15: 373-81.
3. Krause LS, Cobb CM, Rapley JW, Killoy WJ, Spencer P. Laser irradiation of bone. I. An in vitro study concerning the effects of the CO2 laser on oral mucosa and subjacent bone. J Periodontol 1997; 68: 872-80.
4. Research, Science and Therapy Committee of the American Academy of Periodontology. Lasers in periodontics. J Periodontol 2002; 73: 1231-9.
5. Aoki A, Sasaki KM, Watanabe H, Ishikawa I. Lasers in nonsurgical periodontal therapy. J Periodontol 2004; 36: 59-7.
6. Watanabe H, Ishikawa I, Suzuki M, Hasegawa K. Clinical assesments of the Erbium:YAG laser for soft tissue surgery and scaling. J Clin Laser Med Surg 1996; 14: 67-75.
7. Eversole LR, Rizoiu IM. Preliminary investigations on the utility of an erbium, chromium YSGG laser. J Calif Dent Assoc 1995; 23: 41-7.
8. Mombelli A, Buser D, Lang NP. Colonization of osseointegrated titanium implants in edentulous patients. Early results. Oral Microbiol Immunol 1988; 3: 113-20.
9. Becker W, Becker BE, Newman MG, Nyman S. Clinical and microbiologic findings that may contribute to dental implant failure. Int J Oral Maxillofac Implants 1990; 5: 31-8.
10. Alcoforado GA, Rams TE, Feik D, Slots J. Microbial aspects of failing osseointegrated dental implants in humans. J Parodontol 1991; 10: 11-8.
11. Albrektsson T, Isidor F. Consensus report of session IV. In: Lang NP, Karring T, eds. Proceedings of the First European Workshop on Periodontology. London: Quintessence; 1994: 365-9.
12. Meredith N. A review of nondestructive test methods and their application to measure the stability and osseointegration of bone anchored endosseous implants. Crit Rev Biomed Eng 1998; 26: 275-91.
13. Friberg B, Sennerby L, Meredith N, Lekholm U. A comparison between cutting torque and resonance frequency measurements of maxillary implants. A 20-month clinical study. Int J Oral Maxillofac Surg 1999; 28: 297-303.
14. Meredith N, Book K, Friberg B, Jemt T, Sennerby L. Resonance frequency measurements of implant stability in vivo. A crosssectional and longitudinal study of resonance frequency measurements on implants in the edentulous and partially dentate maxilla. Clin Oral Implants Res 1997; 8: 226-33.
15. Meredith N, Alleyne D, Cawley P. Quantitative determination of the stability of the implant-tissue interface using resonance frequency analysis. Clin Oral Implants Res 1996; 7: 261-7.
16. Barewal RM, Oates TW, Meredith N, Cochran DL. Resonance frequency measurement of implant stability in vivo on implants with a sandblasted and acid-etched surface. Int J Oral Maxillofac Implants 2003; 18: 641-51.
17. Cardaropoli G, Araújo M, Lindhe J. Dynamics of bone tissue formation in tooth extraction sites. An experimental study in dogs. J Clin Periodontol 2003; 30: 809-18.
18. Kesler G, Romanos G, Koren R. Use of Er:YAG laser to improve osseointegration of titanium alloy implants a comparison of bone healing. Int J Oral Maxillofac Implants 2006; 21: 375-9.
19. Türkün M, et al. Bactericidal effect of Er,Cr:YSGG laser on Streptococcus mutans. Dent Mater J 2006; 25: 81-6.
20. Loomer PM, et al. Direct effects of metabolic products and sonicated extracts of Porphyromonas gingivalis 2561 on osteogenesis in vitro. Infect Immun 1994; 62: 1289-97.
21. Walsh JT Jr, Flotte TJ, Deutsch TF. Er:YAG laser ablation of tissue: effect of pulse duration and tissue type on thermal damage. Lasers Surg Med 1989; 9: 314-26.
22. Schwarz F, Olivier W, Herten M, Sager M, Chaker A, Becker J.
Influence of implant bed preparation usingan Er:YAG laser o nthe osseointegration of titaniumimplants: a histomorphometrical study in dogs. J Oral Rehabil 2007; 34: 273-81.
23. Matsuyama T, Aoki A, Oda S, Yoneyama T, Ishikawa I. Effects of the Er:YAG laser irradiation on titanium implant materials and contaminated implant abutment surfaces. J Clin Laser Med Surg 2003; 21: 7-17.
24. Tehemar SH. Factors affecting heat generation during implant site preparation: A review of biologic observations and future considerations. Int J Oral Maxillofac Implants 1999; 14: 127-36.

25. Eriksson AR, Albrektsson T. Temperature threshold levels for heat-induced bone tissue injury: A vital-microscopic study in the rabbit. J Prosthet Dent 1983; 50: 101-7.
26. Stanislawki M, et al. Hard tissue ablation with a free running Er:YAG and Q-switched CO2 laser: A comparative study. Appl Phys B 2000; 72: 1-6.
27. Nordera P, et al. The cutting-edge technique for safe osteotomies in craniofacial surgery: The piezosurgery bone scalpel. Plast Reconstr Surg 2007; 120: 1989-95.
28. Sharawy M, Misch CE, Weller N, Tehemar S. Heat generation during implant drilling: The significance of motor speed. J Oral Maxillofac Surg 2002; 60: 1160-9.
29. Friesen LR, Cobb CM, Rapley JW, Forgas-Brockman L, Spencer P. Laser irradiation of bone: II. Healing response following treatment by CO2 and Nd:YAG lasers. J Periodontol 1999; 70: 75-83.
30. McDavid VG, Cobb CM, Rapley JW, Glaros AG, Spencer P. Laser irradiation of bone: III. Long-term healing following treatment by CO2 and Nd:YAG lasers. J Periodontol 2001; 72: 174-82.