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Piezoelektrik Cerrahi ile Kombine Trombositten Zengin Fibrin Kullanılmasının İmplant Stabilitesini Arttırması

Piezoelectric Surgery Combined with Platelet Rich Fibrin Increases Implant Stability

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Öz

Trombosit konsantrasyon ürünlerinden biri olan Trombositten Zengin Fibrin (TZF), içerdiği yüksek orandaki büyüme faktörlerinden dolayı doku iyileşmesini hızlandırmak için son yıllarda sıklıkla kullanılmaktadır. Bu çalışmada, piezoelektrik cerrahi ile hazırlanmış ve TZF uygulanmış implant yuvası grubu (TZF+) ile piezoelektrik cerrahi ile hazırlanmış ancak TZF uygulanmamış dental implant yuvası grubunun (TZF-) erken iyileşme dönemindeki primer stabilite üzerine olan etkilerinin Rezonans Frekans Analizi (RFA) ile değerlendirilmesi amaçlanmıştır.

Sistemik rahatsızlığı bulunmayan ve ilgili bölgede implant yapabilmek için ileri cerrahi işleme ihtiyaç duyulmayan 17 hasta çalışmaya dahil edilmiştir. Her hastaya iki adet dental implant yerleştirilmiştir. İmplant soketleri piezoelektrik cerrahi ile hazırlandıktan sonra, rastgele seçilen soketlerden biri operasyondan önce hazırlanan TZF ile kaplanmıştır, diğer soket ise kontrol grubu olarak boş bırakılmıştır. RFA ölçümleri Osstell™ ISQ cihazı ile implantasyondan hemen sonra, postoperatif 1., 4., 8. ve 12. haftalarda yapılmıştır.

RFA ile yapılan değerlendirmelerde, TZF+ grubunda TZF- grubuna göre sadece 12. haftada istatiksel olarak anlamlı derecede daha yüksek ISQ değerleri bulunmuştur ($p<0,05$).

TZF'nin implant cerrahisi sırasında uygulanması stabilitenin erken dönemde artmasını sağlamıştır. Ancak bu bulguların, daha yüksek sayıda hasta grubu içeren yeni çalışmalarla desteklenmesine ihtiyaç vardır.

Anahtar sözcükler: Trombositten zengin fibrin, Osseointegrasyon, Rezonans frekans analizi, Piezocerrahi, Dental implantlar.

Abstract

This study aims to compare the clinical healing, implant stability and osseointegration of implants placed in anterior mandible when piezosurgery is used for implant site preparation with and without PRF application.

Seventeen edentulous patients without medical contraindications for dental implant placement in their anterior mandibles were included in the study. After preparing 2 implant sockets in anterior mandible with piezoelectric surgery, one of the randomly selected sockets was packed with PRF before the insertion of the implant (PRF+) and the remaining socket was left empty as a control (PRF–). Then a dental implant was placed in each socket. The intracellular plasma portion of PRF was used to soak the implant placed in the coated socket of PRF. Resonance frequency measurements were made after implant placement and at postoperative 1, 4, 8, and 12 weeks.

Immediate postsurgical mean ISQ of PRF+ implants was 70.32 ± 4.97, and the mean ISQ was 71.55 ± 5.5 in the control group. At the end of the third month, mean ISQ of PRF+ implants was 77.38 ± 5.18 and the mean ISQ was 74.29 ± 5.65 for PRF– group.

Piezoelectric surgery combined with PRF administration increased implant stability throughout the healing period, as evidenced by higher ISQ values. Simple application of this material continues to provide osseointegration.

Keywords: *Platelet rich fibrin, Osseointegration, Resonance frequency analysis, Piezosurgery, Dental implants.*

Introduction

Nutritional habits and poor oral hygiene continue to be the major reasons for premature loss of teeth. Most patients demand for an aesthetic, and functional restoration mimicking natural dentition, which can only be possible using dental implants.

Primary implant stability and avoidance of micromotion during early healing provide successful osseointegration. However, there is a need for an accelerated and predictable healing of dental implants in both healthy and medically compromised patients. Hence contemporary studies focused on this need by utilizing

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improved dental implant surfaces, novel surgical techniques, and various biological strategies involving proteins or drugs to enhance bone implant contact (BIC).

Biological strategies used to expedite and enhance tissue healing include concentrated autologous platelets containing high levels of growth factors that are released during the early phase of wound healing. These proteins are shown to accelerate the healing process by attracting undifferentiated mesenchymal cells to the injured site. Platelet-rich plasma (PRP), platelet-rich fibrin (PRF), and plasma rich in growth factors (PRGF) are various types of platelet concentrations that are utilized in the treatment of bone defects. PRF is a second generation autologous platelet concentrate and a fibrin system consisting of leukocytes and cytokines. Unlike other platelet concentrates, preparation of PRF is a straight-forward protocol that does not require anticoagulants, bovine thrombin or any other gelling agents. A natural polymerization process yields the PRF clot during centrifugation. Unlike PRP preparation techniques that activate the platelets resulting in immediate release of growth factors, and the production of a very light fibrin network, the PRF technique yields a natural fibrin architecture that is responsible for the sustained release of growth factors and matrix glycoproteins for 7 days or more after implantation. PRF can be used directly as a clot or as a strong membrane after compression.[1,2,3]

Piezosurgery enables a meticulous implant site preparation with copious saline irrigation and is shown to reduce surgical complications by avoiding undue trauma to the tissues. Local heat production that can potentially lead to marginal osteonecrosis and impaired bone regeneration is avoided ensuring a rapid wound healing thus decreasing the risk of implant loss.[4,5,6]

The aim of the present study was to compare the clinical healing, implant stability and osseointegration of implants placed in anterior mandible when piezosurgery was used for implant site preparation with and without PRF application.

Materials and Methods

All the patients included in the present study were informed about the purpose and method of the study in accordance with the Ethics Committee approval of Ege University (2014, Decision No. 14-2.1/4). Seventeen edentulous patients with no medical contraindications for dental implant placement in their anterior mandibles were included in the split mouth study. After preparing 2 implant sockets in anterior mandible with piezoelectric surgery, one of the randomly selected sockets was packed with PRF before the insertion of the implant (group PRF+) and the remaining socket was left empty as a control (group PRF–). Then a dental implant was placed in each socket.

Inclusion criteria were the absence of systemic diseases, extraction at least 6 months prior to the placement of dental implants and sufficient residual bone volume to receive two implants of ≥ 3.3 mm in diameter and 10.0 mm in length in anterior mandible. Exclusion criteria were as follows: smoking, insufficient bone volume, parafunctional habits, antitumor chemotherapy, history of localized radiotherapy of the head and neck, blood, kidney and/or liver diseases, immunosuppression, current corticosteroid or bisphosphonate use, mucocutaneous diseases involving the oral cavity, pregnancy and poor oral hygiene.

The local ethics committee confirmed the study protocol. Appropriate patients were informed about the details of the protocol and their written informed consent were obtained before they were taken to study.

2.1. PRF Preparation

Blood from patients' antecubital veins of the patients were taken with a needle (0.8 x 38 mm, 21G). Blood were collected in 9 ml glass-coated plastic vacutainer tubes without an anti-clotting agent (Vacutest Kima srl) and immediately centrifuged at 2,700 rpm for 12 minutes with a table centrifuge (Hettich Zentrifugen EBA 20). Then the fibrin clot formed in the center of each tube was removed and the residues of the red blood cells were scraped with a gauze. The clot was transferred to a PRF box (Process Ltd) and compressed to prepare a PRF membrane. The serum obtained during compression of the fibrin clot was transferred to a syringe.

2.2. Surgical Procedure

All surgical procedures were carried out under local anesthesia (Jetokain, Adeka) by the same surgeon. Crestal and vertical releasing incisions were made, and triangular mucoperiosteal flaps were elevated. Implant osteotomies were prepared with the implant tips of a piezoelectric surgical system (Piezonmaster®, EMS SA, Switzerland). The implant platform was positioned to the alveolar crest, PRF membrane was placed into one of the implant osteotomies as shown in Figure 1 and an implant was thoroughly soaked with PRF liquid before insertion as shown in Figure 2 into the PRF applied osteotomy site as shown in Figure 3 (PRF+ group).

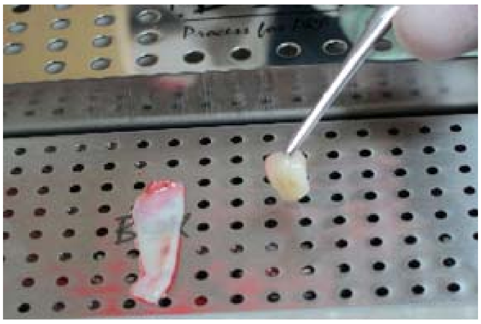


Fig. 1. Preperation of PRF membrane

Fig. 2. Rinsing of the implant with PRF liquid

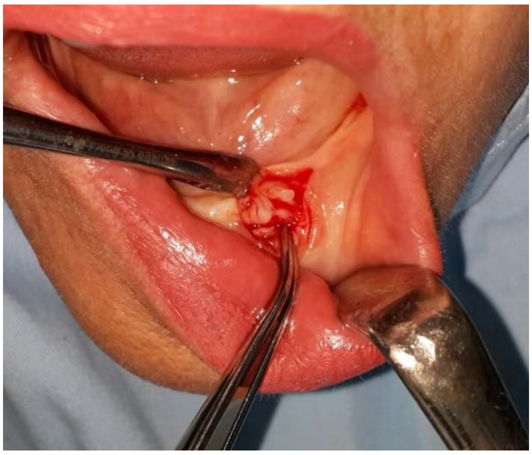


Fig. 3. Application of PRF to the osteotomy site

Control implants were placed without PRF (PRF– group). Straumann® dental implants 3.3 mm in diameter and 10.0 mm in length were used as test implants. (Roxolid TiZr Alloy, Bone Level Implant, Institute Straumann AG, Switzerland). Insertion torque value was set to 50 Ncm during placement of the implants. Healing caps were left exposed and mucoperiosteal flaps were sutured with 5/0 propylene. Post-operative advices included intermittent cold application for 24 hours, a soft diet and oral hygiene instructions. Prescription included 100 mg flurbiprofen tablets bd., and chlorhexidine gluconate mouthwash (0.12%) tds. for a week.

Implant Stability Evaluation

The stability of the implants was evaluated with resonance frequency analysis (RFA). The measurements were carried out with the Osstell-ISQ device (Osstell) by connecting the transducer (SmartPeg) to the implant. Two measurements were made on the mesial and vestibul sites, and mean implant stability quotients (ISQs) were calculated. RFA measurements were performed immediately after surgery and at the 1st, 4th, 8th and 12th weeks post-operatively.

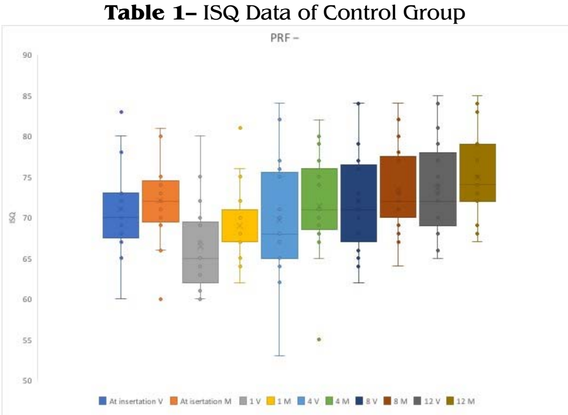
Statistical Analysis

Implants' ISQ values were included in the statistical analysis as independent values. Mean values and standard deviations were calculated for each variable and group. Shapiro-Wilk test revealed normal distribution of the data (P> 0.05). The results were expressed as mean and standard deviation. Time-dependent changes between the groups were assessed by paired t-test. The differences between groups were explored with analysis of variance. All evaluations were performed with SPSS 10.0 software (IBM Corp., New York, USA).

Results

Our study population consisted of 17 patients (10 women and 7 men) with a mean age of 48.3 ± 10.4 years. Thirty-four implants (3.3 × 10.0 mm) were placed that healed without complications; 17 of these implants were assigned to the PRF+ group and 17 to the PRF– group as shown in Table 1 and Table 2.

Table 1– ISQ Data of Control Group



V: Vestibul M: Mesial

Table 2- ISQ Data of Test Group

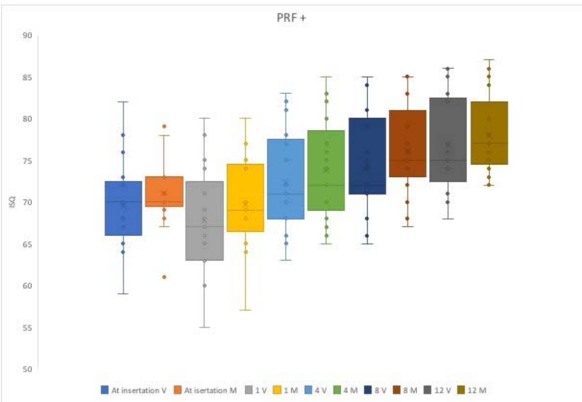


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Table 3- Mean ISQ values of groups

	PRF+ (±mean ISQ)	PRF- (±mean ISQ)	P value
At insertion	70.32 ± 4.97	71.55 ± 5.51	0.029
1week post-op	68.70 ± 5.96	67.73 ± 5.05	0.357
4 weeks post-op	73.08 ± 5.99	70.52 ± 6.87	0.124
8 weeks post-op	75.35 ± 5.86	72.76 ± 5.85	0.054
12 weeks post-op	77.38 ± 5.18	74.29 ± 5.65	0.014

The mean ISQ values of PRF+ and PRF– group and p values are given in the Table 3. PRF+ implant group after surgery was significantly lower than mean ISQ of the control group (P=0.029).

In both groups, maximum increase in osseointegration as measured by RFA was observed between 1 and 4 weeks, however this was not statistically significant. The mean ISQ in the PRF+ group was significantly higher at the end of the third month. (P= 0.014)

Discussion

Factors such as bone augmentation requirements, implant design and dimensions, occlusion, patient's habits, systemic health and clinician's experience influence the decision-making process in immediate loading of dental implants. Additionally, dental implants can be immediately loaded, if appropriate primary stability is achieved as quantified by the implant placement torque of 20 - 45 Ncm and resonance frequency analysis measurement of 60 - 65 ISQ.7 However, the number of patients for whom these conditions can be achieved immediately after implantation is quite limited. Many studies focus on surgical techniques and the applications of biotechnology for the reduction of osseointegration period.[8,9,10,11] Contemporary studies report that piezoelectric devices can be an alternative to conventional methods. Horton et al. showed that an osteotomy made with an ultrasonic device healed more rapidly when compared to an osteotomy made with handpiece and burs in an experimental setting.[12] Pavlikova et al. compared the effects of burs and piezoelectric surgery on bone morphology and they showed that the cavities in the cancellous bone were filled with debris when burs were used, and this in turn lead to mechanical blockage impeding bleeding, whereas, piezoelectric surgery enabled preservation of the cancellous bone structure.[13] In a clinical study by Berengo et al. autogenous bone graft retrieval methods were compared and they showed that osteocytes did not remain vital when round or spiral burs are used, however the vitality of the osteocytes in the grafts were preserved when mechanical instruments and piezoelectric surgery was used. This emphasizes the importance of piezoelectric ultrasonic devices in various oral surgical procedures involving bone, particularly in alveolar distraction osteogenesis, sinus augmentations, harvesting of autogenous grafts, surgically assisted maxillary expansions and dental implant osteotomies.[14]

Our study examined the effect of PRF on the stability and osseointegration of implants. The results demonstrated that PRF application increased the stability of implants from the 1st post-operative week, until the end of 3rd post-operative month. Mean ISQs continuously increased for PRF+ and PRF– implants during this period, between the first and fourth weeks (Table 3). Other studies examined a decrease in stability, generally between the first and sixth post-operative weeks. These differences in results may be based on to either shorter follow-up periods in the other studies or to the fact that PRF accelerates healing.

In a study by Öncü et al. burs were used to prepare dental implant osteotomies and an implant treated with acellular plasma serum (test group) and a non-treated implant (control group) were placed in PRF filled and empty osteotomy sites respectively. Accordingly, they reported that PRF increases implant stability during the healing period. In our study the ISQ values in the PRF– group at 1st week were higher than those reported by Öncü et al., which is probably due to the relatively atraumatic implant site preparation of piezoelectric surgery enabling a faster healing.[15]

Stelzle et al. compared piezosurgical vs. conventional drilling methods for implant site preparation (ISP). They state that the reduction of implant stability in first week is attributed to the following factors.

- Surgical trauma and resorption of necrotic bone.
- Placement of the implant in a narrower cavity results in the formation of compressive forces, that is reduced over time.
- Occurrence of microfractures during immediate loading.

In the healing phase, there is a decrease in stress, which is the result of a tight contact between the implant and bone, a reduction in the stress caused by the compression of the implant into a narrow cavity, and a slight decrease in primer stability (PS) after necrotic layer resorption due to bone trauma and temperature rise during implant surgery. In the post-operative 6 weeks; from the beginning of the resorption process until the formation of the first lamellar bone, the implant-bone contact area decreases and loss of PS is observed. With the formation of the lamellar bone, secondary bone formation occurs and the implant stability decreases.[16]

In a multicenter case series by Vercellotti et al. an innovative ultrasonic implant site preparation (UISP) technique as an alternative to the use of traditional rotary instruments were introduced. A total of 3,579 implants were inserted in 1,885 subjects. In this study, bone healing after osteotomy and osteoplasty procedures using piezoelectric surgery or carbide and diamond burs were compared. Their results revealed that, burs result in bone loss, whereas piezoelectric surgery results in bone gain.[17]

Clinical and in-vitro studies show that mechanical properties of bone affect the primary stability of the implant and the healing period required to achieve adequate stability. As all the implant sites in our study were anterior mandible with Type I bone, it was not possible to compare between different bone types.[18]

Hsu et al. investigated the effects of three three-dimensional (3D) BIC parameters in relation to the implant diameter on primary implant stability. In their study, dental implants with diameters of 3.75, 4, 5, and 6 mm and artificial bone specimens were scanned by microcomputed tomography to construct 3D models. This study revealed how the implant diameter and the three-dimensional (3D) BIC influence the PS of dental implant. Dental implant stability is influenced by the diameter and geometry of the implant, and the quality of bone as well as the surgical technique used. Accordingly, in our study, implant diameter and size were standardized and all the implants used had a diameter of 3.3 mm and a length of 10 mm.[19]

In our study, all implants were placed using an angled hand piece at a torque of 50 Ncm and cover screws were positioned at bone level. However, RFA values were variable (minimum 59 and maximum 83 ISQ). This variability of RFA values in the study implants with the same biomechanical structure raises the questions regarding the dependability of insertion torque alone for assessment of primary stability.

Several studies investigated the effects of application of various biological products on implant surfaces to accelerate bone regeneration and to increase the connectivity between implants and host bone. Dohan et al. reported that after the initial release of growth factors, platelets survived and continued to synthesize growth factors for 7-28 days. The purpose of this study was to analyze the in vitro effects of PRF on human bone mesenchymal stem cells (BMSC) harvested from the oral cavity during ISP. They added that macrophages work with platelets by releasing similar growth factors, thereby increasing the rate of wound healing. They also found that platelets trapped in fibrin network continue to release growth factors in a controlled manner and for longer periods compared to PRP. This sustainable release of growth factors serves to increase the BIC.20 Kotsakis et al. reported woven bone with intense osteoblastic activity surrounded by mineralized areas 6 weeks after PRF application to extraction sockets.[21]

In an observational study by Boora et al. 20 dental implants placed in anterior maxilla of 20 patients were clinically and radiologically reviewed for 3 months, and they reported that the implants placed in the PRF applied osteotomy sites had less bone loss than the implants placed without PRF.[22]

Osstell™ was first used by Meredith in 1996 to clinically assess the factors affecting osseointegration. Meredith et al. reported that Osstell™ is a non-invasive device that can be used for periodic checks to determine stability during the healing period following implantation. This device has been recognized as a reliable diagnostic tool that allows definitive identification of the implants. In recent years, many studies are conducted on the applications of the Osstell™ device. The RFA method, gives reproducible measurements of PS as shown by identification studies. The shear resistance test method provides information about the stability of the implant at the time of implantation only. Studies using the shear resistance method show that this method could provide information about the quality of the bone however it is unable to reveal the risk of implant loss.

Based on the RFA measurements of the 905 consecutive implants Östman et al. reported that PS is related to bone density, gender, implant diameter, antero-posterior and/or maxillary/mandibular position of the implant. They also stated that PS decreases with the increasing implant length.[23]

In a series of in vitro studies by Bardyn et al. the effects of bone thickness and density on RFA was investigated. These studies utilized biomechanical test models, in which RFA, insertion torque and axial loading measurements were utilized. Results revealed that RFA was found to be more effective ($p<0,05$) in detecting changes in bone density and cortical bone thickness, compared to insertion torque and the axial loading test. Thus, RFA makes it easier to distinguish bone density in trabecular bone. Although there is a positive correlation between insertion torque and RFA in the literature, there is no such relation in our study. RFA values were variable despite the fact that insertion torque was fixed.[24]

Balleri et al. clinically and radiographically assessed 45 dental implants in 14 partially edentulous patients that were loaded 1 year previously. The results from this article showed that successfully integrated implants have ISQ levels from 57 to 82 ISQ with a mean of 69 ISQ after 1 year of loading.[25]

Friberg et al. took RFA measurements of 75 Branemark implants placed in the mandibles of 15 edentulous patients at 1, 2, 6 and 15 weeks post-operatively and reported that implant stability was significantly reduced over time.26

In contrast, in a study by Balshi et al. it was found that there is a statistically significant decrease in mean ISQ values within the first month of implant placement. This result is reflection of bone resorption around the implants as part of remodeling. However, there was no decrease in the measured values after 2 months of healing. Balshi et al stated that Osstell™ is capable of detecting minor changes in the implant-bone interface. Accordingly, in our study in order to evaluate primary and secondary stability of dental implants, Osstell™ device that is shown to be objective, non-invasive yielding repeatable measurements.[27]

Bardyn et al. found that ISQ values measured at 6th week post-operatively were not significantly different from ISQ values measured at 10th week in all bone types. However, Nedir et al., indicated that the device could also provide a positive response to mobile implants and suggested that the ISQ values obtained by Osstell ™ were not a reliable diagnostic pathway for definitive identification of mobile implants.[28]

Miyamoto et al. reported that for the 225 screw type implants placed in the maxilla and mandible, there was a positive correlation between PS coefficient (RFA values) and cortical bone thickness evaluated from computed tomography images. Similarly, in cadaver studies, they found a positive correlation between implant stability coefficient values and cortical crest height.29 Akca et al. reported that there was no correlation between ISQ measurements and the amount of implant-bone contact.[30]

Barewal et al. reported that there is a correlation between implant stability coefficient values and bone quality. Their primary goal was to compare the stability of dental implants under three different loading procedures within 16 weeks of placement. Implants were loaded immediately, early (6 weeks), or conventionally after 12 weeks of healing. RFA was performed at follow-up appointments for the first 16 weeks. Implants were classified according to bone type and timing of loading and there was no reduction in stability during the first 4 months of healing.[31]

The difference between groups at the end of follow up period (12 weeks) was significant ($P =0.014$); ie, the ISQs in the PRF + group were significantly higher.

This is the first study to combine piezosurgery and PRF application for dental implant placement; the mean increase in ISQ measurements in the PRF negative group was 2.73 ± 6.01 while the mean increase, in the PRF applied value was 7.05 ± 3.18 ($P>0.05$).

Clinical and in vitro studies show that the mechanical properties of the jawbone determine the PS of the implant and the length of the healing period required to achieve adequate stability. Furthermore, the data suggest that a two-stage surgical procedure from medium-to-soft bone and soft bone types may be needed and a recovery period up to 6 months in low PS may be required. Patient selection is the key to achieving early osseointegration.

Conclusion

In this study, piezoelectric surgery combined with PRF application increased implant stability during the healing period, as evidenced by higher ISQ values. Simple application of this material seems to provide osseointegration. To our knowledge this is the first clinical study utilizing piezoelectric surgery for implant site preparation in combination with PRF application during insertion of dental implants. Clinical trials involving more patients with different bone types are imperative in order to further investigate the possible influence of this setting on PS and implant success.

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