

Effect of Platelet-Rich Plasma on the Outcome of Early Loaded Dental Implants: A 3-Year Follow-up Study

Gulfem Ergun, DDS, PhD^{1*}
 Ferhan Egilmez, DDS, PhD¹
 Isil Cekic-Nagas, DDS, PhD¹
 İnci Rana Karaca, DDS, PhD²
 Suleyman Bozkaya, DDS, PhD²

This study evaluated the effect of local application of platelet-rich plasma (PRP) on the outcome of early loaded implants. Two implants were placed in the posterior region or bilaterally symmetric to the median line of the maxilla. Then, PRP was either applied or not applied to the implant sockets. Outcome measures were prosthesis and implant success as well as biological and prosthetic complications. Stability of individual implants was assessed manually and with a resonance frequency analysis device. The implant stability quotient (ISQ) was recorded on the operation day, on postoperative day 4, and at postoperative week 1. At the end of the first postoperative week, implants with ISQ values >60 were early loaded on day 7 with metal-ceramic crowns. Measurements were repeated at postoperative weeks 2, 3, and 4 and at postoperative months 6, 12, 24, and 36. One of the 64 implants was dropped out after 3 months of loading. No prosthesis failed. There were no prosthetic complications. Statistical analysis revealed significant differences between ISQ values of PRP and non-PRP implants on the operation day. Moreover, no statistically significant differences were found between ISQ values of PRP and non-PRP implants in the follow-up periods ($P > .05$). No appreciable clinical effect was observed when using PRP in the maxilla.

Key Words: *primary stability, resonance frequency analysis, platelet-rich plasma*

INTRODUCTION

Oral implants have exhibited high predictability in supporting fixed prosthetic rehabilitations, provided that certain conditions are met during surgical placement and healing.^{1,2} According to the conventional 2-stage implant protocol for maxillary implants, a healing time of 6 months without loading is considered to be the key for successful osseointegration.^{3,4} For edentulous patients, shortening this time and thus avoiding a long period of wearing transitional removable prosthesis is advantageous for esthetic,

economical, and psychological reasons.⁵ The good outcome of 1-stage surgery and early implant loading may be due to the dense bone of the mandible and the ease in obtaining secure primary implant stability.⁶ Primary implant stability is considered an important parameter for determining the loading protocol.⁷ Although there is no gold standard for measuring implant stability,⁸ several methods have been proposed: clinical assessment by exerting lateral forces with 2 opposing mirror handles, percussion, use of a Dental Fine Tester, and a Periotest device.^{9,10} Furthermore, the use of resonance frequency analysis (RFA) to assess implant stability has been validated by several authors.¹¹ Previous studies have reported the use of RFA to measure stability of the implant-tissue interface at implant placement and determine the possibility of monitoring change in tissue stiffness

¹ Gazi University, Faculty of Dentistry, Department of Prosthodontics, Ankara, Turkey.

² Gazi University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, Ankara, Turkey.

* Corresponding author, e-mail: gulfem@gazi.edu.tr

DOI: 10.1563/AAID-JOI-D-11-00151

during the implant procedure and the follow-up period.¹²

In the posterior maxilla, implant placement may be a problem because of the absence of useful cortical bone and the loose structure of the cancellous bone. In addition, the alveolar process tends to resorb with age, and the maxillary sinus thus enlarges.¹³ Implant stability measurements with RFA have revealed that in dense bone this anchorage most often does not increase during healing, but rather decreases slightly because of marginal bone resorption.¹⁴ Soft bone sites, such as the posterior maxilla, often develop an increased anchorage over time, owing to new bone formation, but the more dense bone structure incorporated at surgery, the less critical this formation is.¹⁵ Thus, osseointegration could be explained as maintaining primary stability rather than creating increased stability. Therefore, immediate function should be a viable option.¹⁶

To promote healing of endosseous oral implants, several measures have been proposed to improve and accelerate osseous healing by increasing bone-to-implant contact,¹⁷ including application of autologous growth factors.¹⁸ Platelet-rich plasma (PRP) is an autologous concentration of platelets in a small volume of plasma; fundamental protein growth factors secreted by platelets to initiate wound healing are also present in PRP. These growth factors include the 3 isomers of platelet-derived growth factor (PDGF- $\alpha\alpha$, PDGF- $\beta\beta$, and PDGF- $\alpha\beta$), transforming growth factor beta (TGF- β_1 and TGF- β_2), vascular endothelial growth factor, and epithelial growth factor.¹⁹ Moreover, PRP contains fibrin, fibronectin, and vitronectin, 3 proteins known to act as cell adhesion molecules.²⁰ Many clinicians have noted an accelerated soft tissue healing response at surgical sites where PRP was used.^{21–25} In previous controlled studies, PRP improved healing results in the treatment of periodontal defects,²¹ ridge and sinus augmentations,²² periodontal flap surgery,²³ intentional replantation,²⁴ and peri-implantitis.²⁵ Moreover, it was proposed that PRP was able to successfully stimulate bone formation around mandibular dental implants.¹⁹

Based on these considerations, the present investigation aimed to evaluate the effect of PRP on early loaded dental implants after a 1-stage surgical procedure in partially edentulous maxillas. Additionally, a second aim was to evaluate the

clinical efficacy of PRP by assessing prosthetic success and complications.

MATERIALS AND METHODS

Patient selection

Ethical approval for this study was granted by the Local Ethics Committee of Gazi University Faculty of Medicine. Surgical procedures of the study were performed at Gazi University by the Faculty of Dentistry, Department of Oral & Maxillofacial Surgery, and the prosthetic rehabilitations were performed at Gazi University by the Faculty of Dentistry, Department of Prosthodontics. A total of 32 patients (15 men and 17 women) who underwent implant treatment in the posterior/premolar region participated in this study between February 2006 and February 2007.

Subjects were required to read, understand, and sign an informed consent form. The mean age of the patients was 44.2 ± 12.5 years. Inclusion criteria were adequate oral hygiene (defined as a modified sulcus bleeding index ≤ 1 and a modified plaque index ≤ 1)²⁶; absence of residual roots, local inflammation, and mucosal diseases; and no history of local radiation therapy. Patients having an adequate bone volume and bone quality type 2 (thick cortical and fenestrated cancellous bone) without the need for hard and/or soft tissue grafting and sinus lift in the posterior maxilla were included in the study. Bone quality was assessed by radiograph and at the time of surgery with respect to the tactile sense of the surgeon. A patient with inadequate bone quality was excluded from the study. Bone volume defines the height sufficient to prevent the implant from encroaching on vital structures and the width sufficient to place the implant within the confines of the existing bone without dehiscence or fenestration. These assessments were done by the same operator. According to the existing condition of the bone, implants with diameters of 3.3, 4.1, and 4.8 mm and lengths of 10 and 12 mm were used (Table 1).

Patients with absolute contraindications for this operation, such as uncontrolled diabetes, long-term steroid usage and blood disorders were excluded. Local exclusion factors included unresolved periodontitis, mucosal and/or occlusal disease, osseous lesions, and/or unresolved extraction wounds (< 4 months healing). Inadequate bone at the time of

TABLE 1
Distribution of implants by site

	Implant diameter	Premolar Region		Molar Region	
		Implant Length			
		10 mm	12 mm	10 mm	12 mm
3.3 mm	9 (1)*	13	-	3	
4.1 mm	6	13	11	7	
4.8 mm	-	-	1	1	

*Number of failed implants is shown in parentheses.

surgery with a resultant need for guided bone regenerative methods and lack of implant stability were also considered reasons for patient exclusion from the study.

The implants were allocated into 2 groups of equal size. In group 1, PRP was applied, and in group 2, PRP was not applied to the implant sockets. Primary outcome measures were implant integration, implant stability, and soft tissue healing. The secondary outcome measures were prosthesis success and complications.

PRP production process

The PRP was prepared using the Curasan PRP kit, which consists of the following parts from Sarstedt (Nümbrecht, Germany): a Multifly set (catalog no. 85.1637.005), 2 multi-adapters (catalog no. 93552213), an 8.5-mL CPDA monovette (catalog no. 01.1610.001), a 9-mL monovette (catalog no. 02.1726.001), a 7.5-mL monovette (catalog no. 02.1726.001), and a 1-mL syringe (reference no. 9161406F). It also included the following parts from Braun (Melsungen, Germany): 2 0.8 × 120-mm injection needles (reference no. 4665643), a 0.8- × 80-mm injection needle (reference no. 4665465), and 2 intake air cannulas (reference no. 4190017).

In the first step of the PRP preparation, at 30 minutes before the surgery, approximately 8 mL whole blood was drawn from the patient.²⁷ Tubes were filled with anticoagulated blood (8 mL blood and 0.5 mL citrate-phosphate-dextrose-adenine for anticoagulation), counterbalanced in a centrifuge, and centrifuged for 10 minutes at 2400 rpm. This process separated the red and white blood cells from the platelet-carrying plasma. The supernatant plasma fraction was then transferred to the second tube with an adapter. This tube was again centrifuged at 3600 rpm for 10 minutes. This

separated the cell-free plasma fraction from the PRP fraction. Because of its higher specific gravity, approximately 0.7 mL of the PRP fraction settled at the bottom of the tube. The PRP was mixed for 20 seconds with a vortex mixer (Reamix 2789, Hecht Assistant, Sondheim, Germany) and transferred to the applicator syringe.^{18,28} The PRP liquid was used in a pure form without adding any agent.

Surgical procedure

Each patient underwent placement of 2 dental implants in the posterior region or bilaterally symmetric to the median palatal suture of the maxilla. A total of 64 titanium dental implants characterized by the chemically modified titanium surface SLActive (Straumann AG, Basel, Switzerland) were inserted. Distribution of implants by site is presented in Table 1. Implants diameters were 3.3, 4.1, and 4.8 mm, and implant lengths were 10–12 mm.

To reduce interoperator variability, a single operator placed all implants. Preoperative antibiotic prophylaxis was provided (amoxicillin 0.5 g, 3 times a day) 1–2 hours before surgery. Surgical procedures were performed under local infiltration anesthesia (Ultracaine D-S, Hoechst Marion Roussel San & Tic AS, Istanbul, Turkey) under aseptic conditions in an outpatient environment. The standard Straumann 1-stage surgery protocol was followed.^{29,30} The final application of the PRP fraction was performed by dipping the implant in PRP liquid for 3–5 seconds before insertion. Then, 0.4 mL of PRP was slowly injected at low pressure into 1 implant socket of every patient. For the control, dental implants were seated on the other implant hole without PRP treatment. The outcome measures used in the current follow-up study were prosthesis and implant success as well as biological

and prosthetic complications, including stability of individual implants.

Measurement of implant stability quotient values using RFA

A wireless Osstell device was used for this study (Osstell Mentor, Integration Diagnostics AB, Gamlestadvägen, Göteborg, Sweden). The SmartPeg with a plastic Osstell mount was manually inserted into the internal connection of the implant and screwed with the aid of a cylindrical plastic holder provided by the company. A torque of 4–5 Ncm was adequate.³¹ Before measurement of the implant stability quotient (ISQ) value, a calibration was performed using a calibration block. The plastic probe of the measuring instrument was brought to within approximately 2–3 mm of the peg. The ISQs were read automatically.

The RFA measurements were conducted in 2 perpendicular directions (mesiodistal and orofacial), twice in each direction. The data were automatically recorded in the device and subsequently transferred to a personal computer. Mean values for every direction and a mean general value for both directions were calculated.

Immediately after the implant was placed, the smart peg was screwed onto the implant and the implant stability was measured (day 0 measurements). Measurements were repeated at days 4, 7, 14, 21, and 28 and at months 6, 12, 24, and 36. A total of 10 measurements were taken for each implant. Outcome measures were evaluated by the same operator.

Clinical procedure, loading, and follow-up protocol

Master impressions were taken on day 7. Fourteen days after implant surgery, RFA measurements were taken. After placement of impression copings, definitive impressions of the maxillary implants were made using transfer copings and a polyether impression material (Impregum, 3M ESPE, Seefeld, Germany). The impression copings were fixed onto the abutment analogs. Cement-retained prostheses were then completed on abutment-level models from a base metal alloy (Master-Tec, Ivoclar Vivadent AG, Schaan, Liechtenstein) and porcelain (VITA VM 13; VITA Zahnfabrik, Bad Sackingen, Germany). The implants were early loaded with temporarily cemented restorations, which were

supported by titanium abutments torqued to approximately 20 Ncm.

Each single crown restoration was adjusted to ensure direct occlusal contact with the opposing arch. Direct occlusal contact was considered to be holding of 20- μ m shim stock foil with firm biting pressure. The occlusion and lateral contacts were carefully adjusted for an even distribution of occlusal contacts. Excursive contacts on the implant-bone reconstructions were avoided whenever possible. All patients were instructed to maintain a soft diet for the first 8 weeks. Periodically, the crown/bridge of every patient was removed, and the SmartPeg was connected to the implant on days 21 and 28 and at months 3, 6, 12, 24, and 36 for RFA measurements.

At each recall visit, the following criteria, proposed by Albrektsson et al,³² were evaluated: (1) no radiolucent zone around the implant controlled; (2) the implant was acting as an anchor for functional prosthesis; (3) confirmed individual implant stability; and (4) no suppuration, pain, or ongoing pathologic processes.

Statistical analysis

Statistical analysis was performed using the Statistical Package for Social Sciences version 11.5 software (SPSS, Inc, Chicago, Ill). Whether the data were normally distributed or not was determined with the Shapiro-Wilk test. Homogeneity of variances was evaluated by Levene's test. Data were represented as mean and standard deviation. Because the data were normally distributed and homogeneous, repeated-measures analysis of variance was used to model the implant stability and test differences between the PRP and non-PRP groups and the effects over time. For multiple pairwise comparisons, data according to Student's *t*-test were compared with measurements of different days. A *P* value <.05 was considered statistically significant. For all possible multiple comparison tests, Bonferroni adjustment was applied to control for Type I error.

RESULTS

Healing and loading period

For the study, 64 implants in 32 patients were allocated to PRP (32 implants) and control or non-

PRP (32 implants) groups. In the present study, 64 implants were loaded with single crowns. Two implants with ISQ values <60 on day 14 were given an additional 4 weeks of healing, and RFA measurements were repeated during the follow-up period. The patients were subsequently offered an implant treatment using the conventional delayed protocol or another form of treatment. One implant that was not treated with PRP (second upper left molar region with a single crown in a 53-year-old male patient) was dropped out to follow-up after the 3-month visit. The implant was removed, and after 3 months, the patient underwent a successful second surgery. The implant was unaccounted for in further statistical analysis. Furthermore, no prosthesis failed and no implant, abutment, abutment screw, or assembly screw fractured during the 3 years of function.

During the follow-up visits, no peri-implant soft tissue infections were noted. Patients reported no adverse effects after dental implant placement. However, in 5 patients, oral hygiene was insufficient, and plaque formation was detected. These patients were instructed and evaluated by the same operator until hygiene was established. Each patient received instructions on maintenance of oral hygiene and was advised to contact the investigators if any concerns arose.

RFA findings

Statistical analysis of RFA values in the follow-up periods for PRP and non-PRP implants are given in Table 2. Mean RFA values for the PRP implants were 75.03 ± 5.91 with a range of 40 to 86 (ISQ), and

those for the non-PRP control group were 73.88 ± 7.18 with a range of 39 to 85 (ISQ) (Figure). No statistically significant differences were seen between RFA values of the PRP group in the follow-up periods ($P = .879$). Likewise, no differences were detected between RFA values of non-PRP control group in the follow-up periods ($P = .354$).

A significant difference was observed between groups only on day 0 of follow-up period ($P = .004$). The PRP group and the non-PRP control group were not significantly different in other periods ($P > .05$) (Table 2).

DISCUSSION

This study of 32 patients treated with early loading in the maxilla was successful because only 1 of 64 implants was dropped out after 3 months of loading. Shorter loading periods than those in conventional implant-loading protocols have become more widely accepted and practiced in recent years, especially because of reported success rates and patient demands for function within a short time after surgery. However, the early loading protocol was reviewed under strictly controlled clinical conditions and protocols and emphasized careful patient selection and screening to maximize the potential success of the procedure.³³ Especially in implant rehabilitation of partially edentulous jaws, surgery and prosthetic treatment are more challenging because of bone properties and anatomic limitations.³⁴ Previous studies reported more implant failures in the posterior regions of the maxilla than in other regions.^{35,36}

TABLE 2

Statistical analysis of resonance frequency analysis values on the follow-up periods for implants treated or untreated with PRP*

Follow-up Period	PRP		non-PRP		P
	Mean ISQ Value	SD	Mean ISQ Value	SD	
During the operation	75.13	5.517	71.64	8.76	.004*
Postoperative day 4	74.87	4.849	73.35	8.24	.385
Postoperative week 1	75.16	5.348	73.94	5.79	.32
Postoperative week 2	75.10	4.865	74.52	5.12	.608
Postoperative week 3	75.14	4.813	74.14	5.84	.402
Postoperative week 4	75.00	4.480	73.79	5.89	.256
Postoperative month 6	74.84	8.721	75.12	8.82	.897
Postoperative month 12	74.92	8.679	75.20	8.84	.897
Postoperative month 24	74.76	7.568	74.92	7.84	.902
Postoperative month 36	73.96	8.126	75.14	6.98	.364

*PRP indicates platelet-rich plasma; ISQ, implant stability quotient; $P < .05$.

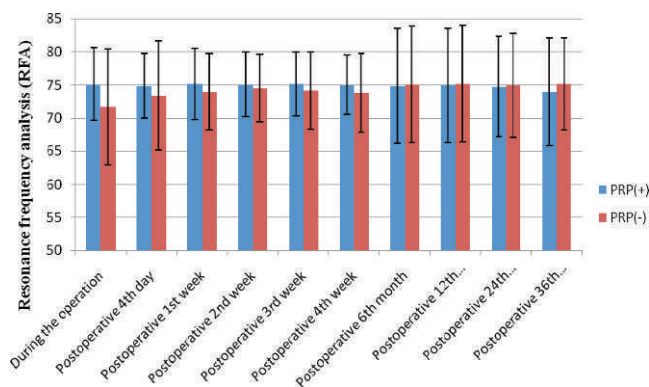


FIGURE. Mean and standard deviation resonance frequency analysis values on the follow-up periods for both implants with platelet-rich plasma (PRP) or non-PRP.

Previous studies reported different ISQ values of 50–90.^{37,38} Moreover, the authors claimed that a primary stability value of 50 was enough to load the implants.³⁹ A previous study by Östman et al⁶ used a primary stability ISQ value of 60 as a threshold value for immediate loading. Similarly, in the present study, an ISQ value of 60 was used as the baseline for early loading of the implants. With the exception of 1 implant loss, no implant, abutment, abutment screw, or assembly screw fractured during the 3 years of function. This is in accordance with the results obtained by Fischer et al.⁴⁰

Regarding the effect of PRP on bone and primary stability of implant, the stimulatory effect of PRP in vitro on the proliferation of osteoblasts seems to start in vivo in the second week. The proliferation in second week is statistically significant from the third week and still exists in the fourth week.⁴¹ Additionally, previous studies reported that local application of PRP increased the amount of newly formed bone around the implant and increased bone density.^{19,42} In animal experiments, the PRP, which was used to support the osseointegration of endosseous dental implants, resulted in significantly increased bone regeneration.⁴³ Therefore, the effect of PRP on the maxilla was evaluated in the present study. However, no constructive effect of PRP was seen. Although there are many methods to prepare PRP,⁴⁴ the Curasan PRP Kit was used to produce autologous PRP for immediate use. A previous study by Weibrich and Kleis²⁸ indicated that this method is acceptable to the patient because it produces less stress on the cardiovascular system and can be done in minutes. Moreover, a previous study by Rutkowski et al⁴⁴ reported that

techniques that produce small quantities of PRP can be time efficient, cost efficient, and easily accomplished by dental auxiliaries.

In the current study, both PRP and non-PRP implants were placed in the posterior maxilla. In addition, in this study, the mean ISQ value of PRP implants was 75.13 on the operation day and 73.96 at the third year. For non-PRP implants, the mean ISQ value was 71.64 on the operation day and 75.14 at the third year. The differences were not statistically significant with the exception of those on operation day, which is a baseline assessment.

No statistically significant differences were observed in the mean ISQ value during the healing process (Table 2). This finding is in accordance with a previous study that investigated the early phases of clinical implant incorporation in relation to jawbone characteristics using RFA and reported no statistical significance over time.⁴⁵

Recently, many researchers have demonstrated comparable results for integration with implants using a more condensed 1-stage early loading protocol in edentulous maxillae.^{40,46} Previous studies suggested that early loading of dental implants is possible when a high degree of primary implant stability is achieved.^{47,48} Early loading of implants after 14 days of healing seems to be a valuable treatment option for clinicians and can be recommended under clearly defined clinical conditions. Additionally, in a review by Esposito et al,⁴⁹ loading strategies have been evaluated. A previous study compared immediate-delayed implants placed on average 10 days after extraction with delayed implants placed on average 3 months after extractions.⁵⁰ After 5 years, there were no statistically significant differences between the groups with respect to the level of the peri-implant marginal mucosa and the resorption of the alveolar bone.⁵⁰ Moreover, in another study, immediate and delayed loading protocols were compared, and the researchers found no statistically significant differences for prosthesis and implant failures.⁴⁹ Likewise, in the present study, most of the implants achieved good primary stability, which was documented by a high ISQ value (PRP mean ISQ = 75.1 ± 4.9; non-PRP mean ISQ = 74.5 ± 5.1).

The results from this limited study on 32 patients indicate that early loading protocols might be applied to maxillary implants. However, adding PRP on early loaded implants does not result in a

more advanced level of ISQ. Besides, the design of this follow-up study has several limitations, making it difficult to compare the results with different clinical situations. The first was the differences in sample size. Another limitation concerns the variation in observation periods. Further investigation is required to evaluate the marginal bone loss and peri-implant mucosa to validate the treatment concept for implant-supported prostheses.

ABBREVIATIONS

ISQ: implant stability quotient
 PDGF: platelet-derived growth factor
 PRP: platelet-rich plasma
 RFA: resonance frequency analysis
 TGF: transforming growth factor

NOTE

This study was presented at the 35th European Prosthodontics Association in Bern, Switzerland, September 29 to October 1, 2011.

REFERENCES

- Rodrigo D, Aracil L, Martin C, Sanz M. Diagnosis of implant stability and its impact on implant survival: a prospective case series study. *Clin Oral Implants Res.* 2010;21:255–261.
- Albrektsson T. Principles of osseointegration. In: Hobkirk JA, Watson RM, eds. *Color Atlas and Text of Dental and Maxillofacial Implantology.* St Louis, Mo: Mosby; 1995:9–19.
- Adell R, Lekholm U, Rockler B, Branemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. *Int J Oral Surg.* 1981;10:387–416.
- Branemark PI, Zarb GA, Albrektsson T, eds. *Tissue Integrated Prostheses: Osseointegration in Clinical Dentistry.* Chicago, Ill: Quintessence Publishing Co; 1985.
- Bergkvist G. Immediate loading of implants in the edentulous maxilla. *Swed Dent J Suppl.* 2008;196:10–75.
- Östman PO, Hellman M, Sennerby L. Direct implant loading in the edentulous maxilla using a bone density-adapted surgical protocol and primary implant stability criteria for inclusion. *Clin Implant Dent Relat Res.* 2005;7:60–69.
- Gapski R, Wang HL, Mascarenhas P, Lang NP. Critical review of immediate implant loading. *Clin Oral Implants Res.* 2003;14:515–527.
- Al-Nawas B, Wagner W, Grotz KA. Insertion torque and resonance frequency analysis of dental implant systems in an animal model with loaded implants. *Int J Oral Maxillofac Implants.* 2006;21:726–732.
- Meredith N. Assessment of implant stability as a prognostic determinant. *Int J Prosthodont.* 1998;11:491–501.
- Isidor F. Influence of forces on peri-implant bone. *Clin Oral Imp Res.* 2006;17(suppl 2):8–18.
- Nkenke E, Hahn M, Weinzierl K, Radespiel-Troger M, Neukam FW, Engelke K. Implant stability and histomorphometry: a correlation study in human cadavers. *Clin Oral Imp Res.* 2003;14:601–609.
- Meredith N, Shagaldi F, Alleyne D, Sennerby L, Cawley P. The application of resonance frequency measurements to study the stability of titanium implants during healing in the rabbit tibia. *Clin Oral Implants Res.* 1997;8:234–243.
- Fürst G, Gruber R, Tangl S, et al. Sinus grafting with autogenous platelet-rich plasma and bovine hydroxyapatite. A histomorphometric study in minipigs. *Clin Oral Implants Res.* 2003;14:500–508.
- Friberg B, Sennerby L, Lindén B, Gröndahl K, Lekholm U. Stability measurements of one-stage Branemark implants during healing in mandibles, a clinical resonance frequency analysis study. *Int J Oral Maxillofac Surg.* 1999;28:266–272.
- Friberg B, Sennerby L, Meredith N, Lekholm U. A comparison between cutting torque and resonance frequency measurement of maxillary implants: a 20-month clinical study. *Int J Oral Maxillofac Surg.* 1999;28:297–303.
- Maló P, Rangert B, Dvårsäter L. Immediate function of Brånemark implants in the esthetic zone: a retrospective clinical study with 6 months to 4 years of follow-up. *Clin Implant Dent Relat Res.* 2000;2:138–146.
- Ergun G, Nagas IC, Yilmaz D, Ozturk M. Prosthetic rehabilitation of edentulous ridges following alveolar distraction osteogenesis: clinical report of three cases. *J Oral Implantol.* 2011;37:183–191.
- Monov G, Fuerst G, Tepper G, Watzak G, Zechner W, Watzek G. The effect of platelet-rich plasma upon implant stability measured by resonance frequency analysis in the lower anterior mandibles. *Clin Oral Implants Res.* 2005;16:461–465.
- Marx RE, Carlson ER, Eichstaedt R, Schimmele Strauss J, Georgeff K. Platelet-rich plasma: growth factor enhancement for bone grafts. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 1998;85:638–646.
- Powell CA, Bannister SR, Mackey SA, Maller SC, McDonnell HT, Deas DE. Periodontal wound healing with and without platelet-rich plasma: histologic observations and assessment of flap tensile strength. *J Periodontol.* 2009;80:985–992.
- Okuda K, Tai H, Tanabe K, et al. Platelet-rich plasma combined with a porous hydroxyapatite graft for the treatment of intrabony periodontal defects in humans: a comparative controlled clinical study. *J Periodontol.* 2005;76:890–898.
- Mannai C. Early implant loading in severely resorbed maxilla using xenograft, autograft, and platelet-rich plasma in 97 patients. *J Oral Maxillofac Surg.* 2006;64:1420–1426.
- Demiralp B, Keceli HG, Muhtarogullart M, Serper A, Demiralp B, Eratalay K. Treatment of periapical inflammatory lesion with the combination of platelet-rich plasma and tricalcium phosphate: a case report. *J Endod.* 2004;30:796–800.
- Tozum TF, Keceli HG, Serper A, Tuncel B. Intentional replantation for a periodontally involved hopeless incisor by using autologous platelet rich plasma. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2006;101:e119–e124.
- Petrungaro PS. Treatment of the infected implant site using platelet-rich plasma. *Compend Contin Educ Dent.* 2002;23:363–366, 368, 370 passim; quiz 378.
- Mombelli A, van Oosten MA, Schurch E Jr, Land NP. The microbiota associated with successful or failing osseointegrated titanium implants. *Oral Microbiol Immunol.* 1987;2:145–151.
- Tözüm TF, Demiralp B. Platelet-rich plasma: a promising innovation in dentistry. *J Can Dent Assoc.* 2003;69:664.
- Weibrich G, Kleis WK. Curasan PRP kit vs. PCCS PRP system. Collection efficiency and platelet counts of two different methods for the preparation of platelet-rich plasma. *Clin Oral Implants Res.* 2002;13:437–443.
- Buser D, von Arx T. Surgical procedures in partially

edentulous patients with ITI implants. *Clin Oral Implants Res.* 2000;11:Suppl 1:83–100.

30. Buser D, von Arx T, ten Bruggenkate C, Weingart D. Basic surgical principles with ITI implants. *Clin Oral Implants Res.* 2000;11:59–68.

31. Ohta K, Takechi M, Minami M, Shigeishi H, Hiraoka M, Nishimura M. Influence of factors related to implant stability detected by wireless resonance frequency analysis device. *J Oral Rehabil.* 2010;37:131–137.

32. Albrektsson T, Zarb GA, Worthington P, Eriksson RA. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. *Int J Oral Maxillofac Implants.* 1986;1:11–25.

33. Szmukler-Moncler S, Piattelli A, Favero GA, Dubruille JH. Considerations preliminary to the application of early and immediate loading protocols in dental implantology. *Clin Oral Implants Res.* 2000;11:12–25.

34. Friberg B, Jemt T, Lekholm U. Early failures in 4,641 consecutively placed Branemark dental implants: a study from stage 1 surgery to the connection of completed prostheses. *Int J Oral Maxillofac Implants.* 1991;6:142–146.

35. Adell R, Eriksson B, Lekholm U, Branemark PI, Jemt T. Long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. *Int J Oral Maxillofac Implants.* 1990;5:347–359.

36. Balleri P, Cozzolino A, Ghelli L, Momicchioli G, Varriale A. Stability measurements of osseointegrated implants using Osstell in partially edentulous jaws after 1 year of loading: a pilot study. *Clin Implant Dent Relat Res.* 2002;4:128–132.

37. Cho IH, Lee YI, Kim YM. A comparative study on the accuracy of the devices for measuring the implant stability. *J Adv Prosthodont.* 2009;1:124–128.

38. González-García R, Monje F, Moreno-García C. Predictability of the resonance frequency analysis in the survival of dental implants placed in the anterior non-atrophied edentulous mandible. *Med Oral Patol Oral Cir Bucal.* 2011;16:e664–e669.

39. Rabel A, Köhler SG, Schmidt-Westhausen AM. Clinical study on the primary stability of two dental implant systems with resonance frequency analysis. *Clin Oral Investig.* 2007;11:257–265.

40. Fischer K, Stenberg T, Hedin M, Sennerby L. Five-year results from a randomized, controlled trial on early and delayed

loading of implants supporting full-arch prosthesis in the edentulous maxilla. *Clin Oral Implants Res.* 2008;19:433–441.

41. Weibrich G, Hansen T, Kleis W, Buch R, Hitzler WE. Effect of platelet concentration in platelet-rich plasma on peri-implant bone regeneration. *Bone.* 2004;34:665–671.

42. Anitua E. Plasma rich in growth factors: preliminary results of use in the preparation of future sites for implants. *Int J Oral Maxillofac Implants.* 1999;14:529–535.

43. Kim SG, Chung CH, Kim YK, Park JC, Lim SC. Use of particulate dentin–plaster of Paris combination with/without platelet-rich plasma in the treatment of bone defects around implants. *Int J Oral Maxillofac Implants.* 2002;17:86–94.

44. Rutkowski JL, Thomas JM, Bering CL, et al. Analysis of a rapid, simple, and inexpensive technique used to obtain platelet-rich plasma for use in clinical practice. *J Oral Implantol.* 2008;34:25–33.

45. Huwiler MA, Pjetursson BE, Bosshardt DD, Salvi GE, Lang NP. Resonance frequency analysis in relation to jawbone characteristics and during early healing of implant installation. *Clin Oral Implants Res.* 2007;18:275–280.

46. Nordin T, Graf J, Frykholm A, Helldén L. Early functional loading of sand-blasted and acid-etched (SLA) Straumann implants following immediate placement in maxillary extraction sockets. Clinical and radiographic result. *Clin Oral Implants Res.* 2007;18:441–451.

47. Sullivan D, Vincenzi G, Feldman S. Early loading of Osseotite implants 2 months after placement in the maxilla and mandible: a 5-year report. *Int J Oral Maxillofac Implants.* 2005;20:905–912.

48. Turkyilmaz I, Sennerby L, Tumer C, Yenigul M, Avci M. Stability and marginal bone level measurements of unsplinted implants used for mandibular overdentures. A one-year randomized prospective clinical study comparing early and conventional loading protocols. *Clin Oral Implants Res.* 2006;17:501–505.

49. Esposito M, Grusovin MG, Polyzos IP, Felice P, Worthington HV. Timing of implant placement after tooth extraction: immediate, immediate-delayed or delayed implants? A Cochrane systematic review. *Eur J Oral Implantol.* 2010;3:189–205.

50. Esposito MA, Koukouloupoulou A, Coulthard P, Worthington HV. Interventions for replacing missing teeth: dental implants in fresh extraction socket (immediate, immediate-delayed and delayed implants. *Cochrane Database Syst Rev.* 2006; 4:CD005968.