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Application of Platelet-Rich Plasma as an Accelerator of the Secondary Stability of Immediate-Loaded Implants

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learning objectives

After reading this article, the reader should be able to:

- discuss the problems associated with the immediate loading of implants.
- describe the influence of PRP on peri-implant healing.
- describe a protocol for immediate functional loading of intraosseal implants.

ABSTRACT

The problems associated with the immediate functional loading of osseointegratable implants are related to loss of stability, which could lead to implant failure. This article describes a protocol for the immediate functional loading of osseointegratable implants that relies on high primary stability and the acceleration of secondary stability by the use of platelet-rich plasma (PRP) as a source of autogenous growth factors. Changes in implant stability are measured by resonance frequency analysis and the success rate of PRP-treated implants is compared with the success rate of a control group of untreated implants.

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A significant part of the clinical research on immediate functional loading is focused on the loss of stability of the implants, usually in the first 2 to 6 weeks after implant placement. This is the main cause of failure in immediate-loaded implants.[1-4]

The loss of the stability of the implants is often due to the remodeling of the lamellar bone, which holds the implant stable and surrounds it with newly formed woven bone. Most of the described protocols for the immediate functional loading of implants aim to maintain a low rate of bone remodeling, usually by decreasing the bone trauma caused during the surgery or after functional loading[1-3] and keeping the primary stability higher for a longer time. This article describes a way to improve the success rate of immediate-loaded implants by accelerating secondary stability.

The application of platelet-rich plasma (PRP) in bone grafting is already well known. In high concentrations, the PRP autogenous growth factors (such as platelet-derived growth factor, transforming growth factor ß1, vascular endothelial growth factors, insulin-like growth factor, fibroblast growth factors, and other active molecules) accelerate the process of forming of new-woven bone.[4-8] Because of this ability, the application of PRP to immediate-loaded implants may lead to improved and accelerated contact osteogenesis over the implants, possibly by speeding up the increase of the secondary stability of these implants. The author postulates that this in turn may prevent the decrease of the stability of implants during the first few weeks after immediate loading.

Despite these facts, several studies on the influence of the PRP on osseointegration do not give a positive evaluation on its effect on the implant stability,[9-14] or if they do, they concern the quality of the peri-implant bone at the point of osseointegration as evaluated by histomorphometric analysis. This does not account for PRP's influence on implant stability. All of these clinical and experimental studies do not adhere to the main principles established by Davies in his theory on contact osteogenesis.[15,16] According to this theory, one of the most important circumstances for successful contact osteogenesis in the stage of osteoconduction is the fibrin matrix, which should be well attached to the implant surface. The fibrin network will ensure the migration of the osteogenic cells at the implant surface. At the implant surface, osteogenic cells become osteoblasts and start the production of bone matrix. The fibrin network has to withstand the contractile forces generated by migrating cells, which are influenced by the chemotaxic factors released by the degranulating platelets and absorbed on the implant surface.

Therefore, the application of PRP with immediate-loaded implants is most adequate if the activation of PRP, the degranulation of platelets, and the building up of the fibrin matrix start immediately after the contact of the autologous PRP with the implant surface. If the PRP was activated earlier and the PRP gel was already formed, the full potential of the PRP could not be exploited to improve and accelerate the osseointegration in the early stage of osteo-conduction because

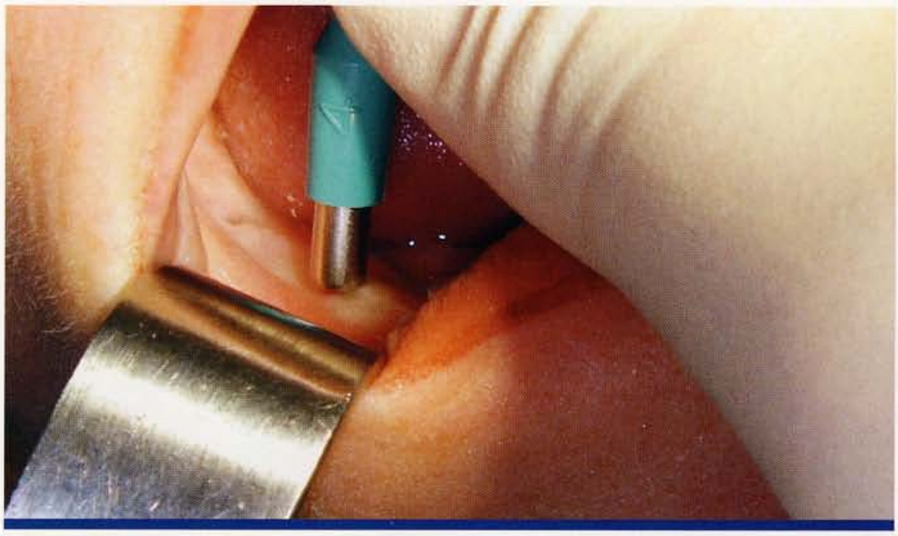

Figure 1 Removing the soft tissues covering the osteotomy bone site by tissue punch.

Figure 2 The implant osteotomy in progress using a 2-mm drill.

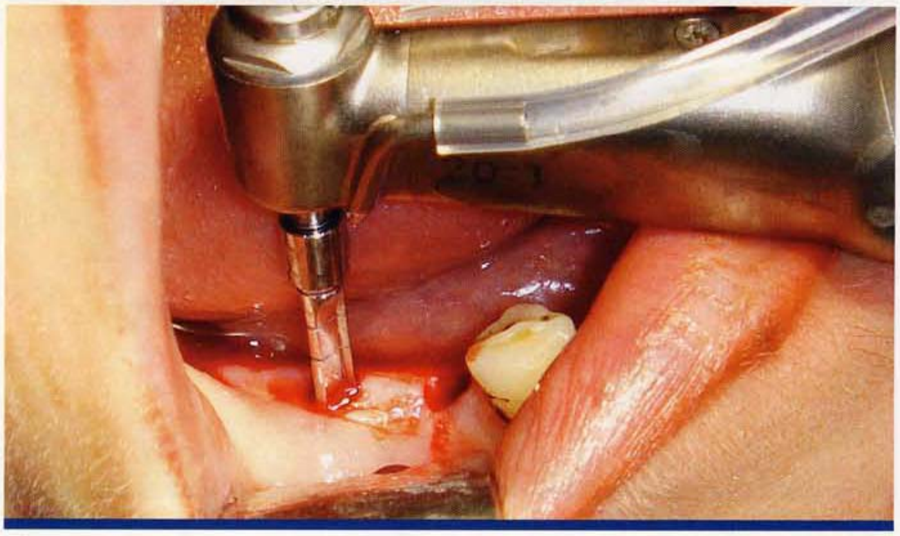

Figure 3 The final 4.3-mm osteotomy drill.

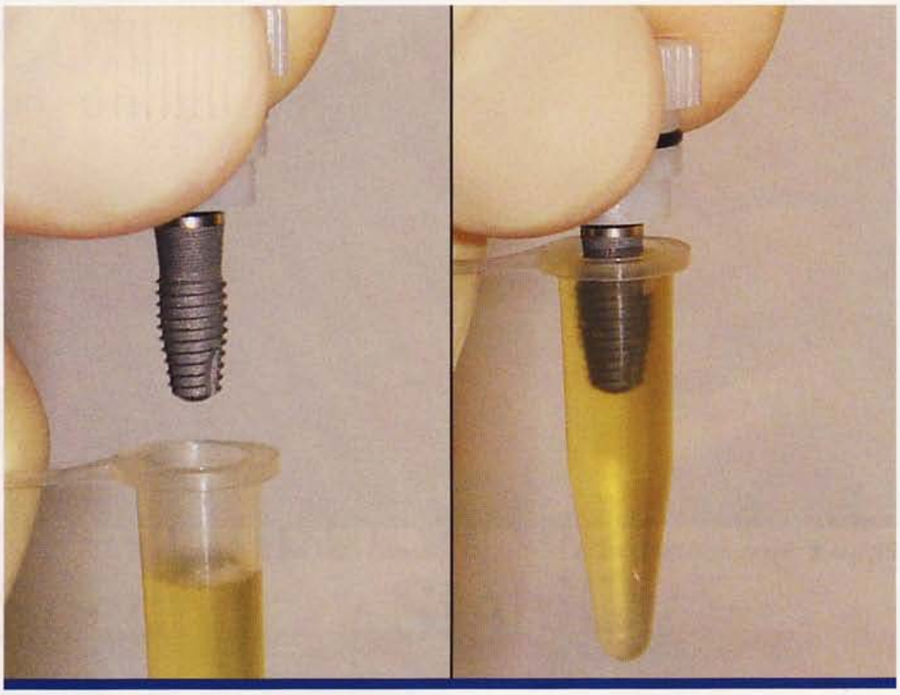

Figure 4 The implant is treated with PRP.

of the consumption of the fibrinogen during the coagulation process. This is the keystone of the protocol for immediate functional loading of implants.

If the implant surface is treated with PRP immediately after PRP's activation with a 10% solution of calcium chloride, it will promote the degranulation of most of the platelets at the implant surface and the building up of the surface fibrin matrix. Contact between PRP and the dioxide layer of a titanium implant allows water and molecules such as fibrinogen and platelets to be absorbed.[17-19] The contact of platelets with the implant surface is an additional cause for degranulation.[15,16] Platelets release chemotaxic substances, which stimulate the migration of osteogenic cells toward the implant surface and activate other platelets to degranulate as a part of a chain reaction. The application of calcium chloride as an activator of PRP coagulation alone, without thrombin results, has a better effect on the peri-implant healing, as demonstrated in the following study.

MATERIALS AND METHODS

A total of 21 patients participated in the study. Eighty-six implants were inserted and immediately loaded; 11 of these were placed immediately after tooth extraction. The requirement for such implants was that the dimensions of the post-extraction socket were smaller than the osteotomy. This ensured that the whole implant surface was supported by "new" bone, with none of the walls of the post-extraction socket remaining. Forty-four of the implants were treated with PRP. In the rest of the implants, PRP was not used, but all other conditions were the same. The implants were inserted in bone described by Misch as type D2, class A.[20] The implants used in the study were Endure™ implants (IMTEC Corporation, Ardmore, OK). These implants offer excellent primary stability because of their double-tapered shape—an anatomical design with a taper at the apical region and another at the crestal module. The anatomical shape of Endure implants is appropriate for immediate placement, as it fits to the shape of the post-extraction socket in most of the cases and closes its orifice.

After evaluating the patients and the usual preparation for implant surgery, PRP was obtained through the patients' own blood. Venous blood was drawn in sterile containers containing 1 ml of citrate-phosphate-dextrose-adenine (CPDA-1). The PRP separation was made in a centrifuge. The first spin was at 2,400 rpm for 10 minutes. With this spin, the erythrocytes were separated from platelet-poor plasma (PPP). With the second spin, at 3,600 rpm for 15 minutes, the PRP was separated from the PPP. The whole PRP separation procedure was performed under aseptic conditions.

The osteotomy and placement protocol for Endure implants was very simple,

Figure 5 The implant is placed in the osteotomy site by holding it by the container's cap.

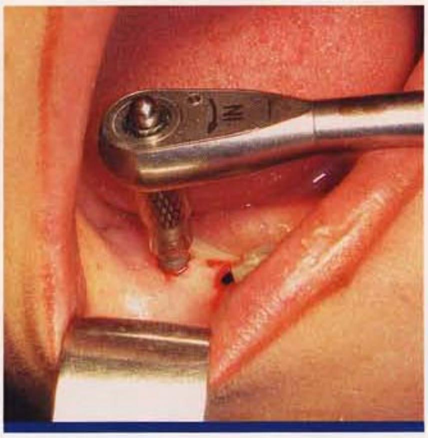

Figure 6 The final seating of the implant by torque wrench.

Figure 7 Measuring the implant stability by RFA. The "Smartpeg" attaché at implant platform and the measuring probe are shown.

which shortened the duration of the procedure, saved time, and minimized the possibility of errors made by the clinician during the procedure. In the immediate functional-loading protocol, the author used a flapless procedure that preserved the crestal bone blood supply. It began with removal of the mucosa covering the osteotomy site by a tissue punch (Figure 1). The drilling procedures were performed under irrigation with a sterile 0.9% saline solution. The author drilled the pilot hole with a 1.6-mm diameter pilot drill. The pilot drill was externally irrigated. The other drills that followed had external and internal irrigation. The osteotomy continued with a sequence of drills of increasing diameters: 2 mm, slightly less than 3.5 mm, and slightly less than 4.3 mm (Figure 2 and Figure 3). The osteotomy was performed at 900 rpm. Following the osteotomy, the PRP was activated by a 10% solution of calcium chloride. The author treated the implants by dipping them in the PRP, avoiding any contact with the walls of the container in which the PRP was kept (Figure 4). The implant was placed in the osteotomy hole by holding it by the cap of the container in which the sterile implant was provided (Figure 5). The final seating of the implant was executed with a torque wrench (Figure 6). The torque wrench (Adjustable Torque Wrench, IMTEC Corporation) allows adjustment of the torque from 15 Ncm to 70 Ncm. It can be used with the Endure hexagonal adaptor. The minimal required torque is 50 Ncm. The primary stability of the implants that reached 50 Ncm or higher torque was evaluated by resonance-frequency analysis (RFA). The author placed a cover screw on the implants that could not satisfy the requirement for the minimal torque of 50 Ncm, and, therefore, their loading was delayed for 3 months or longer to ensure better conditions for successful osseointegration of the implants.

The second requirement for immediate loading is to reach a primary implant stability quotient (ISQ) value of at least 60 by RFA. Therefore, measurement of the stability by RFA (Figure 7) was displayed in ISQ values.

One-piece, non-hexed shouldered abutments (Simplified Shouldered Abutment, IMTEC Corporation) were placed on the implants that satisfied these requirements (Figure 8). The angle between the longitudinal axis of the abutment and the abutment walls was 6°, which spared the necessity of abutment preparation in most of the cases. If the abutments had to be shortened, they were marked, and the preparation was performed after they were removed from the implant to avoid heating up the implant and compromising the primary stability by the vibration. The PRP gel, which was already formed, was applied into the peri-implant gap.

Figure 8 One-piece shouldered abutments placed on the implants.

Figure 9 Checking the occlusion of the temporary crowns.

A TOTAL OF 21 PATIENTS PARTICIPATED IN THE STUDY. EIGHTY-SIX IMPLANTS WERE INSERTED AND IMMEDIATELY LOADED; 11 OF THESE WERE PLACED IMMEDIATELY AFTER TOOTH EXTRACTION.

Prefabricated temporary crowns were placed over the abutments. The author used at least two or more splinted implants as co-abutments for all of the implants included in the research. After the adjustment and removal of the tight occlusal contacts, the crowns were relined with nonacrylic resin and cemented by temporary cement (Figure 9).

Every 2 weeks, a visit for RFA measurement of implant stability was scheduled. If the registered ISQ value dropped below 50, the implant was unloaded by replacing the abutment with a short cover screw.

RESULTS AND DISCUSSION

The stability of the implants was evaluated every 2 weeks for 12 weeks (Figure 10). The implants that were treated with PRP maintained their stability at more than 50 ISQ, demonstrating a 100% success rate. Three of the implants that were not treated with PRP demonstrated stability below 50 ISQ in the sixth week. These implants had to be unloaded and the procedure for their immediate loading failed. The success rate of the immediate loading protocol with non–PRP-treated implants was 92.85%, despite demonstrating good osseointegration 5 months after their insertion. The 11 immediately-placed

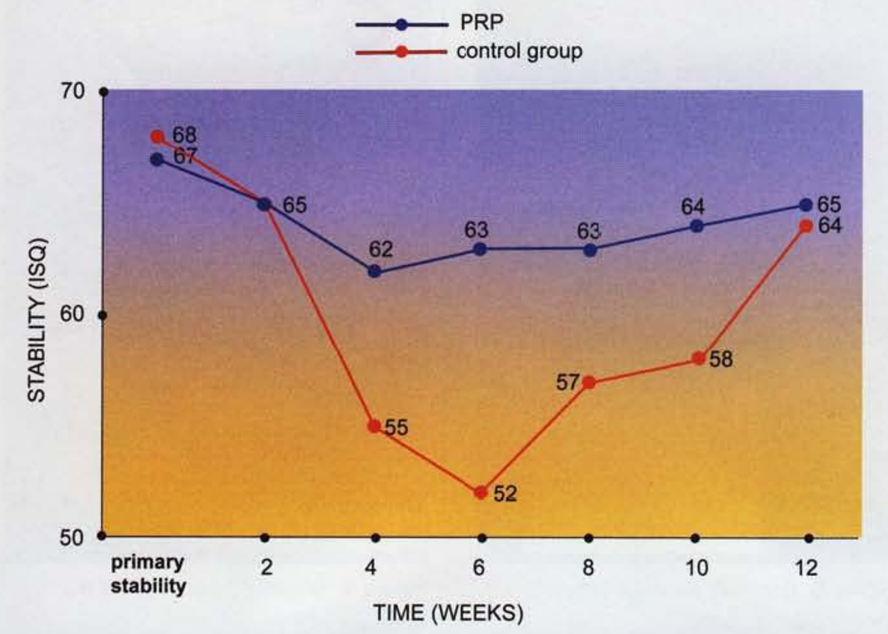

Figure 10 The results of the RFA (implant stability measured in ISQ).

implants had the same success rate as implants with delayed placement.

CONCLUSION

The application of PRP with the protocol for immediate functional loading avoids the loss of implant stability in the first 4 to 6 weeks after implant placement and loading. This can be explained by the acceleration of the processes that improve the secondary stability of the implants or the osseointegration and peri-implant healing process.

PRP application is a cost-effective way to improve the performance of immediate-loaded implants. It is a protocol that could be applied to any titanium implant (eg, with sandblasted and acid-etched or titanium plasma spray surface treatment). PRP application does not exclude the requirement for gaining good primary stability, which depends on implant design and dimensions, insertion protocol, and bone volume and quality; however, when used in conjunction with the Endure implants in this study, excellent primary stability was demonstrated. Additionally, RFA is a method that could be used to prevent the failure of an implant by tracing the changes in the implant stability during the stage of osseointegration.

DISCLOSURE

The author has received an honorarium from IMTEC Corporation.

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1. How many weeks after implant placement was a loss of stability observed with the immediate-loaded implants?
- **a.** 1 week
- **b.** 2 to 6 weeks
- **c.** 6 to 8 weeks
- **d.** 8 to 12 weeks

2. PRP is a source of:
- **a.** osteo-conductive factors.
- **b.** osteo-inductive factors.
- **c.** growth factors.
- **d.** bone morphogenic proteins.

3. The migration of the osteogenic cells at the implant surface in the stage of osteo-conduction is ensured by:
- **a.** collagen matrix.
- **b.** fibrin matrix.
- **c.** PRP.
- **d.** bone morphogenic proteins.

4. At the implant surface osteogenic cells become:
- **a.** osteoblasts.
- **b.** osteocytes.
- **c.** osteoclasts.
- **d.** pre-osteoblasts.

5. PRP is activated by 10% solution of:
- **a.** sodium chloride.
- **b.** calcium chloride.
- **c.** thrombine.
- **d.** hydrochloric acid.

6. In the described protocol, the implants are treated with:
- **a.** PRP.
- **b.** PPP.
- **c.** autogenous blood.
- **d.** bovine thrombine.

7. The minimal required torque, which should be reached at final seating of 4.3-mm immediate-loaded implants, is:
- **a.** 20 Ncm.
- **b.** 35 Ncm.
- **c.** 50 Ncm.
- **d.** 80 Ncm.

8. The minimal required ISQ value obtained with RFA measurement of the primary implant stability for immediate-loaded implants should be:
- **a.** 20 ISQ.
- **b.** 50 ISQ.
- **c.** 60 ISQ.
- **d.** 100 ISQ.

9. Below which value of ISQ should the dentist unload the implants and delay their functional loading?
- **a.** 20 ISQ
- **b.** 50 ISQ
- **c.** 60 ISQ
- **d.** 100 ISQ

10. In what described protocol is the peri-implant gap involved?
- **a.** PRP gel application
- **b.** antibiotic solution application
- **c.** chlorhexidine application
- **d.** bovine thrombine application