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Effect of Injectable Platelet Rich Fibrin with Chitosan-Bioactive Glass on Bone Regeneration around Dental Implant

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ORIGINAL STUDY

Effect of Injectable Platelet-rich Fibrin With Chitosan-bioactive Glass on Bone Regeneration Around Dental Implants

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Abstract

Purpose: The current study aimed to evaluate the effect of injectable platelet-rich fibrin (I-PRF) mixed with chitosan-bioactive glass scaffold on soft and hard tissue healing around dental implants. **Patients and methods:** A total of 14 patients, ranging in age from 20 to 45 years, were divided into two groups randomly. Group A: Immediate dental implants were placed associated with chitosan-bioactive glass (CBG). Group B: Immediate dental implants were placed associating CBG mixed with injectable platelet-rich fibrin (CBG + I-PRF). Implant stability and its measurements were evaluated for each group and compared between groups. **Results:** In the mean of implant stability, a statistically significant difference existed within group A as implant stability increased from baseline immediately after implant insertion to follow-up period after 6 months. Also, statistically significant difference existed in the mean of implant stability within group B as implant stability increased from baseline immediately after implant insertion to follow-up period after 6 months. However, there was no significant statistical difference in the mean of implant stability and soft tissue thickness between the two groups. **Conclusions:** CBG and CBG mixed with I-PRF have a positive effect on bone regeneration.

Keywords: Chitosan-bioactive glass (CBG), Immediate implant, Implant stability, Injectable platelet-rich fibrin (I-PRF), Regeneration

1. Introduction

Immediate implant placement (IIP) is used to decrease the number of surgical procedures and the duration of therapy. Also, the immediate placement into a fresh extraction socket could counter the alveolar bone structure as a result of tooth extraction [1].

Buccal bone defects and even soft tissue alteration may be present before or after tooth extraction, resulting from bone remodeling or pathosis that leads to a deficient alveolar ridge. So regenerative procedures may be required with IIP [2].

One of the obstacles that may be present during IIP is the presence of a jumping gap between the implant and extraction socket that can lead to the formation of a bony defect, especially in the buccal area. The buccal bone defects may threaten the survival of dental implants. To overcome this problem, surgical techniques such as bone grafting and different barriers to fill the space around the implants and enhance bone regeneration of buccal defects were suggested to retain hard and soft tissue structures and regenerate lost bone [2].

Regeneration of bone tissue defects through using suitable biomaterial may improve current clinical studies. Therefore, alternative modalities rely on tissue engineering-based grafts have been done to recreate the damaged tissue. Several biopolymers and bioceramics are being used nowadays to create an artificial extracellular matrix. Chitosan is a natural biopolymer with osteoconductive ability to create scaffolds for bone tissue engineering applications due to its nontoxic and minimal foreign

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body response and fibrous encapsulation. However, chitosan-based scaffolds lack mechanical strength and structural stability in hydrated conditions and hence to overcome this we fabricated a composite scaffold of chitosan combined with bioglass, which increases mechanical strength, reduces excessive swelling behavior, and improves the structural stability of the scaffold in hydrated condition, and also it improves the osteogenic potential. The tissue regeneration and integration with natural bone tissue is facilitated by a scaffold. So for bone tissue engineering applications, the established composite scaffold may be a proper biomaterial [3–6].

Injectable platelet-rich fibrin (I-PRF) is used as an autografting material to improve bone regeneration through intrinsic growth factors. The development of this injectable formula of PRF allows the clinicians to use platelet concentrates easily which either can be used alone or combined with numerous biomaterials easily. Taking advantage of slower and shorter centrifugation speeds, a higher presence of regenerative cells with higher concentrations of growth factors can be observed when compared with other formulations of PRF. I-PRF has been developed from venous blood without using anticoagulants, which is based on low-speed concept (700 rpm, 60×*g*) for only 3 min, which gives the ability to release higher concentrations of growth factors and induce higher fibroblast migration and expression of PDGF (platelet derived growth factor), TGF-β (transforming growth factor beta), and collagen. The addition of I-PRF to chitosan-bioactive glass (CBG) will lead to polymerization in 15 min, which may play a role as a bioactive agent capable of stimulating tissue regeneration [7–9].

2. Patients and methods

2.1. Study design

This study included 14 implants for patients suffering from a nonrestorable tooth in the maxillary aesthetic area. Our participants were selected from the outpatient clinic of the Department of Oral Medicine and Periodontology, Oral Diagnosis and Radiology, Faculty of Dental Medicine, Al-Azhar University (Code:REC-ME-22-06).

2.2. Sample size

For evaluating the effect of adding CBG and CBG mixed with I-PRF around the immediate dental implant, an independent t-test was used to compare the two groups. A total sample size of 14 patients (7 in every group) was sufficient to determine an impact value ranging from 1.42 to 1.48 with a power (1-β error) of 0.8 (80%). Using a two-sided hypothesis test with a significance level (α error) of 0.05 for data, the patients were randomly divided into two groups [10].

2.3. Inclusions and exclusion criteria

Both sexes of age 18–50 years, patients free from any systemic disease that may contraindicate periodontal surgery, absence of periodontitis, or periapical pathology (23). Patients requiring extraction of maxillary teeth in the aesthetic zone with consequent immediate implant placement, patients clinically indicated for bone grafting around dental implants in the anterior and premolars area, with at least a 3 mm of bone beyond the root apex to guarantee primary fixture stability and a phenotype of keratinized gingiva in the surgical site not less than 1 mm thick were included. However, smokers, patients with coagulation defects or anticoagulation treatment will be excluded. Pregnant women, vulnerable groups (handicapped, mental retardation, etc.), and periodontal surgical treatment in the previous 24 months on the involved sites were excluded from this study.

Clinical and other evaluation parameters: All the cases were evaluated thoroughly by clinicoradiological assessment including chief complaints, past medical history, personal and family history, and extra-oral and intra-oral examination. Cone beam-computed tomography was used to record bone height and then the width of the area of interest to choose the suitable implant size (diameter and length) and to draw the implant future recipient site using available data and preoperative intraoral photographs. Full-mouth supragingival and subgingival scaling was done followed by proper oral hygiene instructions. Patients were free of any systemic disease [11].

2.4. Surgical procedure

All surgical steps were carried out under strict aseptic conditions. This was followed by local anesthesia of the surgical area (Articaine 4% with noradrenalin 1 : 100 000), after testing anesthesia. Intrasulculer incision was performed opposite to the hopeless tooth or the remaining root to create a pouch to expose the crestal bone of the tooth and then atraumatic extraction was done [12].

The implant site was prepped according to the surgical protocol of Human Tech (RatioPlant Avantgarde made in Germany) to the desired dimensions under copious irrigation with normal saline. The final osteotomy diameters matched the

implant sizes. During implant site preparation, care was taken not to interfere with the neighboring teeth and the angulation of placement was identical to the preexisting tooth. Group A (CBG): The CBG was placed between the implant and the facial plate of the bone. Group B(CBG + I-PRF): CBG mixed with injection platelet-rich fibrin (I-PRF) that was taken from intravenous blood of 10 ml tube without anticoagulant was centrifuged at 700 rpm for 3 min (60×*g*) at room temperature by a Duo Centrifuge (Process for PRF, Nice, France). The upper liquid layer was collected. The implants were placed in the palatal wall of the anterior teeth and the palatal root of premolars under the crestal bone by 1 mm. The implant fixture was covered by healing abutment and suturing using 5/0 figure 8 Vicryl sutures as shown in Fig. 1.

At 6 months after surgery, the healing abutment was removed and then the stability using Osstell for all implants by the situation of a smart peg into the fixture of the implant, which is secured into the implantation, and the use of a transducer, which is held adjacent to and upright to the SmartPeg without really creating touching the placement. Then the abutment supplied by the implant system company was placed. After that proper adjustment of the abutment and direct impression was made for fixed appliance construction by a heavy and light rubber base impression material. The final crown is made of porcelain fused to a metal cemented on an abutment.

2.5. Postoperative instructions

After surgery, all patients were instructed to apply extra oral ice bags (10–20 min) over the implant site to prevent hematoma formation and to prescribe an antibiotic (Megamox 1 g twice/day for 7 days), analgesic (Ibuprofen 600 mg 3 times/day for 3 days), and wash with a 0.12% chlorhexidine gluconate oral wash two times daily after surgery for 2 weeks.

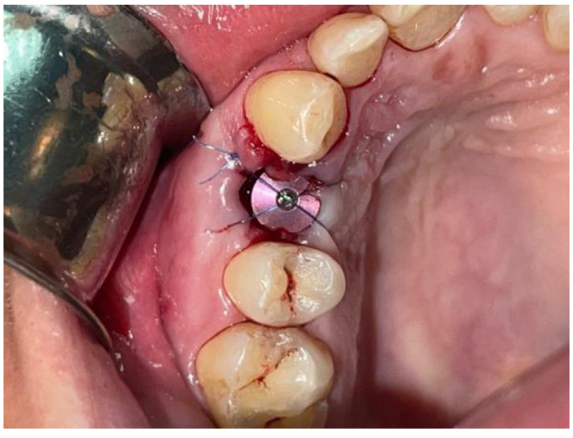

Fig. 1. A photograph showing suture around the healing abutment.

2.6. Statistical analysis

To compare normally distributed data, one-way ANOVA test was used followed by a post hoc test for multiple comparisons between different groups. For non-normal distributed data, Kruskal–Wallis was used followed by the Mann–Whitney test for pair-wise comparisons between groups. *P* greater than or equal to 0.05 was considered statistically significant (95% significance level), and Shapiro–Wilk test was used for assessing data normality. SPSS Statistical Package was used for statistical evaluation (version 25, IBM Co. USA).

3. Results

3.1. Implant stability

3.1.1. Changes in implant stability within the groups

Within group A, the mean of implant stability was (52.43 ± 1.77) after insertion immediately and increased to (66.58 ± 5.36) after 6 months. The mean of implant stability differed statistically significantly between the two-time intervals. (*P* value = 0.003). However, the mean of implant stability within group B was (51.48 ± 2.21) after insertion immediately, this number increased to (72.42 ± 5.49) after 6 months. In the mean of implant stability, there was a statistically significant difference between two time intervals at *P* value = 0.003 Table 1.

3.1.2. Changes in implant stability between two groups

At baseline, there was no statistically significant difference in the mean of implant stability between the two groups (group A (52.43 ± 1.77), group B (51.48 ± 2.21)) at *P* value = 0.485. However, the mean of implant stability increased after 6 months in group B (72.42 ± 5.49), but there was no statistically significant difference between the two groups in the mean of implant stability at *P* value = 0.199 Table 2.

Table 1. Mean ± SD of Implant Stability within the two groups at different time intervals.

	Group A	Group B
At baseline	52.43 ± 1.77	51.48 ± 2.21
After 6 months	66.58 ± 5.36	72.42 ± 5.49
P value	0.003^{S}	0.003^{S}

NS, nonsignificant; S, statistically significant at *P* less than or equal to 0.05.

Table 2. Mean ± SD of Implant Stability between two groups at different time intervals.

	Group A	Group B	*P*-value
At baseline	52.43 ± 1.77	51.48 ± 2.21	0.485^{NS}
After 6 months	66.58 ± 5.36	72.42 ± 5.49	0.199^{NS}

NS, nonsignificant; S, statistically significant at *P* less than or equal to 0.05.

3.2. Soft tissue thickness

3.2.1. Changes in soft tissue thickness within the group

Within group A, the mean of soft tissue thickness was 2.17 ± 0.75 mm before implant and increased to 2.33 ± 0.52 mm after 6 months of implant. There was no significant difference in the mean of soft tissue thickness between the two time intervals (*P* value = 0.715). However, the mean of soft tissue thickness within group B was (2.17 ± 0.75 mm) before implant and increased to 2.33 ± 0.52 mm after 6 months of implant. There was no statistically significant difference in the mean of soft tissue thickness between the two time intervals (*P* value = 0.715) Table 3.

3.2.2. Changes in soft tissue thickness between groups

At baseline, there was no significant statistical difference in the mean of soft tissue thickness between the two groups before implant insertion (*P* value = 1.00). After 6 months, there was no statistically significant difference in the mean soft tissue thickness between the two groups (*P* value = 1.00) Table 4.

4. Discussion

Dental implants have established themselves as a reliable method for the rehabilitation of edentulous areas. Before implant there were two options available for replacing missing teeth either fixed or removable prosthesis. Dental implants have several advantages over conventional methods of replacing missing teeth as it has a high success rate, improve maintenance of bone in the edentulous site, and decrease sensitivity of the adjacent teeth [12,13].

Table 3. Mean ± SD of soft tissue thickness within the two groups at different time intervals.

	Group A	Group B
At baseline	2.17 ± 0.75	2.17 ± 0.75
After 6 months	2.33 ± 0.52	2.33 ± 0.52
P value	0.715^{NS}	0.715^{NS}

NS, nonsignificant.

Table 4. Mean ± SD of Soft tissue thickness between two groups at different time intervals.

	Group A	Group B	*P*-value
At base line	2.33 ± 0.52	2.33 ± 0.52	1.00^{NS}
After 6 Months	2.17 ± 0.75	2.17 ± 0.75	1.00^{NS}

NS, Nonsignificant.

IIP in freshly extracted sockets shows many advantages: it decreases the number of the procedures and short time duration for prosthetic placement as tooth extraction, implant surgery, and restorative treatment are done at the same time; an immediate mechanical support to the papillae and midfacial gingival tissues permit the tissues to be conserved as there is only one surgical procedure, and an ideal aesthetic result through a correct positioning of fixture and its angulation. However, there is lack of stabilization between the walls of the alveolar bone and the implant after immediate placement in addition to existences of buccal wall defect [14].

Therefore, the aim of this study was to examine the effects of CBG and I-PRF mixed with CBG on the bone regeneration of immediate implant placement. A randomized study was applied on 14 patients. Smokers were excluded from this study as it decreased bone mineral density and reduced blood supply. Smoking and its releasing substances as nicotine has been shown to restrict osteoblast proliferation and secretion of osteogenic mediators such as bone-morphogenic protein 2. Nicotine has been shown to promote the development of osteoclast-like cells when combined with LPS. Also, patients should be free from any systemic conditions that affect osseointegration.

Bone regeneration is important around the immediate dental implant to enhance implant stability and osteointegration. The main obstacle for the clinician is the change IN alveolar bone height and width after tooth loss and therefore a variety of regenerative techniques have been undertaken. For example, the use of platelet concentrates including I-PRF releases growth factors that are taken from the patient's own blood to allow new tissue regeneration.

Chitosan is a biopolymer obtained from nature, possessing antifungal, antibacterial activities, mucoadhesion, nontoxicity, biodegradability, and biocompatibility. These properties make chitosan-based biomaterials highly beneficial for various applications. Recently, a lot of approaches have been developed for preparing chitosan-based materials for dental and implant engineering applications. Chitosan induce bone formation by stimulating osteoblast formation along with its capacity to regenerate the connective tissue formation [15].

I-PRF is the third generation of platelet concentrate. It presents in liquid form which could be used separately or mixed easily with a variety of

biomaterials. Taking benefit of both slow and short centrifugation speeds, a higher presence of regenerative cells with higher concentrations of growth factors can be observed when compared with other formulations. Recently, the platelet concentrate becomes well known in bone regeneration [16].

As implant stability is one of the most important clinical aspects at clinical implant installation and one of the most important crucial elements in the osseointegration process, we measured the implant stability using the Osstell. The resonance frequency analysis is a direct method for evaluating osteointegration that provides valuable clinical objective data on implant stability. Resonance frequency analysis is a nondestructive and noninvasive technique to measure the stability of dental implants. It is comparable in terms of the direction and type of fixed lateral force application to the implant, as well implant displacement measurement. At any stage of treatment, this method has the potential to provide clinically significant data on the condition of the implant–bone interface [17,18].

In the current study, we measured implant stability immediately after implant insertion and after 6 months and the results showed that in group A there was a statistically significant difference in the mean of implant stability between the two time intervals. I-PRF improves implant stability, accelerate osseointegration by increasing osteoblast differentiation, and promotes bone healing around the implant. I-PRF contains more growth factors than other platelets preparations, which improves the implant healing time. It has a positive effect on implant osseointegration and stabilization values [19].

It was observed that the role of chitosan in bone regeneration around dental implants results in an increase in bone formation and implant stability [20].

Also, in the current study we measured implant stability immediately after implant insertion and after 6 months, and results showed that in group B (CBG + I-PRF) there was a statistically significant difference in the mean of implant stability between the two time intervals. I-PRF has positive effects on implant stability, and I-PRF can be safely used in dental implant surgery and promotes bone healing around dental implants.

As regards soft tissue thickness, no study measured the effect of chitosan with I-PRF on soft tissue thickness around dental implants. Further studies should be carried out to evaluate its effect.

4.1. Conclusions

In this study, we found that CBG and CBG mixed with I-PRF could be used with immediate implants to improve bone formation and have a positive effect on increasing implant stability.

4.2. Recommendation

Further studies with a longer period are needed.

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Conflict of interest

There was no conflict of interest.

References

[1] Cosyn J, De Lat L, Seyssens L, Doornewaard R, Deschepper E, Vervaeke S. The effectiveness of immediate implant placement for single tooth replacement compared to delayed implant placement: a systematic review and meta-analysis. J Clin Periodontol 2019;46:224–41.
[2] Chen K, Li Z, Liu X, Liu Q, Chen Z, Sun Y, et al. Immediate implant placement with buccal bone augmentation in the anterior maxilla with thin buccal plate: a one-year follow-up case series. J Prosthodont 2021;30:473–80.
[3] Kim YH, Lee HJ, Cho KA, Woo SY, Ryu KH. Conditioned medium from human tonsil-derived mesenchymal stem cells inhibits glucocorticoid-induced adipocyte differentiation. PLoS One 2022;17:e0266857.
[4] Levengood SL, Zhang M. Chitosan-based scaffolds for bone tissue engineering. J Mater Chem B 2014;2:3161–84.
[5] Akilbekova D, Shaimerdenova M, Adilov S, Berillo D. Biocompatible scaffolds based on natural polymers for regenerative medicine. Int J Biol Macromol 2018;114:324–33.
[6] Singh BN, Veeresh V, Mallick SP, Jain Y, Sinha S, Rastogi A, et al. Design and evaluation of chitosan/chondroitin sulfate/nano-bioglass based composite scaffold for bone tissue engineering. Int J Biol Macromol 2019;133:817–30.
[7] Miron RJ, Fujioka-Kobayashi M, Hernandez M, Kandalam U, Zhang Y, Ghanaati S, et al. Injectable platelet rich fibrin (i-PRF): opportunities in regenerative dentistry? Clin Oral Invest 2017;21:2619–27.
[8] Ezzatt OM. Autologous platelet concentrate preparations in dentistry. Biomed J Sci Tech Res 2018;8:6712–21.
[9] Thanasrisuebwong P, Surarit R, Bencharit S, Ruangsawasdi N. Influence of fractionation methods on physical and biological properties of injectable platelet-rich fibrin: an exploratory study. Int J Mol Sci 2019;20:1657.
[10] Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007;39:175–91.
[11] Lokwani BV, Gupta D, Agrawal RS, Mehta S, Nirmal NJ. The use of concentrated growth factor in dental implantology: a systematic review. J Indian Prosthodont Soc 2020;20:3–10.
[12] Silva KC, Zenóbio EG, Alencar Souza PE, Soares RV, Cosso MG, Rebello Horta MC. Assessment of dental implant stability in areas previously submitted to maxillary sinus elevation. J Oral Implantol 2018;44:109–13.
[13] Nicholson J W. Titanium alloys for dental implants: a review. Prosthesis 2020;2:100–16.
[14] Kan JYK, Rungcharassaeng K, Deflorian M, Weinstein T, Wang HL, Testori T. Immediate implant placement and provisionalization of maxillary anterior single implants. Periodontol 2000 2018;7:197–212.
[15] Sharifianjazi F, Khaksar S, Esmaeilkhanian A, Bazli L, Eskandarinezhad S, Salahshour P, et al. Advancements

in fabrication and application of chitosan composites in implants and dentistry: a review. Biomolecules 2022;12: 155.

[16] Thanasrisuebwong P, Kiattavorncharoen S, Deeb GR, Bencharit S. Implant site preparation application of injectable platelet-rich fibrin for vertical and horizontal bone regeneration: a clinical report. J Oral Implantol 2022;48: 43–50.

[17] Tanaka K, Sailer I, Iwama R, Yamauchi K, Nogami S, Yoda N, et al. Relationship between cortical bone thickness and implant stability at the time of surgery and secondary stability after osseointegration measured using resonance frequency analysis. J Periodontal Implant Sci 2018;48: 360–72.

[18] Bafijari D, Benedetti A, Stamatoski A, Baftijari F, Susak Z, Veljanovski D. Influence of resonance frequency analysis (RFA) measurements for successful osseointegration of dental implants during the healing period and its impact on implant assessed by Osstell mentor device. Open Access Maced J Med Sci 2019;7:4110–5.

[19] Güvenç S, Durmuşlar MC, Ballõ U. The effects of injectable platelet-rich fibrin on implant stability. Int J Oral Maxillofac Implants 2022;37:1145–50.

[20] Fasolino I, Grazia M, Soriente A, Demitri C, Madaghiele M, Sannino A, et al. Materials Science & Engineering C Osteoinductive and anti inflammatory properties of chitosan based scaffolds for bone regeneration. J Clin Periodontol 2019;46:224–41.