EVALUATION OF TWO DIFFERENT GRAFTING MATERIALS USED DURING IMMEDIATE POST-EXTRACTION IMPLANT PLACEMENT FOR RETAINING MANDIBULAR OVERDENTURES

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ABSTRACT

Immediate implant placement in fresh extraction sockets has the advantages of few surgical exposures, short treatment time, and maintenance of alveolar bone height and width. The purpose of this study was to evaluate the regeneration potential of the new platelet rich fibrin (PRF) when used as an adjunct during immediate implantation following extraction of the mandibular cuspids. Twenty implants were immediately installed into the mandible of ten patients following extraction of their two mandibular hopeless cuspids. For each patient, one implant was installed utilizing synthetic bone, while the other was installed utilizing PRF as grafting materials inserted around the implants. The mandibular arch was restored using implant retained overdentures after four months of implant installation. Implants were radiographically evaluated in terms of bone height and density changes. Results showed a significant difference in bone height changes between the two implant grafting materials in the first two months following implant installation. However, there was a non-significant difference in bone height changes starting from implant loading after four months till the end of the study period. Regarding bone density changes, there was a significant increase in bone density changes around implants installed using PRF compared to those installed using synthetic bone during the different time intervals except in the last six months-interval of the study, where the difference became non-significant. In conclusion, PRF material appeared to have better and faster potential for bone regeneration in cases of immediate implantation compared to synthetic bone.

INTRODUCTION

Immediate implant placement following tooth extraction (type 1) has gained popularity because it reduces treatment time, number of surgeries and post-extraction bone loss. However, this is potentially challenged by inadequate keratinized mucosa for flap adaptation and difficulties in achieving primary stability. Moreover, it has been proven that post-extraction bone loss is an inevitable biological process, which affects treatment outcomes.[1]

The advent of novel osseous regenerative techniques has significantly increased the functional and esthetic potential of dental implants by restoring alveolar ridge defects to their original dimensions, which allows for optimal implant placement and in turn increases the credibility of dental implant therapy as a unique treatment alternative.[2] Over the past years, numerous studies have confirmed

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the reliability of implants placed at the time of tooth extraction.[3-5] Small osseous defects, which are frequently found adjacent to implants placed at the time of tooth extraction, can be grafted with autogenous bone obtained from edentulous ridges or other intraoral sites.[6,7] Clinicians have also used other materials and methods to augment small bony defects adjacent to dental implants, including demineralized freeze-dried bone (DFDB) and barrier membranes.[8-11] Becker et al[12] reported a 93.3% 5-year implant survival rate with clinically insignificant crestal alveolar bone loss for immediate implants that were augmented with barrier membranes.

Since its inception by Chaukron et al[13] in 2001 for the first time in dental implantology, platelet-rich fibrin (PRF) became an accepted and most extensively worked upon current biological material with immense regenerative potential. PRF is a second generation platelet concentrate widely used to enhance bone generation. It is a strictly autologous fibrin matrix containing a large quantity of platelet and leukocyte cytokines. Its advantages over platelet-rich plasma (PRP) include ease of preparation/application, minimal expense, and lack of biochemical modification (no bovine thrombin or anticoagulant is required).[14,15] The proprietary process for PRF preparation separates the blood cells from the platelets and plasma proteins during an initial low speed centrifugation of a patient's blood. A second centrifugation converts fibrinogen to fibrin in the presence of $CaCl_2$ and the fibrin cross-links to form a matrix that contains viable platelets, which in turn releases a relatively constant concentration of growth factors over a period of 7 days.[16]

Direct interactions between fibrin and osseous cells during healing are insufficiently documented. On the other hand, numerous animal studies deal with the fibrin effect on osseous healing. The results are contradictory; osseous healing is either improved or remains unchanged.[17] From a fundamental point of view, it is still difficult to know if the addition of a fibrin clot really permits enhancement of new bone deposition. PRF can be considered as a natural fibrin-based biomaterial favorable to the development of a microvascularization, accelerated wound closing with fast cicatricial tissue remodeling. Its molecular structure with low thrombin concentration is an optimal matrix for migration of endothelial cells and fibroblasts. This matrix carries all the favorable constituents present in a blood sample. Furthermore, this fibrin matrix contains leukocytes and promotes their migration. Despite the fact that cytokines trapped in PRF are gradually released and able to accelerate the cellular phenomenon, these cytokines seem to have a secondary rule in the bioactivity of PRF. The structure of the fibrin network is thus the key element of all improved PRF healing processes.[18-20]

Some of the PRF applications were described in oral and maxillofacial surgery, preimplant and implant surgery.[21,22] It was assessed that a sinus grafting material built with allograft and PRF in equal volumes was suitable for implantation after only 4 months and potentially even more mature than a sole allograft after 8 months.[23] It was also shown that PRF membranes were easy to use during Summers osteotomy and offered a good compromise as filling material, shock absorber during sinus floor elevation, and healing support for the damaged Schneiderian membrane.[24]

There is evidence to show that post extraction implants have survival rates similar to implants in healed sites. However, evidence is lacking to demonstrate the superiority of one grafting protocol or material over the other with respect to healing of peri-implant defects with post extraction implants.[25] Given the growth factor prevalence, it would be expected that PRF healing potential within an extraction socket might result in enhanced wound healing compared to those sites treated with

non-viable graft materials. To test this hypothesis, this study was designed to compare PRF to synthetic bone grafting material placed around immediately installed implants in fresh post-extraction sockets of mandibular cuspids for retaining mandibular overdentures.

MATERIALS AND METHODS

All patients attending the outpatient clinic of the Removable Prosthodontic Department, Faculty of Oral and Dental Medicine, Cairo University over a period of two years, presenting with mandibular edentulous arch except for their two cuspids were screened for participation in the present study. This research has been approved by the local research ethics committee. Inclusion criteria of selected patients included mandibular cuspids with poor prognosis indicated for dental extraction. Reasons of extraction included grade III or IV mobility, severe gingival recession, unfavorable crown to root ratio, low periodontal attachment level, non-restorable carious lesions and root fractures. Other inclusion criteria included enough residual bone adjacent to the cuspid area sufficient for implant installation (4–5 mm width), as preliminary detected from cone-beam X-ray imaging and confirmed later during pilot drilling, adequate interarch space, good oral hygiene, and normal maxillo-mandibular relationship. Patients had dentulous or partially edentulous upper arch that could be restored to full dentition. Exclusion criteria included insufficient bone width or height at the proposed implant sites, periapical pathosis related to either of the mandibular cuspids, maxillomandibular skeletal discrepancy, limited inter-arch space, parafunctional habits, heavy smokers, and any medical condition or disease that may affect implant placement and integration or bone behavior.

Over the screening period, only 10 patients satisfied the inclusion criteria. Their age ranged from 51-64 years (mean=55). They were informed about the aim and design of the study and a written consent was obtained from them.

Upper and lower alginate preliminary impressions were made and poured into stone casts. Jaw relation records were used to mount the casts. The necessary mouth preparations including periodontal and conservative treatment, occlusal adjustments, as well as restoration of missing upper teeth were planned and carried out at that stage.

Following cast modification by cutting off the two cuspids to the level of the residual ridge, a mandibular waxed denture was processed to be used as a temporary prosthesis, and duplicated into clear acrylic resin template, which was later modified to be used as a radiographic template during subsequent radiographic measurements.

Surgical and prosthetic protocol

Prophylactic medication in the form of oral antibiotic (2 gm/day amoxicillin-clavulanate) was given starting one hour preoperatively. Corresponding implants' length and diameter were selected for each case, aided by the cone beam X-ray imaging (Scanora 3D, Soredex, Tuusula, Finland). Under local infiltration anesthesia, the first cuspid was atraumatically extracted by the aid of a periotome (HiFriedy, Chicago, IL, USA). The socket was irrigated using saline and inspected for any residual infection or bony spicules/chips. Two small buccal vertical incisions on either side of the socket were made to create a partial thickness flap for proper socket closure after placement of the grafting material. Successively wider drills were used to complete the preparation of the osteotomy site to a depth of at least 2 mm apical to the original socket depth. Dentium implant system (Dentium, Samsung-dong, Seoul, Korea) was used in this study. The first implant was threaded till it flushed with bone level. (Fig 1) Before inserting the cover screw, the smart peg provided by the implant system was screwed into the implant to measure primary implant stability using the Osstell system

(Integration Diagnostics AB, Gothenburg, Sweden). Following cover screw insertion, highly resorbable bone grafting material (Osteon II, Genoss, Korea) was placed around the implant. It is a synthetic osteoconductive bone graft substitute composed of 70% hydroxyapatite (HA) and 30% beta-tricalcium phosphate(b-TCP). The socket was then properly sutured.

Following the same surgical procedures, and before installing the second implant into the post-extraction socket of the second cuspid, PRF was prepared following the technique described by Choukroun.[13] A blood sample (10 ml) of the patient was taken during the surgery in a sterile test tube just prior to tooth extraction. Immediately after the blood draw, the test tube (without anticoagulant) was centrifuged at 3000 rpm for 12 minutes (Process, Nice, France). Single spin produced 3 layers (Fig.2).

The PRF clot with attached RBC's was then gently grabbed and removed from the test tube using pliers and the attached red blood cells were scraped off and discarded. (Fig. 3) The PRF clot was then placed on the metal grid in the PRF Box (Process Ltd., Nice, France), and covered with the compressor and lid to form the PRF membrane. (Fig.4)

The PRF was then inserted around the implant following implant installation (Fig.5,6).

Again implant stability was measured using the Osstell before inserting the cover screw. The flap was repositioned and carefully sutured.

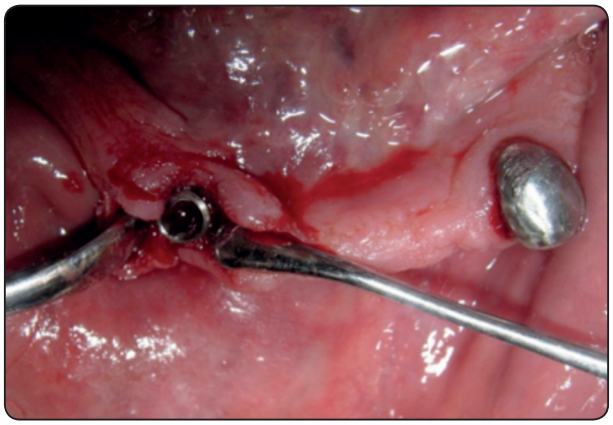

Fig. (1) Immediate post-extraction implant placement into socket of extracted cuspid.

Fig. (2) The three layers produced after centrifugation: top is platelet poor plasma, middle is PRF, and bottom layer contains red blood cells (RBC's).

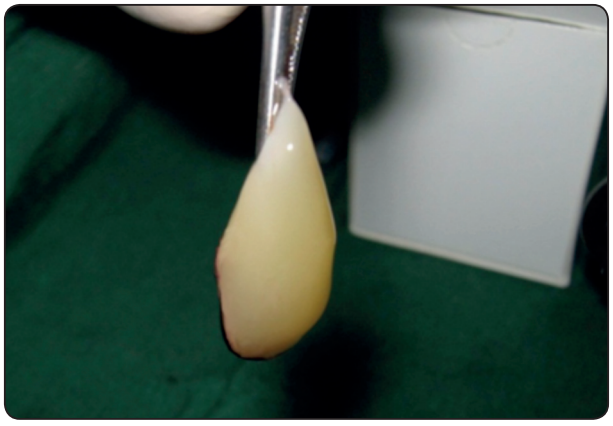

Fig. (3) PRF separated from RBCs

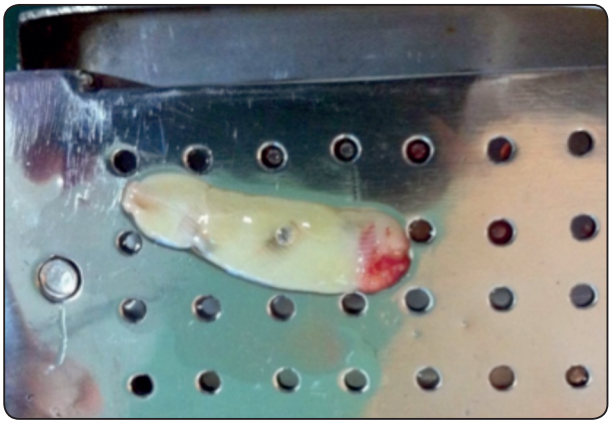

Fig. (4) PRF is placed on the grid in the PRF box.

All patients received 2gm/day amoxicillin-clavulanate and 50 mg/8 hours non-steroidal anti-inflammatory analgesics for 5 days postoperatively. Postoperative instructions included a soft diet for two weeks and appropriate oral hygiene measures with 0.2% chlorhexidine mouth rinse.

The mandibular provisional prostheses were excessively relieved at the implant site and relined by tissue conditioner (GC Europe N.V., Leuven, Belgium.) which was changed every month.

Three months following implant installation, implants were exposed and healing collars were connected. After one week, the healing collars were replaced by locator abutments (Dentium, Samsung-dong, Seoul, Korea) which were screwed to the implants and tightened in place. (Fig.7)

The conventional steps of mandibular overdenture construction were followed. At the time of denture delivery (about four months following implants' installation), block out spacers were slipped around the locator abutments to facilitate the pickup procedures. The metal housings with their processing caps were then placed directly over the locator abutments. A window was opened in the denture corresponding to the abutment areas. The female caps with their metal housings were then directly picked up into the denture's fitting surface using self-cure acrylic resin while the patient was biting in centric occlusion.

After removing excess resin, the overdenture was placed in the patient mouth and adjusted. A clinical remount was performed and occlusion was adjusted to ensure the presence of bilateral balanced occlusion. Each patient was asked to return the next day for post placement evaluation.

Patients were recalled one week following denture delivery for any complaints and further adjustments were done accordingly. They were instructed on the after care of their abutments and dentures and were provided with detailed instructions concerning

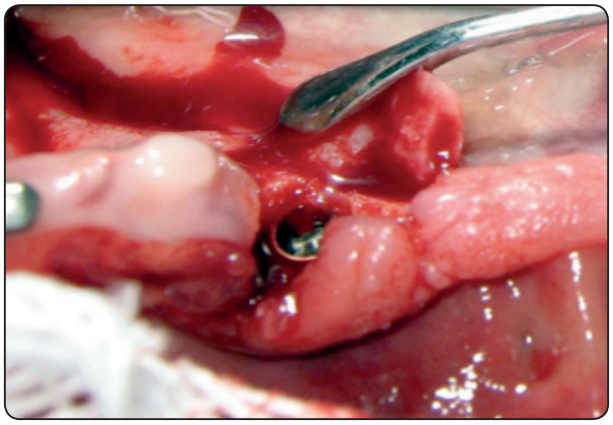

Fig. (5) PRF ready for insertion around installed implant.

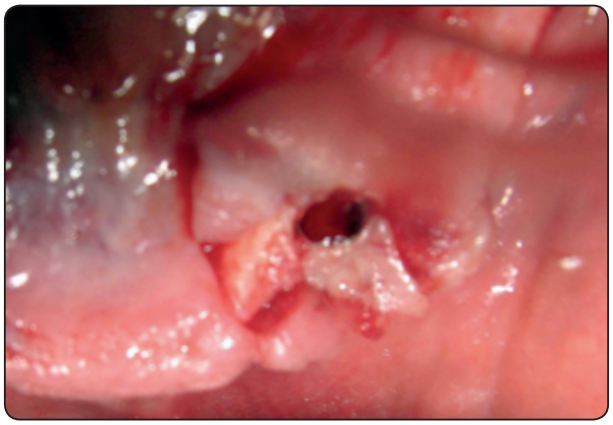

Fig. (6) PRF inserted around installed implant

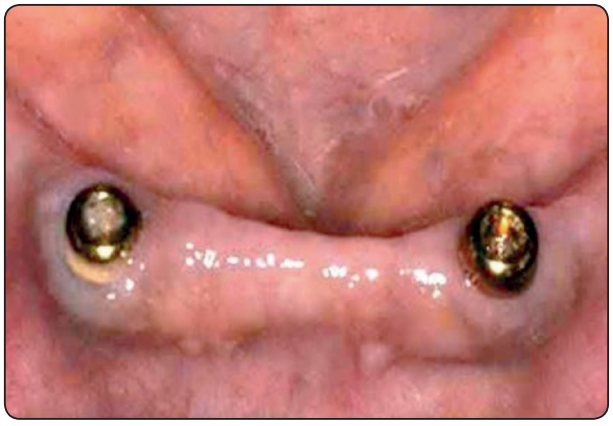

Fig. (7) Locator abutments screwed into installed implants.

strict oral hygiene measures especially around the abutments.

Follow-up protocol

Radiographic evaluation

Radiographic measurements were performed starting two months after implant installation then at four, six and twelve month intervals. Intra-oral direct digital radiography using the Digora system (Orion corporation, Soredex, Finland) was used to assess the following:

1- Marginal bone height measurements (linear analysis)

The linear measurement system supplied by the special software of the Digora system was used for assessing marginal bone height changes mesial and distal to the implant fixtures during the different follow-up intervals of the study. The distances from the top of alveolar bone crest to the top of the fixture shoulder at the mesial and distal surfaces were measured. The mean values of the mesial and distal bone height measurements for each implant during the follow-up intervals were added and their means were calculated.

2- Bone density measurements (densitometric analysis)

The software of the Digora system was again used for assessing bone density changes mesial and distal to the implant fixtures during the different follow-up intervals. Three lines were drawn parallel to the mesial and distal implant surface; the first line extended from the first flute of the implant to the implant end passing tangential to the flutes of the implant and perpendicular to a tangent drawn to the implant apex, the second line was 1 mm apart, equal and parallel to the first line. The same procedure was repeated for the third line. Bone density along each of the three lines was recorded and then the mean value of the three readings was calculated for each surface. The mean values of the mesial and distal bone density measurements for each implant during the follow-up intervals were calculated.

Statistical analysis

All data was collected, tabulated and statistically analyzed. Descriptive statistics was presented as mean changes and standard deviations (SD). Student t test was used to compare radiographic bone changes of each implant grafting material. Paired t test was used to assess radiographic bone changes within each grafting material by time. P-value of 0.05 was considered statistically significant.

RESULTS

Only one implant that was grafted with synthetic bone failed after 4 months of its installation. This implant had a mean stability of 42 implant stability quotient (ISQ) at the time of implant installation. The corresponding patient was excluded and substituted with another patient, where two new implants were installed following the same previous procedures.

Bone height changes

The effect of time on changes in marginal bone height adjacent to implants with both grafting materials during the different time intervals is represented in Table (1). Inspection of means and standard deviations throughout the different time intervals revealed marginal bone loss with both materials during the first four months of implant installation as well as the following twelve months of implant loading (after denture delivery). Such changes were statistically significant with both materials ($P \leq 0.05$).

Statistical analysis of reduction in implant bone height by time revealed statistically significant difference between PRF and synthetic bone grafting materials in the first four months of implant installation, where bone reduction was significantly less in case of PRF. However, there was no significant difference in bone height changes between the two materials during the different time intervals of the study following denture delivery ($P > 0.05$).

Bone density changes

The effect of time on bone density changes adjacent to implants with both grafting materials during the different time intervals is represented in Table (2). Inspection of means and standard deviations throughout the different time intervals revealed bone density increase around both implants during the different time intervals. Such changes were statistically significant around both implants (P≤0.05).

Statistical analysis of increase in implant bone density by time revealed statistically significant difference between PRF and synthetic bone grafting materials, which was in favor of the former during the different time intervals of the study (P≤0.05) except in the last six months-interval of the study, where the difference became non-significant (P>0.05).

TABLE (1) Bone height changes around both implants during the various follow-up intervals.

	Bone height changes after 2 months			Bone height changes from 2 - 4 months			Bone height changes from 4 - 6 months			Bone height changes from 6 - 12 months		
	Mean (mm)	S.D	t value	Mean (mm)	S.D	t value	Mean (mm)	S.D	t value	Mean (mm)	S.D	t value
Synthetic bone	0.392	0.09	9.74*	0.291	0.19	3.42*	0.180	0.15	2.68*	0.295	0.18	3.66*
PRF	0.534	0.13	9.19*	0.361	0.18	4.48*	0.232	0.19	2.73*	0.342	0.20	3.82*
Synthetic bone vs. PRF (t value)	2.84*			0.85			0.68			0.55		

**** = statistically significant at p≤0.05***

TABLE (2) Bone density changes around both implants during the various follow-up intervals.

	Bone density changes after 2 months			Bone density changes from 2 - 4 months			Bone density changes from 4 – 6 months			Bone density changes from 6 - 12 months		
	Mean	S.D	t value	Mean	S.D	t value	Mean	S.D	t value	Mean	S.D	t value
Synthetic bone	4.290	1.56	6.15*	4.447	1.67	5.95*	1.642	1.07	3.43*	3.575	1.38	5.79*
PRF	6.090	1.93	7.06*	6.213	1.88	7.39*	2.825	1.42	4.45*	4.944	1.68	6.58*
Synthetic bone vs. PRF (t value)	2.29*			2.22*			2.10*			1.99		

**** = statistically significant at p≤0.05***

DISCUSSION

One of the requisites for successful osseointegration has been to allow ossification of extraction sockets before placement of implants. Therefore, a patient may wait up to 12 months for an extraction socket to completely ossify before implant placement.[26] The delay during socket healing coupled with an added surgical stage result in greater inconvenience and discomfort to the patient. Complete healing of the socket may also be associated with crestal resorption and reduction of alveolar bone available for implant placement because alveolar atrophy begins soon after extraction.[27] The objective of this study was therefore directed to evaluate a recent biologic material, the PRF, as regards its healing potential, compared to synthetic bone, when placed around immediate implants in the extraction sockets of the two mandibular cuspids, aiming at reducing the healing time needed for supporting and retaining a mandibular overdenture.

Bone density seems to be of great importance, not only in primary implant stability, but also in the predictability of implant outcome. [28] In the present study, PRF grafting around the immediately placed implants in fresh extraction sockets resulted in significantly higher peri-implant bone density changes compared to synthetic bone especially during the early healing intervals following implant installation, which extended through the first six months. This may be related to the accelerated physiologic healing and bone regeneration potential of the PRF, which is strongly documented in the literature.[18,29,30,31] The platelet cytokines (PDGF, TGF-b, IGF-1) are gradually released as the fibrin matrix is resorbed, thus creating a perpetual process of healing.[22]

The findings of the present study were in accordance with that of Simon et al,[32] who found that healing in extraction cuspid sockets was more rapid when using PRF matrix compared to non-viable material. They explained that sites containing demineralized freeze dried bone allograft (DFDBA) had little new bone at six weeks. By twelve weeks, those sockets had osseous fill but DFDBA particles were still noted in coronal areas. It was concluded that PRFM alone may be the best graft for ridge preservation procedures in terms of its rapid healing potential in the extraction sockets, which was related to the prolonged presence of growth factors in such healing sites. These findings, according to Becker et al,[33] may be due to one of the important benefits of PRF when grafted into extraction sites, which is the improved bone quality at such healed sites, as it will not contain non-vital bone chips. On the other hand, non-vital DFDBA chips may take years to become resorbed by macrophages. Not only will the non-vital graft material delay normal bone formation, but the residual chips may also weaken the host bone and/or create less than optimum bone next to dental implants.

The Osstell system utilized in this study uses resonance frequency analysis (RFA) as a method of measurement of primary stability of implants as advocated by several author.[34-36] This method requires the placement of an electronic transducer on the implant head or prosthetic abutment with a retaining screw, and the passage of a low-voltage current, which is undetectable to the patient, through the transducer. Resistance to the vibration of the transducer in the surrounding bone is digitally registered. A recent study of immediate implants found a 2-3 year cumulative survival rate of 97.8%, and a mean stability of all implants at the time of tooth extraction of 62.0 ± 9.8 implant stability quotient (ISQ) and at 1 year of 64.0 ± 9.8 ISQ. Implants with ISQ values >50 are considered clinically stable.[37] The sites that receive implants at the time of tooth extraction or within a short time after extraction may demonstrate a slight decrease in crestal bone width.[3,38] In the present study, primary implant stability was measured using the Osstell at the time of implant installation to confirm implant

stability at that stage. The cause of failure of one implant was probably due to its low recorded ISQ (<50) at the time of installation.

The two studied grafting materials were placed around implants within the same patient at the same time to be under nearly the same circumstances and to exclude any external variable other than the grafting intervention, so that the results become more reliable and valid.

The decision for implant loading protocol followed in this study was the delayed loading after four months following implant installation. According to a study by Choukroun et al,[18] a cystic cavity filled with PRF will be totally healed in two months instead of the 6 to 12 months required for physiologic healing. However, in order to be in the safe side, and to give sufficient time for physiologic healing to take place, implant loading was postponed till the end of the fourth month following implant installation. According to the results of this study, as regards the significant bone density and height changes, which was in favor of PRF grafting around immediately installed implants, especially in the early healing intervals, this protocol (PRF grafting) may be recommended for early implant loading (as early as two months following post-extraction implant placement) However, this point still needs further clinical investigations.

PRF was selected as a grafting material around immediate implants being the simplest and cheapest technique that can be used currently in daily practice to produce autologous fibrin membrane or physiologic platelet concentrate without any addition or manipulation. Many PRF clots can be produced simultaneously and a very significant volume of biomaterial can be produced in less than 20 minutes.[39]

In reviewing the regenerative outcomes of post extraction implants, it was concluded that bone augmentation procedures are effective in promoting bone fill and defect resolution in peri-implant defects following immediate (type 1) and early (type 2) placement. Moreover, peri-implant defects associated with immediate (type 1) and early (type 2) placement may heal spontaneously when the peri-implant defect is less than 2 mm in width and the facial bone wall is intact.[25] The PRF can be used alone when there is a minimal gap between bone and implant. For a more substantial gap (or in the absence of one or more cortical walls, dehiscence, or in an extraction site where immediate implantation is contraindicated), PRF may be used in conjunction with allogenic bone or with synthetic bone substitutes to minimize the number of surgeries. Lastly, in the case of crestal bone augmentation, either horizontal or vertical, the application of PRF membranes to cover autogenic or allogenic bone grafts is particularly useful.[40] Accordingly, in the present study, extraction sockets where implant defect was more than 2 mm in width were excluded from PRF placement, and were shifted to the other protocol of synthetic bone grafting. This was intended to evaluate the effect of the regeneration potential of the PRF per se in the socket without the need for addition of any artificial bone grafting material. The use of PRF as sole filling material according to Simonpieri et al[41] seems able to stabilize a quite high amount of peri-implant bone up to the implant end. PRF, as a natural and optimized blood clot, seemed the adequate adjuvant to secure and improve the natural bone regeneration around implants.[42]

CONCLUSION

Within the limitations of this study, it may be concluded that using PRF as a grafting material around implants immediately placed into fresh extraction sockets of mandibular cuspids for retaining mandibular overdentures enhances bone regeneration and reduces healing time compared to synthetic bone grafting material.

RECOMMENDATION

Further investigations on different grafting materials used during immediate post-extraction implant placement and their osteoinduction and healing potential are still needed.

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