ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 4, Issue – 5, September - 2021, Page No. : 57 - 70

A Comparative evaluation of different bone augmentation materials used in immediate dental implant placement

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Citation of this Article: Phibadahun Sohmat, Mayank Singh, Bhaskar Agarwal, Raghuwar Dayal Singh, Pooran Chand, Niraj Mishra, Anjani Kumar Pathak, **"**A Comparative evaluation of different bone augmentation materials used in immediate dental implant placement"**,** IJDSIR- September - 2021, Vol. – 4, Issue - 5, P. No. 57 – 70.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Aims: One of the challenges in immediate implant placement is to place an implant matching the extracted tooth dimensions. The jumping gap (> 2 mm) between the immediate implant and bone is required to be filled in 3-dimensions with biocompatible material to enhance osseointegration. Hence, the aim of this study was to comparatively evaluate different types of bone augmentation materials in immediate implants.

Materials and methods: Total 30 subjects were equally divided into three groups - Group I [xenograft], Group II (beta tricalcium phosphate & hydroxyapatite bone graft) and Group III (hydroxyapatite bone graft). After achieving

primary implant stability, each of the graft materials were mixed with platelet rich fibrin and placed accordingly.

Results: Marginal bone loss in Group I (0.46 and 0.74) was significantly less compared to Group II (0.52 and 0.87) and Group III (0.55 and 0.86),at 1 and 3 months respectively. There was no statistically significant difference in implant stability quotient (68.10 ± 2.96, 67.70 ± 2.50 and 67.00 ± 1.83,) , Pink esthetic score (10 ±.57,6.60±.52 and 7.00 ±.67) and white esthetic score (7.90±.57, 7.60±.52 and 7.63±.51) among the three groups at 3 months of time interval.

Conclusions: There was significantly less marginal bone loss in Group I compared to Group II and Group III at 3 months, but there were no significant difference in implant stability and esthetic scores among all the three groups at 3 months.

Keywords: Bone augmentation, allograft, immediate implants, fresh extraction socket, marginal bone loss.

Introduction

There is enough scientific evidence to support immediate implant placement in comparison to the conventional two-stage delayed implant placement.[1,2]Immediate placement of implant is preferred over delayed implant placement because it has certain advantages like the elimination of period for healing and ossification of the socket, lesser surgical appointments, reduction of the edentulous period, reduction of the total expense, alveolar bone width and height can be preserved therefore operatory time is reduced with lesser damage to the tissue and hence making immediate implant treatment more acceptable to patients and surgeon. The extraction site allows the implant to be guided along the long axis of the tooth which make orientation of the implant easier and result in satisfactory prosthetic restoration. Modern surgical and regenerative techniques with implants immediately placed into prepared extraction sockets have provided a predictable gap repair with bone substitutes and soft tissue grafts, have helped to eliminate problems about bone deficiencies, and allowed implant placement according to prosthodontic needs.[3]

However, morphology of the site, deficiency of keratinized tissue, pathology in the periapical tissue, thin gingival biotype, and incomplete closure of the extraction site by soft tissue have some effects on the immediately placed implants.[4]

Despite the advancement in diagnostic facilities, there are some challenges in immediate implant placement, one of which is to place an implant that matches the size of the extracted tooth socket. A gap may be present between bone and the surface of the implant. When the gap is greater than 2mm it will be required to be filled with a material that is biocompatible and able to enhance osseointegration. Therefore for this purpose bone augmentation materials are required to fill the gap, which

may be Autograft , Freeze-Dried Bone Allograft (FDBA), Hydroxyapatite (HA), Beta Tricalcium Phosphate, Bioglass, Polytetrafluoroethylene (PTFE) Membrane, Connective Tissue Barriers, Hard Tissue Replacement Polymer, Xenografts, Block or particulate Graft Materials, Guided Bone Regeneration(GBR) and Growth and Differentiation Factors. As per scientific evidence and available studies, no bone graft had shown any difference or superior outcome over the other types of bone graft. [5-6]In the present study, it was planned to evaluated the three commonly used graft materials that are; onexenograft(Tioss®, Chiyewon; Korea)and two alloplastic bone grafts {beta- tricalcium phosphate & hydroxyapatite bone graft (SYBOGRAF® - Plus, Educare Pharmaceuticals (P) Limited; India) and hydroxyapatite (HA) bone graft (SYBOGRAF® - Plus, Educare Pharmaceuticals (P) Limited; India)} in immediate implant placement, both clinically and radiographically, at different time intervals.

The objective of the study was to comparatively evaluate the three types of bone augmentation materials used in immediate implants in terms of; marginal bone loss, stability of the implant, and esthetics at different time intervals. The null hypothesis was that there will be no difference among all the three bone graft materials in terms of marginal bone loss, stability and esthetics of the immediate implants.

Materials and Methods

Total30 subjects were selected with the age group of 18-60 years and equally divided into three groups. Group I comprised of xenograft with platelet-rich fibrin (PRF), Group II beta-tricalcium phosphate &hydroxyapatite bone graft with PRF, and Group III hydroxyapatite bone graft with PRF. The Inclusion criteria of the study were adequate bone volume and oral hygiene to accommodate an endosseous dental implant placement following immediate placement protocols, one or more maxillary or mandibular anterior teeth that require extraction leading to a single-tooth gap and jumping gap greater than 2 mm(Fig 1).The exclusion criteria were patients with current smoking habit (moderate or heavy smoking i.e. ten cigarettes or more per day) or any substance abuse, para-functional habits, systemic disease that prevents standard dental implant therapy, the patient currently undergoing chemotherapy/radiotherapy or drugs that interfere with the study and anatomic conditions of the extraction sites that prevent immediate implant placement.

Figure 1: Jumping gap between implant and buccal bone

Consent of each of the patient was taken. The present study was approved by the University ethics committee (registration no. ECR/262/Inst/UP/2013/RR-16) vide letter no 863/Ethics/R.Cell-18, dated 02-07-2018.

After administration of 2% lignocaine with adrenaline (1:80000) for local anesthesia, the offending tooth was extracted. For PRF, blood was withdrawn from the subject and was placed in the centrifugation machine at 2700 rpm for 12 minutes.[7] The osteotomy site was prepared with a sequential increasing diameter of bone drills. After achieving primary implant stability (35 N-cm), each of the graft materials was mixed with PRF and placed accordingly as per the available bone in each of the three groups of subjects (Fig 2).

Figure 2: Graft mixed with platelet rich fibrin placed around implant

Stability of Implant was checked by Resonance frequency analysis (RFA) using Osstell ISQ (Osstell AB, Gamlestadsv, Sweden) (Fig 3). It provides a clinically, noninvasive measure of implant stability. The value of RFA is Implant Stability Quotient (ISQ), whose value ranges from 1 to 100, as this value increases the stability of implant also increases.[8]

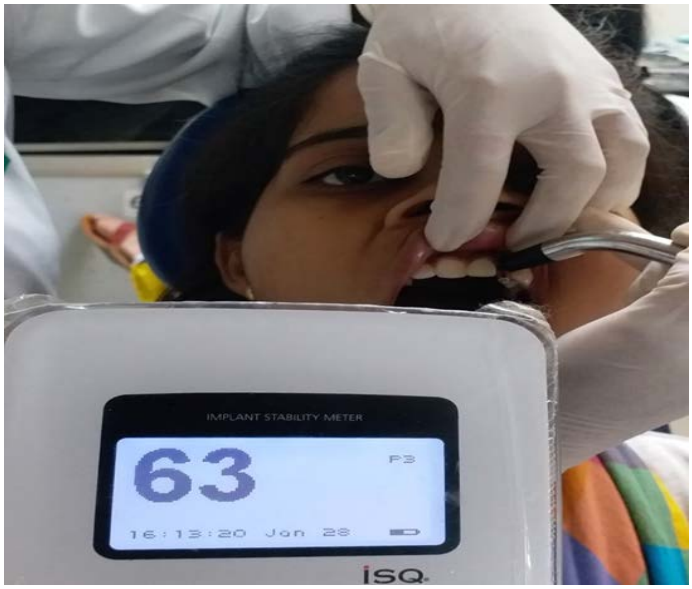

Figure 3: Implant Stability Quotient value at the time of implant placement

White esthetic score (WES) and Pink esthetic score (PES) were used to measure the esthetic score.[9]Marginal bone loss was measured by a standardized intra-oral periapical radiograph (IOPAR) by using individualized positioning stent and then evaluated by image-j software (Java-based image processing software, NHI, USA).[10]

These investigations were repeated at 1 month and 3 months of implant placement. This will be followed by a collection of data, evaluation, and statistical analysis. Statistical Package for the Social Sciences (SPSS Inc, Chicago, IL, USA) version 25 software was used for statistical analysis of the collected data.

Characteristics	No of patients (n=30) (%)
Gender:	
Males	23 (76.7%)
Females	7 (23.3%)
Missing tooth:	
Central incisor	15 (50.0%)
Lateral incisor	13 (43.3%)
Canine	2 (6.7%)
Age intervals:	
18 to 35 years	21(70.0%)
36 to 50 years	5(16.7%)
51 to 60 years	4(13.3%)
Arches:	
Maxilla	25(83.3%)
Mandible	5(16.7%)

Table 1: Basic characteristics of patients

Results

The basic characteristics of subjects were summarized in Table 1. The overall proportions of males (76.7%) were higher than females (23.3%). Patients having fractured, grossly carious teeth, root stumps, and mobility in the esthetic region were selected. While comparing the missing tooth, central incisor (50.0%) was the most common tooth that is missing followed by lateral incisors (43.3%), and canine (6.7%). The majority of the subjects were around the age range of 18 – 35 years (70%), followed by age range of 36 – 40 years (5%) and least was 51 – 60 years (4%). It was also found that 83.3% of the involved teeth were in the maxilla and only 16.7% were in the mandible.

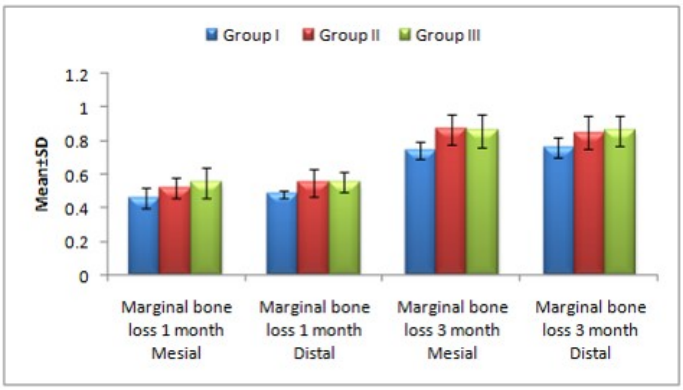

Figure 4: Comparison of Marginal bone loss for group I, II and III at different time interval.

Comparison of marginal bone loss among group I, II and III is shown in figure 4. It was found that there was significantly lesser marginal bone loss in group I ($p < 0.05$) as compared to group II and III at 3 months

Table 2 shows comparative marginal bone loss between group I and II, group I and II, and group II and III. It shows that group I had significantly less bone loss compared to group II at 3 months, but there was no significant marginal bone loss at 1 month of time interval. Group I shows significantly ($p<0.05$) less bone loss compared to group III both at 1 month and 3 months. However there was no statistically significant comparative marginal bone loss in group II and group III, both 1 and 3 months of time intervals. Table 3 shows the difference of marginal bone loss at 1 month between mesial and distal site, it was found that the distal site has more marginal bone loss compared to the mesial site (p-value = 0.044).

Table 4 shows that there was no statistically significant marginal bone loss between mesial and distal site (p-value <0.05) of the implant among all the groups, at the time interval of 3 months. Table 5 shows the comparison of implant stability quotient among group I, II and III, which denote no statistically significant difference in implant stability quotient among the three groups. Table 7 shows a comparison of PES and WES among group I, II and III. There was no significant difference in esthetic score among the three groups.

Discussion

Dental implants can be placed in a complete healing state 6–12 months post tooth extraction.[11,12] However, it was reported that during the initial six months of tooth extraction, 23% loss of alveolar bone volume occurred with sequential of 11% alveolar bone loss during the later 5 years.[13]

Several techniques and modifications have been introduced in implant dentistry which are less invasive and more esthetic approaches during the placement of implants. One of these innovations was to place the implant immediately after the tooth extraction, thus eliminating the need for 4 to 6 months post-extraction healing and remodeling period.[14] Immediate placement of implant was shown to be a highly successful approach with several advantages in comparison with the conventional technique, such as a decrease in the number of surgical procedures, improved implant orientation during placement due to clear visualization of the extraction socket borders, preservation of the remaining alveolar bone dimensions, and improved esthetics by stabilizing the surrounding soft tissues.[15-17]

However, the site's morphology, inadequate keratinized tissue, thin biotype of tissue, periapical pathology, and incomplete closure of soft tissue over the implantation site have some adverse impact on the immediate implants;

Parameters	Group I vs Group II p-value	Group I vs Group III p-value	Group II vs Group III p-value
Marginal bone loss 1 month Mesial	0.147	0.020	0.621
Marginal bone loss 1 month Distal	0.063	0.037	0.966
Marginal bone loss 3 month Mesial	0.005	0.009	0.968
Marginal bone loss 3 month Distal	0.059	0.037	0.976

Table 2: Comparison of marginal bone loss between group I &group II, group I & group III and group II & group III at different time interval and at different site

Parameters	Mesial at 1 month	Distal at 1 month	% mean change	p-value
	mean±SD	mean±SD		
Marginal bone loss	0.47±0.14	0.50±0.13	-6.38	0.044

Table 3: Comparison of marginal bone loss at 1 month between mesial and distal sites

therefore, proper diagnosis, selection of cases and evaluation are mandatory to get a successful results.[18-20]

Another main challenge that remains unresolved is the space that exists between the surface of the implant and bone in immediately placed implant. This space is called 'The Jumping Distance.' This space occurs due to the difference in the form and size of wall of the socket and morphology of the implant. This may cause bone resorption and consequence formation of a bony defect especially in the labial area.[21] Therefore, surgical techniques including the use of bone grafting materials as well as using different barriers to fill the space around the implants were proposed to maintain hard and soft tissue architecture and to regenerate lost bone in areas where bony defects occurred.[22]

There are different types of bone augmentation materials, such as bone grafts and its substitutes including autografts, allografts, xenografts, and alloplastic. These materials may have osteogenic, osteoinductive or osteoconductive properties to help in the formation of new bone.[23]

In this present study, osteoconductive graft materials viz one xenograft and two alloplastic graft materials with PRF were used in immediate implant placement, to aid and improve bone formation around the implant. PRF is

Parameters	Mesial at 3 months	Distal at 3 months	% mean change	p-value
	mean±SD	mean±SD		
Marginal bone loss	0.76±0.20	0.77±0.19	-1.32	0.701

Table 4: Comparison of marginal bone loss at 3 months between mesial and distal sites

	Graft Material						p-value
	Group I		Group II		Group III		
	Mean	SD	Mean	SD	Mean	SD	
Implant Stability Quotient Initial	48.90	3.51	48.6	6.90	50.00	5.79	0.841
Implant Stability Quotient 1 month	56.80	4.87	57.3	2.50	56.90	4.82	0.961
Implant Stability Quotient 3 months	68.10	2.96	67.7	2.50	67.00	1.83	0.608

Table 5: Comparison of Implant Stability Quotient among group I, II and III at different time intervals.

resorbable and can be used to prevent the migration of undesirable cells into bony defect and to provide a space to allow for the immigration of osteogenic and angiogenic cells as well as mineralization of the newly formed bone.[24,25]

Yilmaz et al. (2014)[26] compared stereologically as well as histologically the healing effects of PRF and β-TCP. The study was done in standardized bone defects in pig's tibiae. The results showed that there was greater bone formation around the implant when both PRF and β-TCP were used in combination rather than alone. PRF may facilitate the manipulation of the bone grafts by acting as a biologic adhesive to hold the particles together.[26]

In the present study, implants were placed in anterior maxillary and mandibular regions which is the main esthetic area of the oral cavity because these regions are most noticeable and of maximum concern to the patient with regards to esthetics.[27-29] Central incisor (50.0%) were the most commonly involved teeth for replacement followed by lateral incisors (43.3%) and canine (6.7%) as shown in table 1.Previous studies have shown that anterior teeth are more prone to fracture/ loss due to trauma. This study is accordance with the other studies, which found that trauma occurred most often in the central incisors followed by lateral incisors of the maxilla.[30, 31]

In the current study, only single-rooted teeth were selected. According to a study conducted by Atieh et al. (2010)[44 32], found that placement of immediate implant in the posterior region especially molar sites does not provide a better results, this is due to the larger size of the extraction sockets that affect the primary stability of the implant and hence the success of the implant.

This study found that the mean mesial site marginal bone loss in Group I were 0.46 and 0.74 at 1 and 3 months respectively and mean distal site marginal bone loss were 0.48 and 0.76 respectively at 1 and 3 month, which was lesser compared to Group II which had mean mesial site marginal bone loss 0.52 and 0.87 at 1and 3 months respectively and mean distal site marginal bone loss of 0.55 and 0.85 at 1and 3 months respectively and Group III which had a mean mesial site marginal bone loss of 0.55 and 0.86 at 1and 3 months respectively and mean distal site marginal bone loss of 0.55 and 0.86 at 1and 3 months respectively (Fig. 4). Hence, in the present study it was found that there was less crestal bone loss both at the mesial and distal side in Group I (xenograft with PRF) compared to Group II (beta-tricalcium phosphate & hydroxapatite with PRF) and Group III (hydroxyapatite with PRF) at the time intervals of 1 and 3 months, which was statistically significant.

The results showed statistically significant less marginal bone loss in Group I than Group II and Group III as shown

	Graft Material						p-value
	Group I		Group II		Group III		
	Mean	SD	Mean	SD	Mean	SD	
PES 3M	7.10	.57	6.60	.52	7.00	.67	0.152
WES 3M	7.90	.57	7.60	.52	7.63	.51	0.398

Table 6: Comparison of PES and WES among group I, II and III at 3 months

In table 2 at 3 months, however at 1 month the difference in marginal bone loss was not statistically significant when group I is competed to group II. When group II and group III were compared, the difference in marginal bone loss was not significant (Table 2).

Artas G et al.(2018)[33] found that the difference was not significant among different bone grafts i.e, deproteinized bovine bone (DPB), hydroxyapatite (HA), calcium phosphate (CaP), graft materials and allogenic bone, in the formation of new bone or in Vascular endothelial growth factor (VEGF) expression after 3 months. Histological and immune histochemical analyses were carried out and the result showed that, the difference in bone formation among the different graft materials was not significant. C.E. Nappe et al (2016)[34] also found in his study that when the percentage of newly formed bone was compared, the results showed no difference between the alloplastic graft and the xenograft and between the allograft and the alloplastic graft. Therefore the result of this study was not alike with other studies as given, it may be due to variations in sample size and clinical situations.

In this study, when crestal bone loss of mesial vs distal sites were compared among all three groups at different time intervals, it was found that, marginal bone loss was more in distal compared to mesial site at 1 month, which was statistically significant (Table 3). However, it was observedthe difference was not significant in marginal bone loss between mesial vs distal site at 3 months of time intervals (Table 4).Rasouli Ghahroudi et al. (2014)[35]did not find any difference in bone loss at the mesial and distal sides of the maxillary and mandibular implants as well as that occurs at these sides between the maxillary and mandibular implants which was per the present study in 3 months.

Implant stability was also evaluated at different time intervals of initial, 1, and 3 months. It was found that mean implant stability quotient of group I, II, and III at initial phase i.e. at time of implant placement were 48.90 ± 3.51,48.60 ± 6.90 and 50.00 ± 5.79 respectively, at 1 month were 56.80 ± 4.87,57.30 ± 2.50 and 56.90 ± 4.82 respectively, and at 3 months were 68.10 ± 2.96, 67.70 ± 2.50 and 67.00 ± 1.83 respectively (Table 5). The result showed that the difference was not significant among the three groups in Implant Stability Quotient.

Sang Ho Jun et al. (2018)[36] reported that the correlation was not significant between the bone changes and stability of the implant. Seung-Min Yang et.al (2008)[49 37] found that the correlation was not significant between the marginal bone resorption and the implant stability in patients with a normal or high bone density.

Another parameter which was compared was esthetics in different groups. Esthetic evaluation was done by Implant esthetic score.[9] In this study, esthetic score was also recorded at 3months of time interval. It was found that the

mean Pink Esthetic Score as given in table 6 for group I, group II and group III were 7.10 ±.57, 6.60±.52 and 7.00 ±.67 respectively with a p-value of 0.152 and the means White Esthetic Score of group I, group II and group III were 7.90±.57, 7.60±.52, and 7.63±.51 respectively with p-value 0.398 which were statistically not significant.

Therefore the difference was not significant in implant esthetic score among all the three different groups. As it was observed esthetics depends on the thickness of gingival biotype like thick or thin, which was not measured in the present study.

In immediate implant placement, adequate tissue biotype is necessary to achieve a satisfactory esthetic result.[38, 39,40] When the tissue biotype is thick, there is a greater mucosal thickness around the implant and they are more resistant to gingival recession; therefore patients who have thick tissue biotypes are ideal candidates to receive immediate placement of implant because of a lesser chance of recession, thus resulting in better esthetics.[39, 40,41]

The Pink and White aesthetic score is a useful tool not only to compare studies and various surgical techniques but also in assessing the cases objectively.[9] It also helps us distinguish between the surgical (PES) and laboratory/Prosthodontic (WES) interactions and helps educate the surgeon, restorative dentist, and dental ceramist to achieve ideal stable long term aesthetic outcomes in the patients. Limitation of this index is in context to facial esthetics where PES/WES score is only a small component. Hence this index is far less significant in patients with a low lip line.

There are certain limitations of this study, which include small sample size, shorter duration of follow up and inability to assess buccal and lingual bone loss due to the inherent disadvantage of the radiographic technique employed to access the bone loss.

Conclusion

Within limitations of the study and based on results obtained following conclusions have been drawn –

1. There was a significantly less marginal bone loss in subjects using xenograft (Group I) compared to the subjects using beta-tricalcium phosphate & hydroxyapatite bone graft (Group II) at 3 months.
2. The difference was not significant whenthe marginal bone loss was compared in subjects using xenograft (Group I) to the subjects using beta-tricalcium phosphate & hydroxyapatite bone graft (Group II) at 1 month.
3. There was a less marginal bone loss which was statistically significant in subjects using xenograft (Group I) compared to the subjects using hydroxyapatite bone graft (Group III) at both 1 and 3 months.
4. There was no difference in marginal bone loss in subjects using beta-tricalcium phosphate &

hydroxyapatite bone graft (Group II) compared to the subjects using hydroxyapatite bone graft (Group III) at 1 and 3 months.

5. Concerning implant stability there was no difference in Implant Stability Quotient (ISQ) value among all the three groups.
6. When groups were compared for the esthetics score, there was no statistically significant difference among the three groups.

There was not much statistically significant difference in marginal bone loss, implant stability, and aesthetic among the three groups, though clinically group I showed better results.

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