

Comparative Bone Graft Evaluation for Dental Implant Success: An Evidence-Based Review

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ABSTRACT: In this review, we provide a comparative evaluation of different bone grafts for dental implants success. We performed a literature review to analyze dental implant success and survival rates after the use of various grafts for bone augmentation. A total of 41 studies were selected and analyzed based on parameters including study design, number of implants placed, total number of participants, type of graft used, site from which graft was obtained, time elapsed between bone augmentation and implant placement, implant survival, and success rates. Results indicate that after a follow-up period of 1–5 yr, respective success and survival rates are as follows: block grafts, 91.5% and 75%; blood derivatives, 91.5% and 96.7%; composite grafts, 80.9% and 94.2%; xenografts and particulate grafts, 100% for both success and survival. After evaluating the available studies, we can report that autologous block grafts, composite grafts, and blood derivatives were the most commonly used grafting materials for bone augmentation before placing dental implants. Xenografts and particulate grafts had 100% success and survival rates, but more studies are needed to assess the impact of these grafting materials.

KEY WORDS: dental implants, bone grafts, autografts, allografts, xenografts, blood derivatives, bone augmentation

I. INTRODUCTION

For oral restoration, the importance of implant-supported appliances is growing. The survival rate of these implants has significantly improved during the past decade to > 90% at 10 yr following implant therapy, impacting patient satisfaction in a positive manner.¹ However, insufficient bone volume and quality poses challenges to implant success rates.² Bone loss can occur due to trauma, periodontitis, and various jaw pathologies, complicating delivery of dental implants. To overcome this challenge and improve treatment success rate, bone augmentation is usually recommended before implant placement.

Materials that are used for bone grafting include autogenous bone grafts, allografts, xenografts, and alloplastic. Each has its own advantages and disadvantages. The gold standard and most used material is autogenous bone due to its osteoconductivity, osteoinductivity, and osteogenicity.³ Allografts, osteoinductive and osteoconductive, are taken from donors of the same species.² Xenografts have osteoconductive properties, and donors are taken from

different species. Alloplastic sources can be derived from synthetic or natural material such as ceramic, hydroxyapatite, tricalcium phosphate, or calcium sulphate and are only osteoconductive.⁴ The objective of this review is to evaluate different types of bone grafts for bone augmentation before dental implant placement and assess whether the grafts produce successful implant osseointegration.

II. MATERIALS AND METHODS

A. Search Strategy

We performed a systematic literature review to identify the studies that are related to the topic of comparative evaluation of different types of bone grafts for dental implant success. Our search strategy incorporated electronic databases, and we evaluated studies published after 1990. We used a controlled vocabulary with different sets of search terms to screen relevant studies. We used PubMed, ResearchGate, Google Scholar, Elsevier, CiteSeerX, EBSCO, Journal of Implant Dentistry, International Journal of Oral

and Maxillofacial Surgery, and Wiley Online Library. We used different combinations of entry terms in the main database research as shown in Table 1.

B. Inclusion and Exclusion Criteria

Please see Table 2 for inclusion^{5–7} and exclusion^{8–10} criteria of this literature review.

C. Implant Success Criteria

To a certain extent, all of the studies that were included in this review varied in measuring implant success. But, all of the studies defined clinical and radiographic guidelines and we used these as a standard baseline for measuring implant survival and success rates. We abided by the following:

1. Radiolucency around the implant should not be present.
2. Recurrent peri-implant infection with suppuration should not occur.¹¹
3. The implant may not have mobility.
4. Persistent complaints of pain or foreign body sensation (dysesthesia) should not be present.

5. Pocket probing should be < 5 mm.^{12,13}
6. Bleeding on probing should not be present.
7. During the first year after the implant placement, 1.5 mm of vertical bone loss is acceptable. In subsequent years, no more than 0.2 mm of vertical bone loss (mesially or distally) is acceptable.^{12,14}

This combination of success criteria was defined by Albrektsson et al.¹³ originally and later adapted by Buser et al.¹⁵ in 1997 and Karoussis et al.¹⁶ in 2003.

D. Study Selection Criteria and Data Extraction

We used multiple databases to select studies related to the topic and performed a three-step exclusion strategy for screening and short listing the relevant studies, as shown in Fig. 1.

E. Intervention Types

Selected studies used multiple augmentation techniques before implant placement. Some of these methods are discussed below.

TABLE 1: Entry terms used in database search

First set of entry terms	Second set of entry terms	Third set of entry terms
Grafts	Implants	(Combination of first and second set)
Bone grafts	Dental implants	Bone grafts and implants
Bone augmentation	Osseointegrated implants	Effect of bone grafts on implant success
Cortical bone chips	Oral implants	Factors affecting implant viability
Cortical bone grafts	Implant-supported prosthesis	
Cancellous bone grafts	Implant results	
Cortico-cancellous bone graft	Implant failures	
Autograft	Implant success	
Allograft	Transmucosal implants	
Xenograft		
Bone enhancement method		
Periosteal graft		
Block graft		
Osseous coagulum		

TABLE 2: Study inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Published in the English language	With early implant failures or patient follow-up of < 6 mo
Related to all types of dental implants	With data duplication (same data, same authors) without addition of new information
With healthy participants only (no underlying conditions)	With only bone grafting procedure for ridge augmentation without implant placements
Conducted on humans	With only implants placement without bone grafting
Evaluated success rates of dental implants placed in the maxillary or mandibular bone augmented by autografts, allografts, and xenografts	Unrelated to bone grafts and implants
With follow-up protocol after implant placement	Without specified implant success criteria, in which only survival rate was mentioned without emphasizing associated factors
Including patients with deficient edentulous ridges	Unrelated to dentistry
	Conducted on animals
	With incomplete information

1. Onlay Graft Augmentation

For reconstruction of vertical and horizontal defects of alveolar ridges, this technique uses homologous or autologous bone blocks either alone or in combination with particulate bone grafts. After surgical exposure of the defect and removal of any irregularities, the bone grafts are stabilized with the help of small screws. To prevent dehiscence and wound exposure, tension-free closure of the surgical site is vital for this technique. Bone graft harvesting can be done intraorally from the chin or mandibular ramus area or extraorally from calvaria or ala iliaca.

2. Allografts

Allografts are harvested from donors including cadavers and grafts that are usually procured from bone banks.

3. Xenografts

Xenografts are obtained from different species (other than human) such as bovine.

4. Composite Bone Grafts

Composite bone grafts can be created from ceramics such as calcium sulphate and calcium phosphate, which are biological active. When combined with growth factors such as strontium, their biological activities increase.

5. Blood Derivatives

These grafts are produced using recombinant DNA technology. Many variations of blood derivative grafts are available including platelet-rich plasma, concentrated growth factor, and bone morphogenetic protein.

F. Bone Graft Failures

Bone grafts can fail due to unforeseen reasons, and preoperative bone graft failure can lead to failure of the complete implant system. The most common causes of bone graft failure are improper stabilization, infection, or wound exposure.¹⁷⁻²² Other risk factors associated can be smoking, periodontal problems, defects in the immune system, osteoporosis, and systemic diseases.^{23,24}

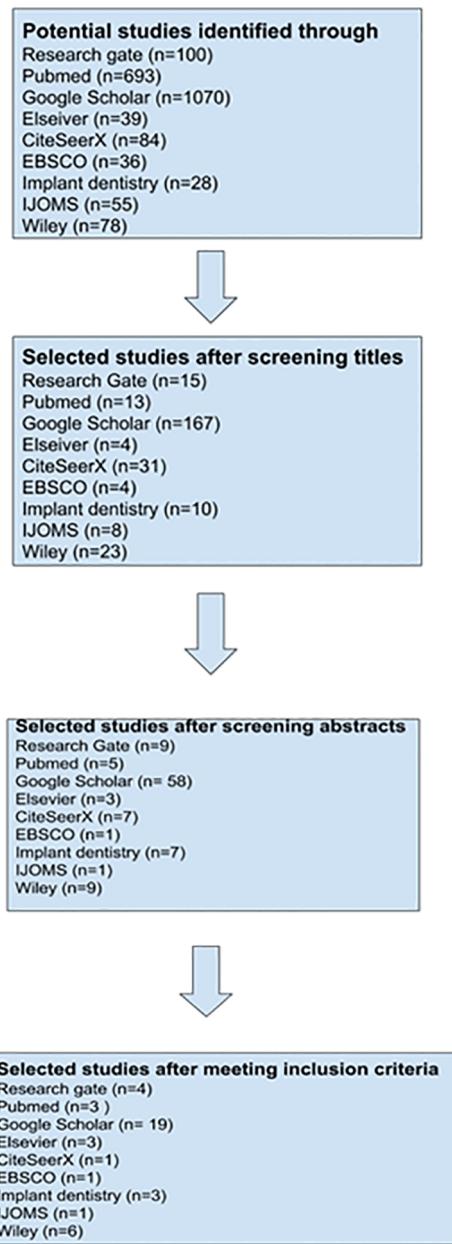


FIG. 1: One–three-step exclusion strategy

III. DISCUSSION

The bone augmentation technique is a gold standard for oral rehabilitation procedures involving implants in atrophic edentulous ridges. For this purpose, different graft materials are available. Every graft material has its own unique properties and depending on requirements, the materials well serve the purpose.

Nevertheless, all grafting materials differ in the procedure's long-term prognosis. Multiple studies have been conducted to compare efficacy and efficiency of all graft materials as well as their effects on implant survival and success rate. For the present literature review, 41 studies were systematically studied to analyze the effects of various graft materials on the long-term success of dental implants. Parameters that we used to compare all studies included the following:

1. Study design (Fig. 2). Mostly are case studies type^{20–34,37,38,55} and few are retrospective case studies^{35,36,39,54}
2. Number of participants (Fig. 3) and participant demographics (Fig. 4)
3. Graft type (Fig. 5)
4. Time elapsed between bone augmentation and implant placement (Fig. 6)
5. Site from which graft material is obtained (Table 3)

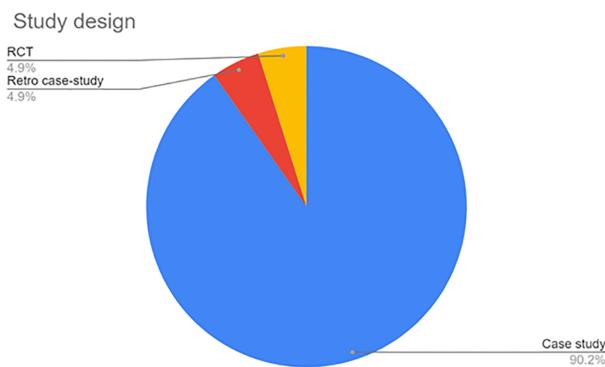


FIG. 2: Study design distribution. RCT, randomized controlled trial.

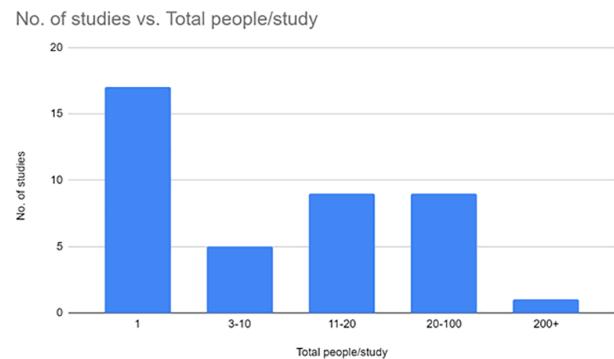
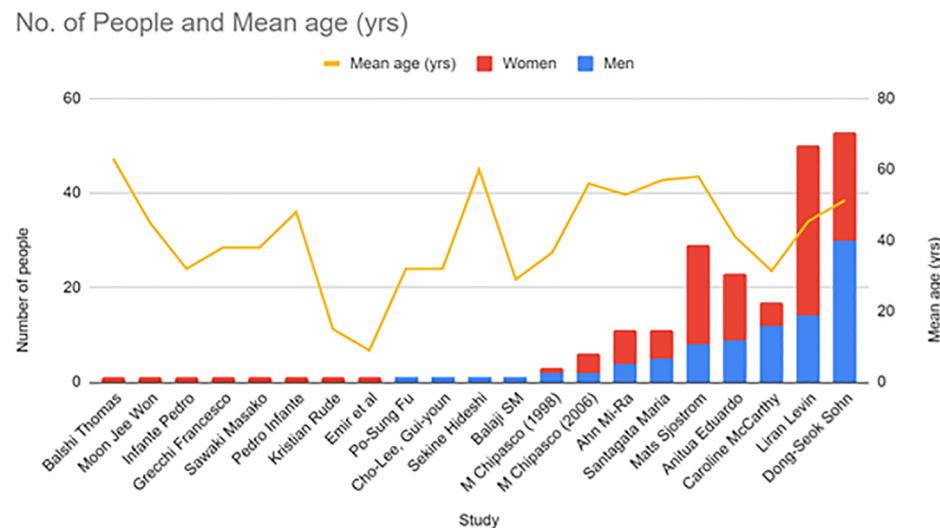
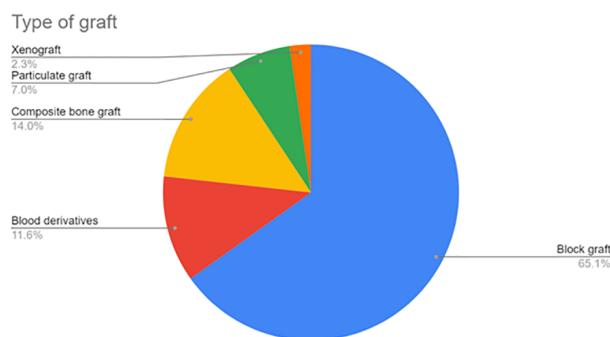
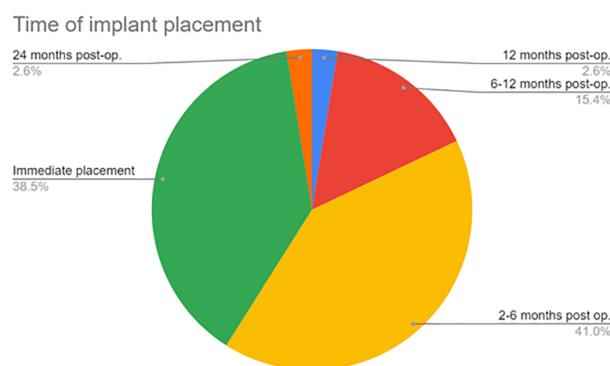


FIG. 3: Patient distribution per study

**FIG. 4:** Patient demographics per study**FIG. 5:** Grafts types used per study**FIG. 6:** Time of implant placement

6. Implant survival rate (Table 4)
7. Implant success rate (Table 5)
8. Total number of implants placed (Table 6).

Details of all included studies are summarized in Table 6.

IV. RESULTS

The effects of different bone graft types on implant success and survival are compared and shown in Fig. 7. We derived the mean values of implant success and survival rates from all studies and compared those against the graft material used. In Fig. 7, the blue bar indicates implant success, the red bar shows implant survival, and the x axis represents the type of graft material.

Results indicate that block grafts have 91.5% success and 75% survival after a follow-up period of 1–5 yr. Blood derivatives have 91.5% success and 96.7% survival after a period of 1–4 yr. Composite grafts have 80.9% success and 94.2% survival after 1–5 yr, and xenografts and particulate grafts both have 100% success and survival rates after follow-up of 1–5 yr. Although xenografts and particulate grafts showed promising results, the number of studies and participants in these studies must be considered. Block grafts were used in more than half

TABLE 3: Graft types and sites

Graft type	Graft site
Block	Rib Fibula Iliac crest Chin Mandibular ramus Scapula
Particulate	PCBM bone collected in osteotomy and drilling
Composite	Fibrin-rich blocks with CGF Autogenous graft + xenograft + autologous PRP
Blood derivative	Plasma-rich protein BMP, BMP-rh2 CGF Peripheral venous blood
Xenograft	Bovine bone

BMP, bone morphogenic protein; CGF, concentrated growth factor; PCBM, particulate cancellous bone marrow; PRP, platelet-rich plasma; rh2, recombinant human 2.

TABLE 4: Implant survival rate with respect to graft type

Graft type	Implant survival (%)
Block	50–100
Blood derivative	93.4–100
Composite	88.4–100
Xenograft	100
Particulate	100

TABLE 5: Implant success rate with respect to graft material

Graft type	Implant success (%)
Block	83–100
Blood derivative	83–100
Composite	61.8–100
Xenograft	100
Particulate	100

(65%) of the studies, whereas other grafts such as xenografts and particulate grafts were used in only 2.3% and 7% of studies, respectively. Thus, more data are required to assess xenografts and particulate graft efficacy for implant success and survival.

V. CONCLUSIONS

In this systematic review, efficacy of bone grafting materials on implant success and survival was assessed and data from 41 studies were evaluated. After careful analysis of various parameters, we can conclude that autologous block grafts, composite grafts, and blood derivatives are the materials of choice for most of grafting procedures. Although xenografts and particulate grafts showed 100% positive results, insufficient literature related to these grafts makes it difficult to broadly assess their efficacy. After a mean follow-up period of 3–5 yr, block grafts showed promising results, with satisfactory implant success and survival rates. More research is needed in this field to explore possibilities with grafting materials, especially xenografts and particulate grafts.

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TABLE 6: Details of all included studies

Reference	Study design	Total participants	Total implants	Graft material	Graft type	Time of implant placement	Implant survival (%)	Implant success (%)
Balaji SM	Case	1	6	Rib graft overlaid with BMP-rh, BMP-2	Block graft Blood derivatives	NA	100	100
Kristian Rude	Case	1	5	Microvascular Osteomyocutaneous fibula graft	Block graft	12 mo postop	100	100
Jose Luis	Case	4	19	Iliac crest, Fibula and Scapula	Block graft	6–12 mo postop	100	100
Emir et al.	Case	1	3	Iliac crest graft	Block graft	4–6 mo postop	NA	NA
Po-Sung	Case	1	1	Autogenous graft from chin	Block graft	4 mo postop	100	100
Hisahiro Kamoi	Case	1	5	Rib bone graft	Block graft	Immediate	100	100
Sekine Hidemitsu	Case	1	5	Iliac graft, PCBMM	Block graft	Right side: 4 mo postop; left side: immediate	100	100
Pedro Infante	Case	1	2	Composite bone graft Xenograft AutograftPRP*	Composite bone graft Xenograft AutograftPRP*	24 mo postop	100	100
Sawaki Masako	Case	1	2	PCBM, RBOG	Block graft	5 mo postop	100	100
Miguel Eugenio	Case	1	8	Iliac crest	Block graft	5 mo postop	100	100
Alencar Juliano	Case	1	2	From osteotomy and drilling	Particulate graft	Immediate	100	100
Grecchi Francesco	Case	1	12	Femur grafts	Block graft	8 wk postop	100	100
Cho-Lee, Gu-youn	Case	1	3	Fibular flap	Block graft	3 mo postop	100	100
Infante Pedro	Case	1	3	Iliac Graft	Block graft	6.2 mo postop	100	100
Taylor Gregory	Case	1	1	Ramus graft	Block graft	6 mo postop	NA	NA
Po-Sung Fu	Case	1	1	Chin graft	Block graft	4 mo postop	NA	NA

TABLE 6: (continued)

Reference	Study design	Total participants	Total implants	Graft material	Graft type	Time of implant placement	Implant survival (%)	Implant success (%)
Santagata Maria	Case	11		Bone particles were harvested during implant site preparation	Particulate graft	NA	NA	NA
Ahn Mi-Ra	Case	11	27	Cancellous Bone marrow	Block graft	5 mo postop	99	97
Moon Jee Won	Case	1	3	Bovine bone graft mixed with fibrin adhesive	Xenograft	Immediate	NA	NA
Schwartz Devorah	Retro case	214	633	Autologous graft mixed with PRP	Block graft Blood derivatives	4–6 mo postop	93.4	83
Anitua Eduardo	RCT	23	NA	PDGF, TGF	Blood derivatives	Immediate	100	100
Chiapasco Matteo	Case	3	22	Iliac crest	Particulate graft	5–6 mo postop	100	100
Balshi Thomas	Case	1	2	Iliac crest	Block graft	Immediate	50	0
Michael Peleg	RCT	63	160	Autogenous composite bone graft	Blood derivatives	Immediate	100	100
Ji Min Kim	Case	33	74	Fibrin rich block with concentrated growth factors	Composite bone graft	5 mo postop	100	98.6
Stefan Lundgren	Case	11	21	Bone flap	Composite bone graft	Immediate	98.7	100
Mats Sjostrom	Case	29	192	Iliac crest	Composite bone graft	6–8 mo postop	90	61.8
F. Hernandez Alfaro	Case	14	108	Mandibular bone graft	Composite bone graft	14–16 wk postop	88.4	77.99
Jee Won Moon	Case	14	31	Peripheral Venous blood	Blood derivatives	Immediate	93.5	NA
Dong-Seok Sohn	Case	53	113	Fibrin blocks with CGF	Composite bone graft	Immediate	95.1	93.5

TABLE 6: (continued)

Gerry M Raghoebar	Case	14	14	Zygomatic rim	Block graft	NA	100	100
J. Elo	Case	65	184	Iliac crest, retromolar area, chin	Block graft	NA	97	NA
M Chipasco	Case	6	23	Calvaria	Block graft	5–8 mo postop	95.7	100
M Chipasco	Case	8	19	Mand ramus	Block graft	3–5 mo postop	89.5	100
E H Vander meij	Case	17	34	Iliac crest	Block graft	Immediate	88.2	NA
E Nystrom	Case	30	177	Ala iliaca	Block graft	Immediate	72.8	83.1
M Chiapasco	Case	15	44	Iliac crest, mandibular ramus	Block graft		90.9	100
R Triplett	Case	99	364	Ilium, Mandible	Block graft	Immediate placement (134) or 6–9 mo postop (260)	87	87.9
S Isaksson	Case	8	46	Iliac crest	Block graft	Immediate	83	83
Liran Levin	Retro case	50	129	Onlay bone graft	Block graft	4–6 mo postop	96.9	NA
Caroline McCarthy	Case	17	35	Mandibular symphysis	Block graft	15 patients: 13–32 wk postop; two patients: immediate	97.1	NA

BMP, bone morphogenetic protein; CGF, concentrated growth factor; NA, not available; PCBM, particulate cancellous bone marrow; PDGF, platelet-derived growth factor; PRP, platelet-rich plasma; RBOG, ramus bone onlay grafting; RCT, randomized controlled trial; TGF, transforming growth factor.

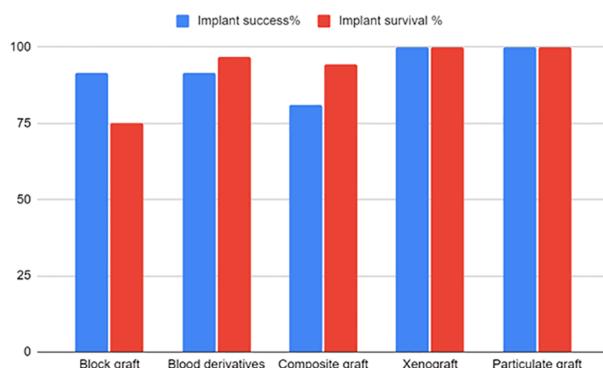


FIG. 7: Comparison of implant success and survival rates with different graft materials

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