



ISSN: 0976-3031

Available Online at <http://www.recentscientific.com>

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 8, Issue, 4, pp. 16434-16438, April, 2017

**International Journal of
Recent Scientific
Research**

DOI: 10.24327/IJRSR

Review Article

COMPARATIVE EVALUATION OF DIFFERENT BONE GRAFT MATERIALS: A REVIEW

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DOI: <http://dx.doi.org/10.24327/ijrsr.2017.0804.0148>

ARTICLE INFO

Article History:

Received 15th January, 2017
Received in revised form 25th
February, 2017
Accepted 23rd March, 2017
Published online 28th April, 2017

Key Words:

Bone graft materials, alveolar ridge
augmentation, bone reconstruction.

ABSTRACT

Success of implant supported prosthesis depends on many factors. The presence of adequate bone at surgical site being one of the important factor. Periodontal conditions, trauma may lead to inadequacy of bone, however with recent developments implant bed can be successfully grafted with variety of materials to increase the bone volume. Bone graft materials are derived from different sources. Choice of the graft material should be based on the technique, amount of graft required, and healing pattern around the bone. This review provides understanding about different graft materials with comparative evaluation of outcome when used alone or in combination with other graft materials.

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INTRODUCTION

With recent developments in field of implantology and long term survival rates of implant supported restoration, replacement of missing teeth with implant supported restoration has become a popular choice among clinicians and patients. However, for the implant to be functional for a longer duration good bone support is required as the masticatory load on the implant is transferred through the bone which lays foundation for the implant. Extraction of tooth is accompanied by significant amount of dimensional changes occurring in socket.^{1,2} Loss of bone structure either through bone resorption followed by tooth extraction or due to trauma may preclude placement of implant owing to presence of insufficient bone which may alter the esthetic outcome, phonetics or prognosis of implant restoration. Paucity of bone at surgical site can be reduced by grafting it with bone graft materials or replacing the lost bone with block bone graft.

Classification of grafts:³

1. Autograft (autogenous graft): Tissue transferred from one location to another within the same individual.
2. Allograft: A graft between genetically dissimilar members of the same species i.e. human tissue.
3. Xenograft: A graft taken from a donor of another species i.e. bovine, porcine, equine bone graft material etc

4. Alloplast: Inorganic, synthetic or inert foreign material implanted into tissue. Eg; Hydroxyapatite, - tricalcium phosphate, Bioglass.

Bone healing and new bone formation after grafting occur through osteogenesis, osteoinduction and osteoconduction. Osteogenic graft materials supply actual viable osteoblasts themselves, osteoinductive materials stimulate primitive mesenchymal cells to differentiate into osteoblasts whereas, osteoconductive materials merely act as a lattice or framework for cell growth.

Rationale

A sufficient volume of bone of adequate biological quality is required for placement of dental implant. In aesthetic regions like the maxillary anterior region, soft tissue requires a solid bony basis as 'soft tissue follows hard tissue'.⁴ Healing in extraction socket results in reduction of about 50% of the initial ridge width over a 12-month period, with two third of reduction in width taking place during the first 3 months of healing. Loss of width in bone is more in the mandibular posterior region.¹ Vertical bone loss of 3-4 mm, or bone volume loss of around 50% has been reported in six months post extraction.⁵ Horowitz et al in their study concluded that less resorption of alveolar ridge occurred when socket preservation was attempted with use of bone graft material as compared to no use of graft material in fresh extraction sockets.⁶ In case of infection or

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trauma additional augmentation may be required to provide bony basis for placement of implant which will be functionally and aesthetically acceptable.

Indications⁴

Bone substitutes are indicated in the following conditions:

1. Augmentation of vertical and horizontal dimension in the maxilla and mandible.
2. In treatment of peri-implantitis to refill the peri-implant bone defect.
3. For preservation of alveolar socket following tooth extraction.

For any bone graft to be successful 4 conditions must exist:⁷

1. The graft matrix must be populated by osteoblasts or primitive mesenchymal cells that can transform into osteoblasts.
2. There should be enough blood supply to the site sufficient to nourish the graft, maintain viability of cells and regenerative healing capacity.
3. The graft material must be stabilized during healing, as mobility may result in distortion of formed blood clot.
4. The mucoperiosteal flap must be approximated without tension on the incision line to ensure tissue continuity and uninterrupted blood supply.

Osteogenesis: It refers to the growth of bone from viable cells transferred within the graft. Autogenous bone is the only graft material available with osteogenic properties.

Osteoinduction: It involves new bone formation from osteoprogenitor cells derived from primitive mesenchymal cells under the influence of one or more inducing agents that emanate from the bone matrix.

Osteoconduction: It involves new bone formation from osteoprogenitor cells derived from primitive mesenchymal cells under the influence of one or more inducing agents that emanate from the bone matrix.

Autografts

Autografts are the bone graft materials harvested from intraoral or extraoral site of the same individual. Autogenous bone has osteogenic, osteoinductive and osteoconductive properties, and is considered to be ideal bone graft material.⁸ However morbidity, unavailability and unpredictable graft resorption are the associated drawbacks.

Advantages and disadvantages of autografts.⁹

Advantages

1. They are biocompatible in nature.
2. They have highest osteogenic potential.
3. They possess adequate mechanical strength.
4. They are available in both cortical and cancellous type.

Disadvantages

1. Additional surgery is required to obtain the graft.
2. Associated with donor site morbidity, postoperative pain and increased risk of fracture of donor site.
3. Limited amount of tissue can be procured.
4. Increase in operative time and cost.

5. There is high variability in quality of harvested bone tissue.

The common sites for harvesting of an autograft in the mandible are chin, angle, lineaobliqua, and corpus, in maxilla tuber, spinanasalis, and crista zygomaticoalveolaris. Calvaria, Pelvic rim, Tibia are the extra oral sites. Autogenous bone graft harvested from mandible has certain advantages as they maintain dense quality during healing period and exhibit minimal resorption.¹⁰ Autograft can be a cortical bone, cancellous bone or combination of both. Cancellous bone graft survive better as compare to cortical bone due to diffusion of nutrients and better revascularization.⁸

Allografts

Allografts are the graft materials which are harvested from members of same species which are genetically non-identical. Their incorporation in existing bone is slower as they lack living cells. Allografts have the advantage of no donor site morbidity but are associated with certain disadvantages like disease transmission, slow and less graft complete incorporation, limited graft availability and cost.¹¹ Allografts are used either fresh or processed before being used. Allografts show some incidence of immunogenic reaction or cross infection.¹² They have been used independently or in combination with autogenous bone or xenografts.

Allografts are generally used in two forms—freeze dried bone allograft (FDBA) and demineralized freeze dried bone allograft (DFDBA).

Mineralized freeze-dried bone allografts FDBA is not demineralized and considered to be osteoconductive.¹³

Demineralized freeze-dried bone allografts They are frequently used for maxillofacial and periodontal grafting. They are osteoinductive owing to presence of bone morphogenetic proteins (BMPs).¹⁴

Xenografts

Xenograft is the graft obtained from different species mainly bovine bone and porcine bone. Proteins from the xenografts are extracted to avoid any immunologic reaction, however this procedure makes them osteoconductive. Recently enzyme-treated equine bone graft material have also been used in which bone collagen is preserved in its native state.^{15,16}

DISCUSSION

Bone grafts serve as source of osteogenic cells and provide mechanical support too.¹³ The potential for regeneration of functional attachment apparatus has been demonstrated in autogenous and allografts.

Autogenous bone has been considered for the augmentation of bone in case of atrophic maxilla and mandible. Autogenous iliac graft when used for ridge augmentation of atrophic maxilla showed good survival result with clinical and radiographic evidence showing low rate of resorption after grafting and implant placement.¹⁷ Similar results were found when lateral or vertical augmentation was done in mandible and maxilla before implant placement with onlay autografts harvested from mandibular ramus or symphysis region. Healing period was followed by resorption at graft site which was more in mandible than maxilla.¹⁸ Combination of autogenous bone

with bovine bone has been used for vertical ridge augmentation with satisfying results.¹⁹ Simion *et al* suggested use of composite containing DBBM deproteinized bovine bone mineral (Bio-Oss) and autograft in ratio of 1:1 for ridge augmentation procedure.²⁰ Use of autografts with membrane hastens bone availability at grafted site.^{21,22} Survival rate of implants placed in sites with autogenous graft was 96.9% with only 5% of the implants showing marginal loss of 1.5 mm or more.²³

Since procurement of autograft is associated with significant morbidity at the donor site and limited availability hence allograft and combination with autogenous and xenograft have been used with promising results. Valenini P *et al* used mixture of bovine porous bone mineral and demineralized freeze-dried bone for maxillary sinus elevation and reported survival rate of 90-96% after implant loading period of two years.²⁴ Lyford R H *et al* reported increase in bone width by 2-4 mm using freeze dried allograft material.²⁵ Similar encouraging result was reported by Keith *et al*.²⁶

Guerrero *et al* reported post loading success rate of 95.2% when allograft was used for maxillary sinus floor augmentation.²⁷ Gustavo Avila *et al* in their study reported that bone augmentation using allograft showed well-organized lamellar bone, in direct contact with allograft particles and advocated combination of cortical and cancellous chips for sinus augmentation.²⁸ Sohn *et al* used allograft for sinus augmentation and found normal healing of hard tissues and favourable bone regeneration histologically.²⁹ Allograft when used in extraction socket with barrier membrane resulted in new bone formation.³⁰ Comparing DFDBA and FDBA for ridge preservation in extracted socket Robert *et al* showed significantly greater bone formation with DFDBA.³¹ However with time there is not much of a difference in bone formation using allograft at extraction site at time interval of 3 months and 6 months.³² Similarly no difference was found in bone formation when using cortical and cancellous FDBA bone for bone preservation in extraction socket.³³ Combination of mineralized and demineralized bone graft showed higher amount of vital bone formation as compare to mineralized bone graft alone.³⁴

Hallman *et al* used autogenous bone, bovine bone and the combination in ratio of 20:80 autogenous bone and bovine bone for maxillary sinus floor augmentation and found similar results. They concluded autogenous bone can be replaced with bovine bone or different combination of autogenous and bovine bone can be used.³⁵ Another study also revealed satisfactory result with combination of autogenous and bovine bone and concluded bovine bone can alone be used for bone augmentation.³⁶ Deproteinized bovine bone was used successfully used for GBR procedures in dehiscence defect with respect to vertical and horizontal growth of bone.³⁷ Lekovic V *et al* found combinations of platelet rich plasma (PRP) bovine porous bone mineral (BPBM) and guided tissue regeneration GTR. are effective in the treatment of intrabony defects present in patients with advanced chronic periodontitis but, GTR adds no clinical benefit to platelet rich plasma and bovine porous bone mineral.³⁸ Most alloplastic materials consist of hydroxyapatite, -tricalcium phosphate, biphasic calcium phosphate, or some type of nonsintered calcium phosphate (reduced calcium content).⁸ Synthetic bone

graft materials has shown potential for new bone formation.³⁹ Hydroxyapatite is a biocompatible slowly resorbing osteoconductive material.^{40,41} Osteoblast differentiation and new bone formation at the surface of porous HA ceramic granules has also been demonstrated.⁴² Pure dense hydroxyapatite is also well accepted by hard and soft tissue in intrabony defects.⁴³

Pure -tricalcium phosphate was used for socket preservation after tooth extraction followed by implant placement. After six months surgical site was found to contain dense bone supporting stable implant.⁴⁴ Shalash MA *et al* conducted ridge augmentation following GBR principle using -tricalcium phosphate and its combination with demineralized bone matrix and found that combination of both is more effective in cases of minimal alveolar ridge defects.⁴⁵ Combination of -tricalcium phosphate and hydroxyapatite in ratio of 60:40 showed better result in bone augmentation compared to allograft (Bio-oss).⁴⁶ Combination of bioactive glass and autografts have also shown satisfactory result.⁴⁷

CONCLUSION

Regenerative or bone filling capacity of different graft materials are comparable. However to increase the potential for regeneration combination of different materials can also be done. Selection of graft material is based on operator preference, type and size of the defect, resorbability of graft material, cost and finally patient acceptance.

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How to cite this article:

Rakshith Hegde *et al.* 2017, Comparative Evaluation of Different Bone Graft Materials: A Review. *Int J Recent Sci Res*. 8(4), pp. 16434-16438. DOI: <http://dx.doi.org/10.24327/ijrsr.2017.0804.0148>
