ORIGINAL RESEARCH PAPER
Volume - 10 | Issue - 07 | July - 2021 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

BONE GRAFT AND IT'S SUBSTITUTES IN THE MODERN ERA OF DENTISTRY: A REVIEW

Dental Science

Dr. Viraj Mohan Ketkar* B.D.S, Terna Dental College And Hospital. *Corresponding Author

Dr. Silky Gabbi B.D.S, Adesh Institute Of Dental Sciences And Research, Punjab.

Dr. Komal Rajendra Agrawal B.D.S , Dr. D.y Patil Dental College And Hospital, Pune.

ABSTRACT

Autogenous bone graft is the gold standard of grafting material. Bone grafts are basically used as a filler and scaffold to facilitate new bone formation and enhance bone healing. The surgeon should have a good knowledge of properties of each bone graft material and should know when to select which type of bone substitute. Most common use of bone grafts in dentistry is in placement of dental implants, for atrophic ridges of edentulous jaw, filling the cavity defect, reconstruction of bone defect due to tumor or cyst removal.

KEYWORDS

Bone Graft, Bone Substitute, Bone Morphogenic Protein, Autograft, Allograft

INTRODUCTION

The eventual use of the bone grafts is the osseous replacement of the bone defect with a healthy bone which is well vascularized and contoured, eliminating any dead spaces. An ideal bone graft has a role to achieve the same histological features as the original bone tissue. It acts as a scaffold for the new bone formation. Indistinct, from the purpose of use it has the ability to regenerate the lost bone structure to its complete integrity. The use of which in order to regenerate relies on their ability of osteogenic, osteoinductive and osteoconductive potential.[1] the search for an ideal bone substitute has been extensively carried out for more than 20 years.[2] Demand for the use of bone graft has increased in traumatology, tumor surgery, infection, revision arthroplasty.[3]

The biologic mechanisms of bone grafting includes: osteoconduction, osteoinduction and osteogenesis [Table 1].

Osteoconduction

Occurs when bone graft material serves as a scaffold for new bone growth, which is perpetuated by the native bone. Osteoblasts from the margin of defect that is being grafted utilize the bone graft material as a frame work upon which they spread and generate new bone.[3]

Osteoinduction

Involves stimulation of osteoprogenitor cells to differentiate into osteoblasts and then begins formation of new bone. The most widely studied type of osteoinductive cell mediators are BMPs.[3]

Osteogenesis

It occurs when vital osteoblasts originating from bone graft material contributes to the growth of new bone along with bone formation.[3]

Osteopromotion

It involves the enhancement of osteoinduction property without possession of osteoinductive properties. For example, enamel matrix derivative enhances the osteoinductive effect of demineralized freeze-dried bone allograft, but it would not stimulate the bone graft alone.[4]

Table 1: Bone Graft Material Overview [5]

BONE GRAFT	STRUCTURAL STRENGTH	OSTEOCONDUCTION	OSTEOINDUCTION	OSTEOGENESIS
AUTO GRAFT				
Cancellous	No	+ + +	+ + +	+ + +
Cortical	+ + +	+ +	+ +	+ +
ALLO GRAFT				
Cancellous				
Frozen	No	+ +	+	No
Freeze-dried	No	+ +	+	No
Cortical				
Frozen	+ + +	+	No	No
Freeze-dried	+	+	No	No

Scaffold [Table 2]

It may be referred as a framework acting as a support which may be either temporary or permanent, natural or synthetic, a three dimensional porous, permeable, biocompatible biomaterial which allows cell adhesion to its surface inducing cell differentiation and proliferation without the risk of tissue rejection or an inflammatory response.[6]

Table 2: Scaffolds Can Be Classified Into Organic And Inorganic

SCAFFOLD TYPE		EXAMPLES
Organic	Natural	Collagen, Chitosan, Silk, etc
	Synthetic	Polyglycolic Acid, Polylactic Acid, etc
Inorganic		Metals, Alloys, Mineral compositions like calcium, potassium, silicate, magnesium, etc

Classification of bone graft materials

There are basically 4 types of bone graft material available for the reconstruction purposes in maxillofacial skeleton [Table 3].

Table 3: Types Of Bone Grafts

GRAFT TYPE	DESCRIPTION
Autograft	Transplantation of viable bone tissue from one region to the other of the same individual.
Alloplast	Implantation of synthetic material(apatite, tricalcium phosphate, bioactive glass, polymers)
Xenograft	Cross- species transplantation of bone tissue
Allogenic	Graft tissue derived from other human being and transplanted to other.

Autogenous bone graft

Autologous or autogenous bone graft are secured from the same individual to whom it is received.[5] It is the most predictable and reliable bone graft material used for the reconstruction purposes in maxillofacial skeleton.[1,5] Most common harvest sites includes ramus, symphysis of mandible. Other sites, such as rib, iliac crest, fibula, calvarium, radius may also be used.[1,5] Several studies have shown the success of autografts.[1] Hip, ramus, symphysis provides us both the cortical and cancellous bone.[5] It is considered as the gold standard as a bone graft due to their immediate availability and high success rate.[2,5] The graft provides volumetric support with structural integrity.[5] Significant advantages such as there is no risk of disease transmission and immunologic reactions which is seen in alloplastic graft material.[5]

The major drawbacks, include donor site morbidity, potential resorption, possible hospitalization, increased cost, size mismatch, additional surgical site is required, limited volume of graft material. Harvesting from the symphysis region may lead to temporary or permanent sensory changes of lip and chin region.[5] While the hip grafts may cause gait disturbances, nerve injury, blood loss, hematoma formation, pelvic instability, cosmetic defects, even chronic pain at the harvest sites.[5]

Allogenic bone graft

Allografts are derived from the same species group, received by a genetically dissimilar individual. Originally these grafts are prepared from the cadaveric tissues.[5] These are typically sourced from bone bank.[4]These graft materials have a major advantage of its availability in abundance, adding to it no donor site morbidity.[5] They are used as a substitute for autografts or autograft expander, eliminating a secondary harvest site need.[1,5] The allografts are processed before being transplanted for the assurance of its safety.[5]

The processed available bone grafts are:

1. Fresh
2. Fresh frozen
3. Freeze dried
4. Demineralized bone grafts

In comparison of mineralized bone graft the demineralized bone graft has the advantage of being osteoinductive and osteoconductive.[1,5] Over a period of time, demineralized freeze-dried bone allogaft can be used alone or in combination with other alternative factors such as platelet-rich plasma(concentration of platelets and growth factors).[2] The major disadvantage seen are disease transmission and immunologic reactions, unlike the autografts.[1,5]The risk of infection is minimized with the development of donar screening tests.[3] Allogenic bone grafts are processed in different particle sizes, creating an impact to a certain degree for its osteoconductive potential.[5] various particle sizes are mentioned in the literature, widely accepting the size of 100 µm to 300 µm to be processing the highest osteoconductive potential.[5] Allografts are available in various preparations such as morselized, cancellous, corticocancellous, cortical, osteochondral, bone segment and demineralized bone matrix.[3]

Alloplastic bone graft

Alloplastic bone graft materials are the bone substitute processed to enhance its properties for handling. These are made synthetically or obtained from hydroxyapitite which is made from bioactive gas.[4,5] Alloplasts uniquely has a property of bonding with bone surface, few of the examples are as follows bioactive glass (forming a chemical bond), calcium sulfate, tricalcium phosphate used in combination with hydroxapitite (both osteoconduction and resorbablity), calcium phosphate cement.[3,4,5] These materials combine with the growth factors to increase biological activity.

Bioactive glass

Bioactive glass comprises of sodium calcium salts, phosphates, silicon dioxide. It is used in irregular particle sizes measuring 90-170 µm (perioglas) or 300-355 micrometer (Biogran). Surface of the particles get coated with hydroxyl-carbonate apatite when this material comes in contact with tissue fluids, which attracts bone forming osteoblasts. It's use does not induce an inflammatory response, for silica-based bio-glasses their resorption completes within 6 months.[7] In recent years, phosphate or borate-based bio-glasses have been developed.[7]

Calcium phosphate cements

Brown and Chow in 1986 invented Calcium phosphate cements. It's bioresorbable in nature and can stay in the body in the body for up to 2 years without resorption, depending on its formulation. Its major advantage is the ability of this paste to shape it according to the complex bony cavity, ignoring the gaps between the implant and the bone. CPC is brittle. It should be used selectively as the clinical outcomes seems not better than the autologous bone or methymethacrylate.[8]

Beta-tri-calcium phosphate ceramics

Beta-TCP ($Ca_3(PO_4)_2$) has been popularly used for dental applications. It is considered as a gold standard for the synthetic bone substitute.It is bioresorbable, biocompatible, osteoconductive in character. Beta-TCP resorbs and completely replaced by remodeled bone within 13-20 weeks after the implantation procedure. Various reports have shown very few complications like infection or nonunion.[9] Though it has suitable mechanical resistance, it is considered lower when compared to the mechanical resistance of cancellous bone or of the allograft bone. Thus it's use should be selective.[10]

Hydroxyapatite

Hydroxyapatite (HA) belongs to the apatites family, of crystalline compounds with crystalline hexagonal lattice. Being a primary mineral component of teeth ($Ca_{10}(PO_4)_6(OH)_2$), it is extremely biocompatible[7] without a risk of inflammatory response. However, the resorption of HA is very slow retained for at least 3 years after the implantation. With a slow bone ingrowth and cell colonization.HA acquires good mechanical properties with a compression resistance of upto 160 MPa, probably to be used in small bone defects with low loading condition.

Xenogenic bone graft

Xenografts are obtained and transferred between different species. Its use was first reported in 1889.[1] They are usually derived from bovine source. The considerable advantage of this graft is the availability in abundance and low cost. They can be used in conjugation with various growth factors such as BMP, PRP. In addition to it this bone graft requires placement of a membrane for its stability due to its poor handling properties.[5]They are used as a calcified matrix.[4]

Growth factors

Bone graft materials are commonly used in conjunction with the growth factors to enhance their properties.

1. Bone morphogenic proteins (bmp)
2. Platelet rich proteins (prp)

CONCLUSION

Autogenous bone as a graft material is considered as the gold standard for grafting purposes. The surgeon should have a good knowledge of properties of each bone graft material and should know when to select which type of bone substitute. Most common use of bone grafts in dentistry is in placement of dental implants, for atrophic ridges of edentulous jaw, filling the cavity defect, reconstruction of bone defect due to tumor or cyst removal. Beta-tri-calcium phosphate ceramics, being the gold standard of synthetic bone graft substitute**.** Various reports have shown very few complications like infection or nonunion. Therefore, its use should be selective.

REFERENCES

1. McAllister BS, Haghighat K. Bone augmentation techniques. J Periodontol 2007; 78:377-396.
2. Sethi AK, Kar IB, Mohanty T, Mishra N, Singh AK. Use of plasma-enriched demineralized freeze-dried bone matrix in postsurgical jaw defects. Natl J Maxillofac Surg 2018;9:174-83.
3. Sohn HS, Oh JK. Review of bone graft and bone substitutes with an emphasis on fracture surgeries. Biomaterials Research2019;23;9;1-7.
4. Kumar P, Vinitha B, Fathima G. Bone grafts in dentistry. J Pharm Bioall Sci 2003;5:125-127.
5. Moussa NT, Dym H. Dent Clin N Am2020;1-18.
6. Dadwal H, Sharma P et al. Recent advancements in the reconstruction of jaw defects: A review. IJDSIR2019;2(5)215-227.
7. de Grado F, Keller L, Gillet YI, Wagner Q, Musset AM, Jessel NB, Bornert F, Offner D. Bone substitutes: a review of their characteristics, clinical use, and perspectives for large bone defects management. Journal of Tissue Engineering 2018; 9:1-18.
8. Afifi AM, Gordon CR, Pryor LS, et al. Calcium phosphate cements in skull reconstruction: a meta-analysis. Plast Reconstr Surg 2010; 126(4): 1300–1309.
9. Gaasbeck RDA, Toonen HG, van Heerwaarden RJ, et al. Mechanism of bone incorporation of β-TCP bone substitute in open wedge tibial osteotomy in patients. Biomaterials 2005; 26: 6713–6719.
10. Gouin F, Yaouanc F, Waast D, et al. Open wedge high tibial osteotomies: calcium-phosphate ceramic spacer versus autologous bone graft. Orthop Traumatol Surg Res 2010; 96(6): 637–645.