IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 21, Issue 5 Ser.1 (May. 2022), PP 22-27
www.iosrjournals.org

Biological and Clinical Aspects of Autogenous Bone Graft with Periodontal Perspective: A Review

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Abstract: *Periodontal disease affects both soft and hard tissue of periodontium leading to gingival inflammation, periodontal pocket/ gingival recession, alveolar bone loss and tooth loss in advance stages. Also, various developmental, mechanical, chemical and thermal traumas result in osseous defects around tooth. Although, different types of bone grafts such as allograft, xenograft and alloplast are available in market to regenerate the defect site, which can be used based on their properties; but the most predictable and gold standard material is autogenous bone graft (harvested from the same individual). Autogenous bone graft has the inherent property of regeneration due to the presence of viable osteoprogenitor cells. Additionally, it has no immunological reaction, more economic and can be harvested from the regional site with minimal trauma or secondary surgical site with different procurement device available. It can be used in management of periodontal intrabony and furcation defects, pre-prosthetic ridge augmentation, sinus lift procedures, guided bone regeneration etc. Furthermore, it can be harvested in different forms and can be combined with different type of graft materials to increases potential and outcome of the regenerative procedures. All the dental clinicians should be well accustomed with the properties of autogenous bone graft as comprehensive periodontal regeneration is unpredictable. Therefore, this review is an attempt to discuss the biological and clinical aspect of autogenous bone grafts in periodontal regeneration.*

Key Words: *bone grafting, bone regeneration, furcation defect, osseous defects, periodontal regeneration,*

Date of Submission: 22-04-2022 Date of Acceptance: 06-05-2022

I. Introduction

Autogenous bone grafts (ABG) are defined as osseous graft taken from a single anatomic site and transplants it to another site within the same individual. It is considered as gold standard treatment option for osseous defect regeneration. They inherently fulfil most important requirements necessary for the bone regeneration, namely; ostogenesis, osteoinduction and osteoconduction due to presence of live osteoprogenitor cells, osteoblast, scaffold, signalling molecule and do not evoke any immunological response in the patient. Osteogenesis can be described as an organic material capable of forming bone directly from osteoblast1. Osteoinduction refers to the ability of the graft to recruit pluripotent mesenchymal stem cells that differentiate into bone-forming osteoblasts and chondroblast. Osteoconduction refers to the geometric scaffolding, which provides an environment for new bone apposition by supporting host capillary ingrowth, perivascular tissue, and osteoprogenitor cells2.

II. History Of Autogenous Bone Grafts

History of grafting is as old as, when one of Adam's ribs was used to create Eve. In modern age it was surgeon Job van Meekeren in 1668, performed the first heterologous grafting procedure on an injured soldier by inserting a fragment of dog skull and after sometime it was found to be fully incorporated3. The structure of bone, which was described by Antoni van Leeuwenhoek in 1674 and gave the concept of haversian canal. In 1743, Duhamel published the results of his experiments on animals and suggested that the periosteum has a pivotal role in the process of osteogenesis (De Boer 1988, Glicenstein 2000)4. In 1820 a German surgeon Philips von Walter, perform the first autologous grafting by replacing a fragment of cranium after trepanation. Leopold Ollier in 1961 studied the phenomenon of bone regeneration and published a document by name "Traité de la régénération des os", describing the term bone graft ("greffe osseuse") for the first time. Scottish surgeon, William Macewen, in year 1880 replaced a mandibular fragment with a graft of rib bone. Phemister in 19145 introduced the modern concept of bone reabsorption "creeping substitution" stated that, "the living cells

on the graft surface proliferate and deposit around the graft lamellae of new bone that gradually replace the dead part inside the graft. The time needed to accomplish this replacement may vary from three months to a year, or even longer depending on the size and thickness of the graft"5. F. H. Albee in 19156 introduced the "rules for using bone grafts", the grafts used by Albee were all autologous. The use of bone grafts for reconstructing intraosseous defects produced by periodontal disease by Hegedus in 19237. Nabers and O'leary, in 19658 treat one, two-wall defect by cortical bone shavings removed by hand chisels during osteoplasty and ostectomy. Urist in 19659 gave the concept of osteoinduction by bone morphogenic protein (BMP) which stimulate the immature cells to differentiated cells and form bone. The objectives of bone graft therapy as stated by Schallhorn et al. in 1970 included10:

• Probing depth reduction
• Clinical attachment gain
• Bone fill of the osseous defect
• Regeneration of new bone, cementum, and periodontal ligament.

III. Types Of Autogenous Bone Graft

A) On the basis of structural form

1.Cortical Bone Graft

Autogenous cortical bone graft, provides an osteoconductive medium best for structural defects that gives immediate mechanical stability required for healing. Therefore. it can be used in ridge augmentation procedure to provide mechanical support and structural stability to resorbable collagen membrane to collapse into the defect. But it has minimal osteoinductive and osteogenic properties. The dense cortical matrix results in relatively slow revascularization and incorporation. As resorption must occur before the deposition of new bone (reverse creeping substitution), limited perfusion and donor osteocytes make this option poorly osteogenic. Nabers and O' Leary (1965)8 have reported a coronal increase in bone height by using cortical bone chips in periodontal defects. Particle size for autologous bone grafts from 125 μm up to 2 mm were reported as preferable. A critical minimum value of particles less than 75-125 μm are rapidly resorbed, and do not participate in effective osteogenesis. These observations could be related to an increased release of growth and/or differentiation factors from the larger surface11. Particles of bone graft which have too small size does not leave enough interparticular space or large enough pores to allow for the migration and ingrowth of cells, blood vessels and bone. Minimum pore size between particles of greater than 100 μ is needed to allow proper vascularization and bone formation12. Studies by Chen et al13 and Ozaki and Buchman14 confirm that cortical grafts in the onlay position show only superficial revascularization occurring in the first 10 to 21 days, and central revascularization by 8 to 16 weeks.

2.Cancellous Bone Graft

Cancellous bone graft provides more osteoinductive and osteogenic substrate, due to porous trabeculae which are lined with functional readily available osteoblasts, resulting in a graft that is highly osteogenic. After implantation, a portion of the donor osteocytes survives, and these osteocytes, combined with graft porosity and local cytokines, promote angiogenesis and host mesenchymal stem cell recruitment. Which turns preosteoblast to osteoblast and lay down the new bone by signalling molecule i.e., bone morphogenic protein (BMP). BMPs belongs to transforming growth factor (TGF)-β-family of growth factors which releases in response to trauma or in bone remodelling phase15.The new blood vessel which arrives from the host bone and enter the graft at the rate of up to 0.5 mm/day16. Neovascularization occurs within the graft as early as 2 days after implantation17.

3.Corticocancellous Bone Graft

Cortico-cancellous bone grafts offer the advantages of both cortical bone by providing rigidity which helps in immediate structural stability and cancellous bone in osteoinductive and osteogenic capabilities via BMPs and viable osteoblastic cells.

4. Intraoral and Extraoral Cancellous Bone and Marrow

Marrow contains an abundance of primitive reticular cells which have pluripotential competence. Extraoral marrow obtained from the iliac crest having hematopoietic character as compared to intraoral marrow spaces which has fattier of fibrous in nature. Intraoral marrow can be obtained from maxillary tuberosity, healing extraction socket and retromolar area. Hiatt and Schallhorn in 197318 found an average fill of 3.44 mm in periodontal defects.

On the basis of clinically used form

1. Osseous Coagulum and Bone Blend

Robinson in 196919 described mixture of bone dust and blood that he termed as osseous coagulum. In a study done on monkey's small bone particles of 100 um could provide an earlier and greater osteogenic activity than

particles 10 times as large20 the use of such material is based on the principle that the small particle size is resorbed and replaced by host tissue. Bone blend are formed to overcome the disadvantages of osseous coagulum as their collection is difficult and the quality of graft is also hampered. When the bone of either form cortical or cancellous harvested by bone rongeurs or trephines, placed in an amalgam capsule and triturated to the consistency of a slushy osseous mass with a particle size in the range of 210 × 105 μm, is bone blend. In comparison to open flap debridement intrabony defect treated with osseous coagulum formed by intraoral sources shows an average bone fill of 2.98mm whereas 0.66mm by open flap debridement21.

2. Autogenous Bone Chips

It can be obtained by particulating the previously harvested bone block by bone mill from the intraoral or extraoral site or from the bone collecting device while doing osteotomy. Particle size ranges from 100 and 300μm22.

3. Block Grafts

Bone blocks can be obtained in corticocancellous form which provide the advantages of both cortical and cancellous portion as rapid vascularization due to coarse trabeculae of cancellous bone and cortical bone provide stability and resistance to deformation. Block grafts can be used for the reconstruction of severely resorbed alveolar ridge in horizontal, vertical or in combined ridge defects23 loss of bone due to trauma, periodontal problem, tooth loss following oncological procedures as pre-prosthetic management before implant placement. The stabilization of block graft can be achieved by bone fixation screw leading to intimate contact to the recipient bone as it is considered as crucial for successful outcome of procedure.

Wang and Boyapati in 200624 gives the "PASS principle" for the successful regeneration of bone where P stands for primary wound closure. It is necessary because it creates an environment that is undisturbed/unaltered by outside bacterial or mechanical insult. P for passive closure of wound edges that enables the wound to heal with less reepithelialisation, collagen formation and remodelling, wound contraction, and overall tissue remodelling. A for angiogenesis it is important to creates an initial blood clot after which it is removed by neutrophils and macrophages that leads to the formation of granulation tissue which is rich in new blood vessels, and these vessels are important for the percussors cells which lay down the osteoid formation leading to mineralization of woven bone. Space is needed to ensure the proliferation of slowly migrating osteoblast cells to populate the wound, resulting in enhanced bone formation while excluding unwanted epithelial and connective tissue cells. S for clot adhesion and wound stabilization which is necessary for wound healing it provides various growth factors (platelet derived growth factor, insulin-like growth factor, fibroblast growth factor), cytokines (interleukin-1, interleukin-8, tumour necrosis factor) and signalling molecules that recruit clearing cells to the wound site. The blood clot serves as the precursor of initial highly vascular granulation tissue. The granulation tissue is then the site of initial intramembranous bone formation and remodelling.

Recipient bed preparation with decortication of bone works on "Regional Acceleratory Phenomenon"25. It enhances revascularization in the grafted site also release platelet derived growth factor (PDGF), BMPs (BMP-2, 4, 6, 7) and availability of osteoprogenitor cells26. The trabecular portion of the donor is placed on the host bone and the cortical aspect is positioned on the surface of the graft. The trabecular portion will provide living bone cells and process of osteogenesis will start, along with there is realise of BMP for osteoinduction so it should be placed closest to the new blood vessels. The cortical graft supports as scaffold provide surface for osteoconduction. This orientation is called as "orthotopic bone graft transplantation" which was described by Mowlem27. The healing of autogenous block grafts has been described as "creeping substitution" where viable bone replaces the necrotic bone within the graft, and is highly dependent on graft angiogenesis and revascularization. In a systematic review on intraoral onlay block grafting, it was found that implant survival rates ranged from 96.9% to 100%, while for vertical augmentation they ranged from 89.5% to 100%28.

Mechanism of healing and incorporation is same but the rate of healing and amount of bone formation of autogenous block bone graft may differ with different donor site. It depends upon various factors how much is the amount of cellular marrow transplanted along with donor bone, the vascularity of the recipient tissue bed, and the stability of the graft29.

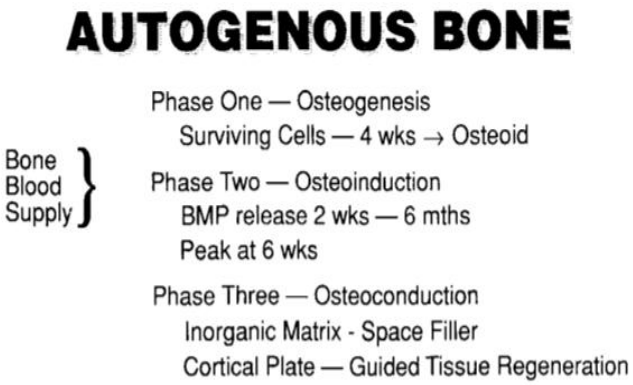

Figure 1: phases of autogenous bone harvesting 16

IV. Site To Harvest Autogenous Bone Graft

Bone can be endochondral or intramembraneous in origin, intramembranous bone is thought to undergo less resorption than endochondral bone. The calvaria, maxillary bones, mandibular body and ramus are of intramembranous origin, whereas the mandibular condyles are of endochondral origin30. The advantages of using mandibular donor site are that it will increase the bone volume and quality or bone density of recipient site. Increased bone density of the recipient site is replicated from symphysis (bone density D-1 and D-2) or ramus (D-2) as donor sites with minimal bone resorption (0%–20%)31. Due to the ectomesenchymal origin of mandible it has better potential for incorporation with recipient site because of a biochemical similarity in the protocollagen of the donor and recipient bone32. There are different intraoral sites from where graft can be harvested like ascending ramus, symphysis, anterior nasal spine, maxillary tuberosity, coronoid process and zygomatic buttress area as per size of the defect33. Extraoral sites can be fibula, iliac crest, tibia, ribs and cranium they provide larger graft volumes, required in cases of large bone deficiency repair. Disadvantages of extra-oral grafts are, it need general anaesthesia, hospitalization, increased morbidity, technique sensitive with clinicians advanced training2.

Table No.1 Comparison of Different Donor Sites2,32,34,35

Site	Bone type	Size (in mm)	Graft resorption	Advantage	Disadvantage	Complications
Symphysis	D1	5-15	Minimal	Easy to harvest corticocancellous bone, large amount	Several post-operative complications, moderate post operative pain and edema	Mental nerve paraesthesia – altered lower lip sensation, chin ptosis, opening of suture line
Ramus	D1, D2	5-10	Minimal	No facial deformity, less post operatory pain and edema	Difficulty in access	Damage of inferior alveolar or/and lingual nerve, Trismus, Hematoma, Fracture
Tuberosity	D4	5	Moderate	Low morbidity Easy bone harvesting Corticocancellous bone Presence of osteoprogenitor cells	Poor quality and quantity of bone, cannot be harvested when 3rd molar is present	Oroantral fistula Hematoma
Zygomatic buttress	D1, D2	2-5	Minimal	Easy bone harvesting Corticocancellous bone	Limited bone quantity	Ocular complications
Coronoid process	D1	5-10	Minimal	No scarring, Low morbidity	Technique sensitive	Trismus, Damage of buccal branch of trigeminal nerve
Anterior nasal spine	D3	2	Moderate	Easy bone harvesting Low morbidity	Limited bone quantity	Basement membrane perforation, Aesthetic alterations

V. Devices Of Procurement Of Autogenous Bone Grafts

Autogenous bone can be harvested by conventional rotatory burs, trephines, bone scrapers, bone chisels, rongeur pliers, and piezoelectric devices. As compared to conventional burs, piezo surgical unit improves operators' sensitivity and control with much less hand pressure. Works in High-frequency oscillations between 24,000 and 29,500 Hz, modulated with a low frequency between 10 and 60 Hz, which improves the healing. Advantages of piezo it does not work in contact to soft tissue, only cuts the bone so it does not damage

the nerve36. It provides bloodless surgical site due to its cavitation effect that makes visibility in the working area much clearer. Piezosurgery inserts do not become hot, which again reduces the risk of postoperative necrosis37. Liang et al. (2010)38 compare the osteoblastic activity and osteogenic potential of autogenous bone graft harvested by bone scraping, low speed drilling, and bone trap filtering it was found that scraper and low-speed drill has more osteoblastic activity and osteogenic potential as compared to bone trap, while osteoinductive proteins are more in low-speed drill as compared to scraper. Miron RJ and Buser et al. (2011)39 compared autogenous bone harvested by bone mill, piezo-surgery, bone scraper, and bone drill (bone slurry) there ability to promote an osteogenic response and found that significantly a greater number of osteogenic cells, elevated mRNA levels of collagen, osteocalcin, and osterix in bone mill and scraper as compared to piezo-surgical unit and bone slurry. Miron RJ et al. (2012)40 found that cell viability is more in bone scraper and bone mill as compared to piezosurgical unit and bone slurry. In conventional burs there is overheating of bone along with metallic contamination leading to toxic effects on living cells and structural bone changes22.

VI. Conclusion

Autogenous bone graft has special property of osteogenesis making it superior to any other bone grafts can be used in ridge augmentation procedures, management of furcation, intrabony defects or in sinus lift procedure. It can be harvested from regional intraoral site, without secondary surgical site and can be done under local anaesthesia in different form like particulate or block form according to defect morphology and patient need, with no immunological reactions and easily harvested using piezo surgical unit. It has been used since centuries as it can be mixed with other type bone graft available in market depending upon the patient and clinician perception and gives the predictable results.

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Dr. Sakshi Chokhandre, et. al. "Biological and Clinical Aspects of Autogenous Bone Graft with Periodontal Perspective: A Review." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, 21(05), 2022, pp. 22-27.