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Review on recent advancements of bone regeneration in dental implantology

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Abstract
Dental implant is an artificial tooth root that is placed into your jaw to hold a replacement tooth or bridge. The use of dental implant for recuperation of missing teeth has expanded treatment options for both patients and clinicians. As a result of recent advancements and researchers in implant designs, materials and techniques the use of dental implants has increased tremendously over the past decades and is expected to expand further more in the future. The patients present with inadequate bone volume represent clinical complexity and often requires additional biomaterials and surgical procedures in order to ensure successful implant treatment. This review outlines the various graft materials used in bone augmentation in order to achieve predictable long term success of dental implants and on the recent advancement in the bone regeneration.

Keywords: Bone regeneration, dental implants, sinus floor elevation, grafts, augmentation

Introduction
Bone loss followed by extraction is a common physiological phenomenon. However this phenomenon takes place with alveolar resorption and subsequent formation of bone within the socket followed by osteoblastic differentiation and osteoprogenitor cells [1, 19]. The rehabilitation of missing teeth with dental implant prosthesis has tremendously increased in clinical practices.

The quantity and quality of available bone on the recipient site attributes to the success of dental implants [2]. Certain factors like periodontal diseases lead to necessity of bone augmentation. Several methods are available to augment the deficient ridge which involves guided bone regeneration, block bone grafting sinus/nasal floor bone regeneration, block bone grafts in sinus/nasal floor bone grafting, interpositional grafting, ridge expansion, protected bone regeneration (titanium mesh), and distraction osteogenesis [1, 19]. A broad range of bone grafting materials, including bone grafts and bone graft substitutes have been applied and evaluated clinically, including autografts, allografts, xenografts and alloplasts.

Classifications
Classification of bone grafts based on material groups [1, 3]:

a. Allograft-based bone graft involves allograft bone, used alone or in combination with other materials (e.g., Grafton, Ortho Blast).
b. Factor-based bone graft are natural and recombinant growth factors, used alone or in combination with other materials such as transforming growth factor (TGF-beta), platelet-derived growth factor (PDGF), fibroblast growth factors (FGF), and bone morphogeneic protein (BMP).
c. Cell-based bone grafts use cells to generate new tissue alone or are added onto a support matrix, for example, mesenchymal stem cells.
d. Ceramic-based bone graft substitutes include calcium phosphate, calcium sulphate, and bioglass used alone or in combination; for example, Osteo Graf, Pro Osteon, Osteo Set.
e. Polymer-based bone graft uses degradable and nondegradable polymers alone or in combination with other materials, for example, open porosity polylactic acid polymer.

Hyatt and Butler [4, 5] have classified tissue grafts as follows:

a. Autograft: Tissue taken from one operative site and grafted in another operative site within the same individual.
b. Homograft/allograft: Tissue taken from one operative site in one individual and grafted in the operative site in another individual of the same specie
c. Heterograft/xenograft: Tissue taken from one individual and grafted in the operative site of another individual of the different species
d. Syngensio grafts: Tissue graft removed from blood related relatives
e. Orthotopic graft: Tissue grafted into an anatomical site normally occupied by that tissue, for example, bone to bone and skin to skin.

Carranaza and Newman [6] have broadly classified bone as shown in Table 1.

Table 1: Carranza (1999) classification of bone graft materials

Autogenous bone		Allograft	Xenograft	None bone graft materials	Alloplast
Bone from intraoral site- Osseous coagulum Bone blend Intraoral cancellous bone marrow transplant Bone swaging	Bone from extraoral sites- Iliac crest Tibia	Freeze dried Decalcified freeze dried bone allograft	Calf bone Kiel bone Anorganic bone	Sclera Cartilage Plaster of paris Calcium phosphate biomaterials Hydroxyl apatite Tricalcium phosphate	Porous hydroxyapatite Non - porous hydroxyapatite HTR polymer Beta tricalcium phosphate Bio-active glass ceramics

Autogenous Bone Graft

An autogenous bone graft is the transplantation of bone from one site within the same person. One of the most complex challenges in implant density is the treatment of large bone defects or deficiencies. Successful regeneration requires the essential components of cells, scaffold and signaling molecules [7, 8]. Autogenous bone graft is the only graft which is considered as the gold standard of bone regeneration as it possesses all of the following properties: osteoinduction, osteoconduction and osteogenesis. Additionally there are no immunogenic complications. The downsides to autograft are the finite quantity available and the donor site morbidity. The bone marrows for grafting defects are generally obtained from iliac crest. The most common disadvantage of autogenous graft is that it requires an extra surgery, usually at the iliac crest, if the patient has large enough supply of bone. This in turn can lead to massive blood loss [9].

Allogenic Bone Graft

Allogenic bone is non vital, osseous tissue harvested from one individual and transferred to another of the same species. Three forms of allogenic bone include fresh frozen, Freeze dried and demineralized freeze dried. Fresh frozen is however rarely used due to the concern related to transmission. The source is usually from a cadaver bone, which is subjected to a treatment sequence which renders its natural to immune reactions and help to avoid cross contamination of host diseases [10]. The major drawback of this graft is that it exhibits a higher resorption rate and a large immunogenic response and less revascularization of the graft [11, 12].

Xenograft

It is the tissue removed from an animal donor and surgically transplanted to a human. A xenograft is most popularly known as bovine organic cancellous bone. It is mainly produced by subjecting bovine bone to a special purpose, which thereby removes its organic components and retains its organic structure. The product so formed contains biological apatite crystals [5]. Long term studies have demonstrated that there is lack of osteogenic response when a xenograft is implanted into either hard or soft tissues [13-15]. Xenografts have also a disadvantage of transmission of bovine or procure viruses or other infective agents.

Alloplastic Materials

The term alloplastic indicates that the material is produced from inorganic sources and contains no animal or human components. Alloplastic materials after a prepacked solution to common reconstructive surgical problems without the need of autogenous grafting and donor site morbidity. The available alloplastic materials include plaster of paris, polymers, calcium carbonate and ceramics. Ceramics are further classified to resobable (eg: tricalcium phosphate and resorbable HA) and non resorbable (dense HA, porous HA and bioglass) [5].

Bioglass developed by Hench is one of the latest and promising substitutes for bone graft materials.

Growth Factors

Among various growth factors widely used, BMP(Bone Morphogenic Proteins) requires special mention as they induce osteogenic precursor cells into osteogenic cells and have shown tremendous bone growth in many clinical studies [16]. Other growth factors apart from BMP include

1. Platelet derived growth factor
2. Transforming growth factor-β
3. Insulin-like growth factor (1)
4. Vascular endothelial growth factor
5. Fibroblast growth factor

Graftless Approch

The introduction of CBCT to the dental office has been integral to this minimally invasive trend. The ability to more accurately diagnose available bone and visualize anatomy enables the clinician to manage cases wit marginal conditions. It also permits the use of computer guided surgery with a flapless approach to further decrease morbidities. Although patients may tend to prefer a minimally invasive approach, dentist should not disregard options that require bone grafting. In ‘graftless’ approach the treatment planning is done by avoiding the need for bone grafting. Reduced diameter or shorter implants maybe utilized when minimal available bone volume is present.

Tissue Engineering

Tissue engineering may be used to regenerate bone by combining cells from the body with growth factors and scaffold cells from the body with growth factors and scaffold biomaterials (Kraigler et. al. 2012). This combination of cells, signaling molecules and scaffold is often referred to as the tissue engineering triad. Growth factors are naturally occurring signaling proteins that can recruit cells and stimulate cell prolitration and differentiation.

Maxillary Sinus Lift (Lateral Approach)

One of the most challenging situations in implant dentistry is the deficiency of the bone in the posterior maxillary region. Resorption of alveolar process due to loss of posterior maxillary teeth causes expansion of sinus cavity into alveolar process. This in turn results in the lack of quantity and quality of bone for implant placement. In this technique bone augmentation is done following a sinus floor elevation with involves elevating the schneiderian membrane from the maxillary sinus floor. Maxillary sinus grafting may also be combined with nasal inlay grafting if the bone volume in the sub nasal area for placement of implants also needs to be increased.

Maxillary Sinus Elevation (Trans Alveolar Aproach)

Maxillary sinus elevation using trans alveolar approach can be recommended in sites with adequate alveolar crest width, initial height of 5mm and flat sinus floor anatomy. This method is considered to be less invasive which involves gentle fracturing by moving the sinus floor and usually performed with the help of osteomers.

Split-Ridge/ Ridge-Expansion Technique

Split ridge/ridge expansion technique refers to the creation of a linear groove in the middle of the ridge with rotary burs or a piezosurgery device and deepening this groove with an osteotome chisel. The lingual or palatal cortical bone is used as a guide and careful tapping with a mallet will advance the chisel into the cancellous part of the bone [15, 16]. It is indicated in utrophic edentulous ridge.

Vertical Distraction Osteogenesis

This technique is mainly used to increase the height of alveolar ridge. In this technique there is creation of new bone along with adjacent soft tissue after gradual and controlled displacement of a bone fragment obtained by surgical osteotomy.

Conclusion

One of the major challenges in implant dentistry is the treatment of large bone defects or deficiencies. Although four categories of grafts are present, autografted is the only one considered to be of gold standard due to its osteoinductivity, osteoconductivity and osteogencity. Traditional approaches are abandoned nowadays by the clinicians as new and less innovative procedures provide better results.

Various bone regenerative materials in the form of gels, particle and scaffolds have also been designed with the help of nanotechnology and engineering and have opened up a new horizon for bone regeneration [17, 18]. The clinicians should however take into account the higher costs of newer tissue engineering techniques against the benefits of simplified surgery, enhanced biologic response, and potential for reduced morbidity.

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