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BONE GRAFT: AN OVERVIEW

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Abstract

Background: *Of the many methods used to repair skeletal defects in reconstructive orthopaedic surgery, bone grafting is involved in virtually every procedure. Grafts serve both a mechanical and biologic function. The science of bone grafting has improved immensely, particularly in the last 20 years, with principles of cellular and molecular biology now incorporated into procedures following the marked improvement in understanding osseous healing. Bone grafts are used across different aspects of reconstructive orthopedics, from the basic treatment of fractures to major limb salvage procedures and complex spinal reconstructions*

Methodology: *We conducted this review using a comprehensive search of MEDLINE, PubMed, and EMBASE, January 1985, through February 2017. The following search terms were used: bone grafts, types of bone grafts, allograft, xenograft, autograft, synthetic graft, graft harvest*

Aim: *In this review, we aim to study the overview of bone grafts, their classification, and how they are harvested*

Conclusion: *In the past few decades, several materials and techniques are being used in bone graft. Some of the products used can be biological, while many are synthetic. Each type of material has its own set of advantages and disadvantages. After the bone is grafted, the body can have variable response, depending on graft type and host immunity. Therefore, proper selection of graft type and harvest location is very crucial for good prognosis and desirable results.*

Keywords: *Bone graft, autograft, allograft, grafting strategies, grafting alternatives*

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INTRODUCTION:

The treatment of post-traumatic skeletal conditions such as delayed unions, non-unions, malunions, and other problems of bone loss is challenging. In a majority of cases, restoration of alignment and stable fixation of the bone can be sufficient for a successful reconstruction. However, in most cases, bone-grafting or bone transport are required to stimulate bone-healing and fill bone defects [1]. Of the many methods used to repair skeletal defects in reconstructive orthopaedic surgery, bone grafting is involved in virtually every procedure. Grafts serve both a mechanical and biologic function. The science of bone grafting has improved immensely, particularly in the last 20 years, with principles of cellular and molecular biology now incorporated into procedures following the marked improvement in understanding osseous healing. Bone grafts are used across different aspects of reconstructive orthopedics, from the basic treatment of fractures to major limb salvage procedures and complex spinal reconstructions. Several factors indicate the success of a graft integration, including the type of bone graft, the site of implantation, the vascularity of the graft and the host-graft interface, the immunogenetics between the donor and the host, preservation techniques, local and systemic factors and the mechanical properties that depend on the size, shape, and type of graft used [2].

METHODOLOGY:

- **Data Sources and Search terms**

We conducted this review using a comprehensive search of MEDLINE, PubMed, and EMBASE, January 1985, through February 2017. The following search terms were used: bone grafts, types of bone grafts, allograft, xenograft, autograft, synthetic graft, graft harvest

- **Data Extraction**

Two reviewers have independently reviewed the studies, abstracted data, and disagreements were resolved by consensus. Studies were evaluated for quality and a review protocol was followed throughout.

The study was approved by the ethical board of King Abdulaziz University Hospital

EMERGENCE OF BONE GRAFT:

Studies show that more than 500,000 bone-grafting procedures are performed every year in the United States, with approximately half of these procedures related to spine fusion. Globally, the numbers are easily double those of the United States, and research indicates a shortage in the availability of musculoskeletal donor tissue that is normally used in such reconstructions. The majority of bone-grafting procedures are spine fusions (50%), followed by general orthopedic procedures and craniomaxillofacial procedures. This potentially represents a market as large as $2 billion per for bone repair enhancers or bone graft substitutes (Data Monitor, personal communication) [3].

The major reason for performing the most common of these procedures, the spinal fusion (arthrodesis), is either instability (excessive motion) of a spine segment or a deformity that is at risk for progression. Most fusions are performed to treat degenerative disorders, with the lumbar spine the most common site of procedures. Although spinal fusion is commonly attempted, non-union is reported to occur in 5% to 45% of patients. Even though this is a disturbing statistic, it also means spine fusion provides an ideal venue for testing bone augmentation devices. The healing of a spine fusion is much better for showing healing progression and improvement on a spine fusion than it is in healing of a fracture repair. Another reason bone augmentation tests are done in spine fusion is that an inadequate supply of autogenous bone graft for performing multilevel spinal arthrodesis [4].

TYPES OF GRAFTS:

As defined by Muschler and Lane, a bonegraft material is any implanted material that, alone or in combination with other materials, promotes a bone healing response by providing osteogenic, osteoconductive, or osteoinductive activity to a local site. An osteogenic material can be defined as one which contains living cells that are capable of differentiation into bone. An osteoconductive material promotes bone apposition to its surface, functioning in part as a receptive scaffold to facilitate enhanced bone formation [2].

Bone graft materials can be divided broadly into autograft, allograft, xenograft, synthetic materials, and combinations thereof.

- Autograft (autogenous graft) refers to bone tissue harvested from and implanted in the same individual. Autograft preparations include aspirated bone marrow, cancellous or cortical bone, or vascularized grafts. Vascularized bone autografts and cancellous graft inserted into a healthy host site may be simultaneously osteogenic (because of the viable cells), osteoinductive (because of the matrix proteins), and osteoconductive (because of the bony matrix). Although only a small fraction of the cells transplanted within devascularized segments of autograft bone survive, they may contribute to an improved healing response [5].

- An allograft is defined as tissue that has been harvested from one individual and implanted into another individual of the same species. In this setting, the host is expected to mount an immune reaction against cells of a fresh allograft, so, when implanting bone allografts, cells are removed thoroughly to minimize immunologic rejection, making it different from typical solid organ transplants. a bonegraft material is any implanted material that, alone or in combination with other materials, promotes a bone healing response by providing osteogenic, osteoconductive, or osteoinductive activity to a local site. An alloimplant might be a better term to describe a bone allograft where cells have been removed thoroughly, though the term is not used commonly by surgeons today [6].

- Xenograft is bone tissue harvested from one species and implanted into a different species. A vigorous immune response precludes the use of most xenograft preparations.

Deproteinated and defatted xenograft bone (Kiel bone or Oswestry bone) shows reduced immune response, but this process also destroys osteoinductive matrix proteins. One study reported osteogenesis in animals and humans when processed xenograft bone was supplemented with autologous bone marrow, but human allograft materials are considered more effective and more widely available at this time. Processed bovine collagen derived from bone or skin seems to be biocompatible and is a component of several evolving bone graft preparations. Collagen is a flexible substrate material, which can be prepared as a gel powder, sponge, paper, or feltlike mesh, depending on methods of preparation and cross-linking [7].

- Synthetic materials have greatly expanded the available tools for bone grafting. Various extracted or synthesized protein growth factors and adhesion molecules. and synthetic osteoconductive materials are becoming available for use in orthopaedic surgery.

These materials vary greatly in osteoconductivity and osteoinductivity, and in mechanical strength, handling properties, and cost [8].

INCORPORATION:

The term incorporation is used to describe the biologic interactions between graft material and host site that result in bone formation leading to adequate mechanical properties. Responses such as the host's inflammatory reaction following surgical trauma from preparation of the graft site, the host's immune reaction to the graft material, and the processes of migration, differentiation cell proliferation and revascularization leading to new bone formation and union between graft and host [9].

There are 5 main biologic events that occur in the graft and graft site during incorporation [9]:

1) Formation of hematoma accompanied by release of cytokines and growth factor
2) Inflammation, migration, and proliferation of mesenchymal, along with fibrovascular tissue development around the graft
3) Invasion of vessels into the graft, often via existing Haversian and Volkmann canals
4) Focal osteoclastic resorption of graft surfaces
5) Intramembranous and/or endochondral bone formation on graft surfaces

OPTIMUM SITES FOR HARVESTING:

Autograft bone can be harvested from a number of different locations, including distal femur, distal tibia, proximal tibia, proximal humerus, iliac crest and distal radius. In addition, vascularized bone grafts from the rib, iliac crest, and fibula as well as intramedullary reamings from the tibia or femur have been used previously as sources of autologous bone. Among all of these different locations, the iliac crest and morselized bone graft from the femoral diaphysis are the most commonly used. There is emerging evidence to suggest that bone harvested from the iliac crest contains factors and cells that stimulate angiogenesis and vascularity. In terms of graft volume, the crest is superior to other conventional sites of harvest [10].

A number of criteria are relevant when evaluating the quality of an autograft source [11]:

1) Assessment of the components of the fracture-healing process provided by the graft, including osteoconduction,

osteoinduction, osteogenesis, and vascularity.

2) Analysis of practical issues, such as the volume of graft obtainable and the ability to obtain structural support from the graft (eg, tricortical iliac crest).

3) The morbidity and potential complications associated with the harvest should be considered.

4) Clinical results/efficacy and the cost of the graft source are of clear importance.

Recently, there has been a great amount of research and clinical interest in a potential “new standard”. The new novel method for harvesting intramedullary reamings from the canal of the femur or tibia involves using the reamer–irrigator–aspirator (RIA). Evidence suggests that the RIA graft even possesses potentially superior osteoinductive and osteogenic properties compared to the ICBG graft, while possessing equivalent osteoconductive and angiogenic properties. Clinical evidence also suggests that RIA results in larger volumes of graft with potentially less harvest site morbidity and pain compared with ICBG [12].

A recent randomized trial of ICBG (anterior or posterior) versus RIA graft for the treatment of long bone nonunions or bone defects was performed in 133 patients. The authors reported no difference in union rates between the 2 grafts, with significantly less donor site pain with RIA. In addition, they found significantly more graft volume with RIA compared with anterior ICBG and significantly shorter operative time when RIA was compared with posterior ICBG [13].

In conclusion, emerging evidence supports the use of RIA bone graft due to the fact that it has the ability to provide large volumes of graft efficiently, while reducing the risk for harvest site morbidity, although ICBG remains the gold standard for autogenous bone grafting. The cost of RIA remains an issue, and further prospective comparisons of the 2 graft sources, including economic evaluations, are warranted [10].

CONCLUSION:

In the past few decades, several materials and techniques are being used in bone graft. Some of the products used can be biological, while many are synthetic. Each type of material has its own set of advantages and disadvantages. After the bone is grafted, the body can have variable response, depending on graft type and host immunity. Therefore, proper selection of graft type and harvest location is very crucial for good prognosis and desirable results.

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