Bone Grafting : An Overview

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Abstract

Bone grafting is the process by which bone is transferred from a source (donor) to site (recipient). Due to trauma from accidents by speedy vehicles, falling down from height or gunshot injury particularly in human being, acquired or developmental diseases like rickets, congenital defects like abnormal bone development, wearing out because of age and overuse; lead to bone loss and to replace the loss we need the bone grafting. Osteogenesis, osteoinduction, osteoconduction, mechanical supports are the four basic mechanisms of bone graft. Bone graft can be harvested from the iliac crest, proximal tibia, proximal humerus, proximal femur, ribs and sternum. An ideal bone graft material is biologically inert, source of osteogenic, act as a mechanical support, readily available, easily adaptable in terms of size, shape, length and replaced by the host bone. Except blood, bone is grafted with greater frequency. Bone graft indicated for variety of orthopedic abnormalities, comminuted fractures, delayed unions, non-unions, arthrodesis and osteomyelitis. Bone graft can be harvested from the iliac crest, proximal tibia, proximal humerus, proximal femur, ribs and sternum. By adopting different procedure of graft preservation its antigenicity can be minimized. The concept of bone banking for obtaining bone grafts and implants is very useful for clinical application. Absolute stability require for successful incorporation. Ideal bone graft must possess osteogenic, osteoinductive and osteocon-ductive properties. Cancellous bone graft is superior to cortical bone graft. Usually autologous cancellous bone graft are used as fresh grafts where as allografts are employed as an alloimplant. None of the available type of bone grafts possesses all these properties therefore, a single type of graft cannot be recomm-ended for all types of orthopedic abnormalities. Bone grafts and implants can be selected as per clinical problems, the equipments available and preference of the surgeon. A search for ideal bone graft is on and may continue till time to time.

Keywords: Bone, Bone graft, Trauma.

Introduction

The term bone grafting refers to the process by which bone is transferred from a source (donor) to site (recipient) (Bojrab, 1997) and indicated in aggressive tumor resection, refractory nonunion, mandibular and calvarial reconstruction, composite defect (bone, skin and muscle), to replace comminuted fragments, to lengthen bones to correct malunions, delayed unions, for early production of bone and osteomyelitis (Brinker et al., 1990). Bone graft used in general as a framework to provide stability, treatment of pseudoarthrosis and to stabilize spinal segments and addition of bone stock in total joint replacement (Friedlaender, 1987). The firs1t recorded attempt to use bone graft was by the Dutch surgeon Job Van Meek'ren in 1668. Church literatures mention first transplantation of a bone graft in a Russian soldier with dog's cranial bone in 1682 (Heppenstall, 1980). As the history reported, religious elders threatened the surgeon to retrieve the bone, when the surgeon attempted to do so; it was already fused in place. Schroeder (1938) used bone grafts first time in veterinary orthopedics.

Principles of Bone Grafting

(1) Osteogenic activity or potentiality of the transplant material.
(2) The ability of graft to survive and proliferate.
(3) The immune response of the host.
(4) The degree of induction that the new transplanted material will experience and
(5) Affinity, which the host tissue exhibit towards the interstices of the implanted bone (McLean and Urist, 1968).

Classification

Knowledge of bone graft classification is

necessary to understand the indications, contra-indications, functions and the biology of various types of bone grafts (Martinoz and Walker, 1999). Autografts are transplantation into the same individual; allografts are in same species while xenografts into different species and isografts into same family. Alloimplants are nonviable graft. Cancellous graft (30-90% porosity) has the greater osteogenic ability. Cortical grafts (5-30% porosity) most commonly used to provide stability (Binnington, 1990). Autogenous/aspirated bone marrow used to provide live undifferentiated mesenchymal. Corticocancellous grafts are combination of cortical and cancellous bone. Osteochondral grafts consist of a bone and articular cartilage. Small chips of bone are particulate graft (Habal and Reddi, 1992). Fresh grafts are removed and used immediately. Free grafts are not vascularized and depend upon the local environment and ingrowth of new vessels to function. Vascularized grafts are segment of whole bone removed with blood vessels and placed with the anastomosis (Finkemeir, 2002). Onlay grafts are simple or massive slats of bone. Inlay grafts are cortical part of bone used for direct inlay or sliding inlay in long bones. The recipient site is carefully prepared and held in place by wedge effect, cortical bone screw, cerclage steel bands and smillie nails. The grafts with muscle insertion are muscle pedicle transplanted into a surgically created slot in the posterior femoral neck in young patients (Habal and Reddi, 1992). The fibula and the rib are commonly used for spine as strut grafts. Clothespin (H) grafts are full-thickness iliac crest bone strips slotted both primarily and distally and then placed between spinal processes for fixation. Orthotopic grafts are placed anatomically at the appropriate site. Heterotopic grafts are placed at inappropriate site. Demineralized bone grafts are prepared by leaching minerals from the bone without destroying the collagenous and non-collagenous protein; prepared in block or powder form. Powder form increases the surface area, more convenient as cells easily penetrate powder and moulds nicely especially as it mixes with blood (Abbott et al., 1947). Synthetic grafts avoid morbidity but are not vascularized, may be infectious, toxic or carcinogenic (Galletti, 1988).

Bone Bank

Bone bank concept was laid by American association of tissue bank and it has been used in veterinary orthopedics for many years (Bojrab, 1997). Bone grafts can be harvested from wing of ileum, proximal humerus, proximal tibia, distal radius, Sternum and ribs (Johnson, 1991). Recipient site is easily defined with radiograph and graft will form scaffold; adequate bridging and stabilization with rigid internal/external fixation require (Burchadt and Enneking, 1978). Preserved grafts are removed before use, prepared and stored. Techniques are boiling, autoclaving, deproteinizing, aqueous merthiolating, freeze-drying (-15^{0}C to -30^{0}C), ethylene oxide sterilization and radiation (Slatter, 2003). Bones have been stored for up to 1 year with colder temperature. Freeze dried grafts may be stored at room temperature under vacuum or be frozen (-700^{0}C) up to 5 years. Frozen graft should be thawed in warm physiological solutions just before use. Cell death results from all these techniques and the grafts functions mainly as space filler and as a scaffold. Careful donor screening and strict adherence to aseptic harvesting technique are not necessary when using ethylene oxide to sterilize bones grafts and graft can be stored up to 3 years. The lower the temperature the longer would remain useful (Tomford et al., 1983). The allografts are labeled with the donor's identification, the date and the bone location. The graft is recultured and radiograph at the time of placement (Slatter, 2003).

Cognizance Taken

Cognizance must be taken in respect to the magnitude and location of the defects, anatomical function of the involved bone and joint, biomechanical stresses and the cosmetic implication's surrounding the defect repair with minimal amount of trauma, biocompatibility and physiological stability (Bojrab, 1997). Trauma should be minimize, oscillating bone saws should not be used as they cause a marked temperature rise leading to cell death. It is best to wrap the graft in the patient's own blood soaked sponge (Slatter, 2003).

Basic Mechnisms

1. Osteogenesis is formation of the new bone by osteoblasts and osteoclasts. Cancellous potentially forms new bone than the cortical graft due to its "spongy" structure.
2. Osteoinduction is a transfer of undifferentiated mesenchyma into osteoblast (Urist,1976).
3. Osteoconduction is three-dimensional process of ingrowth of capillaries, perivascular tissue and mesenchymal cells. New viable bone replaces old necrotic bone by dynamic process known as creeping substitution.
4. Mechanical supports are weight bearing struts that fill in large bony defects therefore providing strength and structure (Slatter, 2003).

Complications

Surgical complications seen are non-union, rejection, fracture (as fixation loosens), premature fracture, infected sequestrum, infection, and osteomyelitis (Slatter, 2003). Immunological graft rejections can be prevented by proper processing. The mechanism of autograft rejection seems to be related most strongly to cellular rather than humoral immunity (Burwell, 1963).

Disadvantages

Disadvantages are limited resources, immune mediated rejection, technical difficulties in vascularized grafts, increase anaesthetic time and post operative bleeding, surgical invasion, morbidity and iatrogenicity. Dehydration jeopardizes the stability of repair. Preserved grafts do not immediately produce bone and risk of morbidity at the donor site (structural weakening, infection, hemorrhage, pain, nerve injury and persistent deformity) (Martinoz and Walker, 1999). Even the lowest dose of radiation can cause destruction of morphogenic property (BMP) of bone (Urist, 1976).

Future Prospects

Future prospects underlying this area may include the use of biopreparations like bioceracol (water-soluble bioceramics, microcrystalline, gelatine, glycerol, sorbitol and nitrox). Collagenous and non collagenous protein within bone will be available to orthopaedic surgeons in the future. Stem cell therapy, development of injectable formulations, better delivery systems and gene therapy applications for growth factors and osteoinductive substances. This article reviews what is currently available and what is on the horizon. In addition, as investigators continue to find new materials and biologic approaches to bone repair, the future of bone graft substitutes continues to be an expanding topic.

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