Bone grafting repairs damaged bones with transplanted tissue

EMILY JANE
Editorial Office, Journal of Orthopaedics Trauma Surgery and Related Research, Poland

19(4) 2024

Perspective

Address for correspondence:
Emily Jane, Editorial Office, Journal of Orthopaedics Trauma Surgery and Related Research, Poland
emily_j@yahoo.com

Statistics

Figures	00
Tables	00
References	00

Received: 04.05.2024;
Manuscript No. jotsrr-24-139403;
Editor assigned: 10.05.2024,
PreQC No. jotsrr-24-139403 (PQ);
Reviewed: 15.05.2024, QC No. jotsrr-24-139403 (Q);
Revised: 21.05.2024,
Manuscript No. jotsrr-24-139403 (R);
Published: 02.06.2024,
DOI.10.37532/18972276.2024.19(4)96

Abstract

Bone grafting is a surgical procedure used to replace missing bone in order to mend complex fractures that pose significant health risks or fail to heal properly on their own. While minor fractures can often heal without the need for bone grafting, severe fractures, like compound fractures, present a higher risk and frequently require this intervention. Bone has a natural capacity to heal completely, but this is typically possible only when the fracture gap is minimal or when there is a suitable scaffold to support the healing process.

Bone grafts come in several forms: autografts, which use bone harvested from the patient's own body usually from the iliac crest, allografts, which use donor bone from a bone bank and synthetic grafts, which are made from biocompatible materials such as hydroxyapatite. These grafts provide a framework for new bone growth, facilitating the healing process. Over the course of several months, the graft material is gradually reabsorbed and replaced by the patient's own bone tissue, resulting in a restored and strengthened bone structure.

Keywords: Bone grafting; Surgical procedure; Complex fractures; Allografts

INTRODUCTION

In reconstructive orthopedics, bone grafting is a surgical procedure used to repair skeletal abnormalities and enhance bone healing. Bone grafts serve both mechanical and biological functions, replacing missing bone to mend complex fractures that pose significant health risks or do not heal adequately. While mild or acute fractures can often heal without grafting, severe fractures, such as compound fractures, typically require this intervention. Bone grafts can be used to repair bones nearly anywhere in the body, with the surgeon often harvesting bone from the patient's hips, legs, or ribs. Occasionally, cadaveric bone tissue is used for grafting.

The bone matrix, which constitutes most of the skeleton, is a hard substance that provides strength to bones and houses living bone cells. These cells create and maintain the matrix, aiding in bone repair and healing when necessary. During a bone graft, the surgeon places a new piece of bone where repair or connection is needed, allowing the cells in the graft to adhere to and integrate with the old bone.

Bone grafts act as a filler and scaffold to stimulate wound healing and bone growth. They are biodegradable and do not trigger an antigen-antibody reaction. The graft material is eventually replaced by the patient's own bone, resulting in a fully integrated new bone area. The principles of osteoconduction, osteoinduction, and osteogenesis underpin the effectiveness of bone grafting.

Bone has the unique ability to fully regenerate, but this process is efficient only when the fracture gap is minimal or when there is a supporting scaffold. Various types of bone grafts are used to facilitate this healing process, including autografts (harvested from the patient's own body, usually from the iliac crest), allografts (sourced from cadaveric bone provided by bone banks), and synthetic grafts (typically made from hydroxyapatite or other biocompatible materials). Over several months, most bone grafts are gradually absorbed and replaced by natural bone as it heals.

Autologous, or autogenous, bone grafting involves harvesting bone from the same individual who will receive the graft. Common donor sites include non-essential bones such as the iliac crest, or areas within the jaw like the mandibular symphysis (chin area) or anterior mandibular ramus (coronoid process), especially in oral and maxillofacial surgeries. This technique is particularly effective for block grafts, where a small block of bone is transplanted in its entirety to the recipient site. The use of autogenous bone is advantageous due to the lower risk of rejection, as it originates from the patient's own body, thereby enhancing the likelihood of successful fusion. However, the availability of donor bone is limited by the amount that can be safely harvested from the patient.

Dentin grafts are derived from extracted teeth and offer a valuable alternative for bone grafting. The chemical composition of dentin is similar to bone, containing 70%-75% hydroxyapatite mineral and 20% organic matrix, mainly type I collagen. Like bone, dentin can be resorbed by osteoclasts, during which it releases growth and differentiation factors that aid in bone repair and regeneration.

Allograft bone, in contrast to autografts, is sourced from a donor other than the recipient. These grafts are typically obtained from cadaveric bones stored in bone banks, donated by individuals who have passed away. Bone banks also collect bone from living donors, particularly patients undergoing elective total hip arthroplasty (hip replacement surgery). During the procedure, the surgeon removes the femoral head to accommodate the artificial hip prosthesis, and this bone can be used as an allograft. Although allografts eliminate the need for a second surgical site on the recipient, they carry a slight risk of immune rejection and disease transmission, although stringent screening and processing minimize these risks.

Alloplastic grafts are synthetic alternatives made from materials like hydroxyapatite, which is the primary mineral component of bone. These grafts may also be composed of bioactive glass or polymers such as microporous polymethylmethacrylate -coated with calcium hydroxide. Hydroxyapatite is highly favored due to its osteoconductive properties, hardness, and compatibility with bone. Tricalcium phosphate is often combined with hydroxyapatite to provide both osteoconductive and resorbable characteristics. Polymers are also used due to their mechanical resilience, biocompatibility, and anti-infection properties, making them suitable for alloplastic grafts.

Autografts offer the advantage of biocompatibility, reducing the risk of immune rejection since the graft material is the patient's own tissue. The most common site for harvesting autologous bone is the iliac crest of the pelvis, but other sites can be used depending on the amount and type of bone needed. In oral and maxillofacial surgery, the mandibular symphysis or the anterior mandibular ramus can provide suitable bone for grafting, particularly for block grafts. These blocks can be placed in the recipient site to provide immediate structural support and osteogenic cells.

Dentin grafts utilize the chemical similarity between dentin and bone to promote healing. The high content of hydroxyapatite and collagen in dentin supports its integration into the bone matrix. As osteoclasts resorb the dentin, they release growth factors that stimulate bone formation and healing, making dentin grafts a valuable option in certain clinical situations.

Allografts provide a practical alternative when the amount of autologous bone is insufficient or when harvesting autografts would pose too great a risk or morbidity. Cadaveric bone from bone banks undergoes rigorous screening and processing to ensure safety. Living donors undergoing procedures like hip replacements contribute viable bone that can be repurposed as allografts. Although the risk of rejection is higher than with autografts, advances in tissue processing have significantly mitigated these concerns, making allografts a widely used option in bone grafting procedures.

Alloplastic grafts are particularly useful due to their customizable properties and availability. Hydroxyapatite and tricalcium phosphate are the most commonly used materials due to their osteoconductive properties, which help guide the growth of new bone along the scaffold provided by the graft. The combination of these materials can provide both the structural support and the resorbability needed for effective bone regeneration. Synthetic polymers, such as microporous, offer additional benefits like mechanical strength and resistance to infection, which can be critical in maintaining the integrity of the graft site and ensuring successful integration with the natural bone.

Bone grafting is often performed alongside other surgical procedures. For example, in cases of severe thighbone fractures, a bone graft may be part of a broader surgical repair strategy. Surgeons typically make an incision in the hip to harvest a small portion of bone, which is then transplanted to the fracture site. The goal is to provide immediate structural support and a scaffold for new bone growth, ensuring a stable and robust healing process.

The physiological basis for bone grafting lies in three primary mechanisms: osteoconduction, osteoinduction, and osteogenesis. Osteoconduction involves the physical support provided by the graft material, guiding the growth of new bone cells along its structure. Osteoinduction refers to the biochemical processes that stimulate precursor cells to develop into mature bone cells. This is often facilitated by growth factors released from the graft material. Osteogenesis is the formation of new bone tissue by the cells within the graft or those recruited to the graft site.

Bone grafts act as a temporary framework that is eventually replaced by the patient’s own bone tissue. This process begins as the body’s natural bone cells migrate into the graft material, where they proliferate and lay down new bone matrix. Over time, the graft material is resorbed and replaced by new bone, resulting in a fully integrated and functional bone structure. This regenerative capacity is unique to bone tissue, setting it apart from most other tissues in the body.

CONCLUSION

Bone grafting plays a crucial role in reconstructive orthopedics, offering solutions for complex fractures and skeletal abnormalities that pose significant health risks. By utilizing various types of grafts-autografts, dentin grafts, allografts, and alloplastic grafts-surgeons can address a wide range of clinical needs. Each type of graft offers distinct advantages and potential applications, allowing for tailored treatment approaches that maximize the chances of successful bone healing and regeneration. The integration of graft material with the patient’s own bone tissue through osteoconduction, osteoinduction, and osteogenesis underscores the sophisticated biological interplay that underpins successful bone grafting procedures.