Chinese Medical Journal®

Clinical guidelines for indications, techniques, and complications of autogenous bone grafting

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Autogenous bone grafts have long been considered the "gold standard" and most effective material in bone regeneration procedures.[1] Autogenous bone grafts are used to repair bone defects caused by nonunion, infection, tumor resection, and spinal and joint fusion.[2] It has been reported that more than 200,000 autologous bone grafts are performed in the United States each year.[3] Although there are no specific statistics on the annual number of bone grafts performed in China, autologous bone grafting is the most common surgical technique in orthopedics. The iliac crest remains the most common donor site, along with the fibula, ribs, tibial metaphysis, proximal humerus, distal radius, and greater trochanter.[4,5] Various bone-graft options provide different amounts and qualities of cortical, cancellous, and corticocancellous bone.[6,7] Autogenous bone graft is osteogenic, histocompatible, provides structural support, and has no risk of disease transmission. The disadvantages of autogenous bone grafting are its limited supply and the increase in the magnitude of surgery owing to the need to harvest bone graft material, which increases the operative time, blood loss, and risk of complications. There are no clinical guidelines or consensus report focused on autogenous bone-grafting indications, techniques, and complication.[8] The Trauma Orthopedic Branch of the Chinese Orthopedic Association and National Clinical Research Center for Orthopedics, Sports Medicine & Rehabilitation developed clinical practice guidelines for indications, techniques, and complications of autogenous bone grafting (detailed information is listed in the Supplementary File, http://links.lww.com/CM9/B551).

Access this article online

Quick Response Code:

Website: www.cmj.org

DOI: 10.1097/CM9.0000000000002691

Definition of autogenous bone grafting

Autogenous bone grafting is defined as the transplantation of bone tissue obtained from a donor site into a bone defect, nonunion, or arthrodesis. Cortical bone is osteoconductive, provides functional support, and is suitable for structural defects. Cancellous bone graft has a viable cell and pore structure, which makes it easy to reconstruct blood vessels. Cancellous bone provides an osteoinductive, osteoconductive, and osteogenic substrate, but is not suitable for structural defects that require immediate mechanical stability. The vascularized bone graft (VBG) is categorized into pedicled and free grafts. A pedicled VBG is transferred from the donor site to the recipient site with its native vasculature preserved. A free VBG has its vascular pedicle divided, permitting transfer to virtually any location.

Recommended strength

The recommendation strength is based on a combination of the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system and the characteristics of clinical practice in China. Using the weighted value of each characteristic, the experts who wrote the guidelines scored the recommendations individually using a grading system [Supplementary Tables 1–3, http://links.lww.com/CM9/B551].

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Chinese Medical Journal 2024;137(1)
Received: 25-12-2022; **Online:** 18-07-2023 **Edited by:** Yanjie Yin

Types of autogenous bone grafts

Autogenous bone is considered the gold standard for most applications in orthopedics because of the physiologic properties of autogenous bone as biocompatible, bioresorbable, osteoconductive, osteoinductive, and structurally supportive. When selecting the graft donor area, clinicians must consider the location of the bone defect, the position of the patient during surgery, and the required amount of graft material. The most common site for bone harvesting is the anterior iliac crest, along with the posterior iliac crest, ribs, fibula, tibial metaphysis, distal radius, and greater trochanter of the femur. Different donor areas have different indications, techniques, and complications. The most common complications are donor site pain, nerve injury, infection, fracture, an extended surgical time, increased blood loss, and limited bone graft material (grade IA).

Autologous bone grafts comprise non-vascularized and VBGs. Non-vascularized autogenous bone is divided into cortical, cancellous, and corticocancellous bone. The most common vascularized bone flaps are harvested from the iliac crest with the deep circumflex iliac artery, the fibula with branches of the peroneal artery, the ribs with the posterior intercostal artery, and the distal end of the radius with the supraretinacular artery (grade IIA).

Indications, techniques, and complications of non-vascularized bone grafts

Anterior iliac crest bone grafting

The anterior iliac crest is the most common donor site for autologous bone grafting (grade IA) and is suitable for treating severe open fractures, bone defects, delayed union, nonunion, tumor bone defects, joint fusion, and interbody fusion. The techniques for anterior iliac crest bone grafting include the curettage technique, bicortical or tricortical technique, trapdoor technique, trephine technique, and acetabular reamer technique (grade IIIA). The anterior iliac crest provides a large amount of cancellous, unicortical, bicortical, and tricortical bone. The complications of anterior iliac crest grafting are pain, nerve injury, hematoma formation, infection, incisional hernia, vascular injury, and donor site fracture (grade IA).

Posterior iliac crest bone grafting

The posterior superior iliac spine is the most common source of autogenous bone graft material during posterior spine fusion or procedures that require a large amount of bone graft material. The trapdoor technique is recommended to protect the integrity of the iliac crest and internal plate, and the depth of resection is limited to 4 to 6 cm to prevent damage to the sacroiliac joint and superior gluteus artery. Complications at the posterior iliac crest donor site are pain, neurovascular injury, avulsion fracture, hematoma, infection, incisional hernia, gait disturbance, sacroiliac joint invasion, and ureteral injury. Injury to the sacroiliac joint and superior gluteal artery can be avoided (grade IA).

Autologous rib bone grafting

An autologous rib bone graft is suitable for the reconstruction of defects in the spine, maxillofacial region, or limbs. *In situ* rib split transplantation is recommended, in which the rib is split in the coronal plane, the deep cortex is preserved *in situ*, and the superficial half of the rib cortex and cancellous bone are removed. This method is technically simple, requires a short operation time, does not damage the pleura, and reduces donor site complications. The complications of autologous rib bone grafting are pneumonia, persistent atelectasis, superficial wound dehiscence, pneumothorax, intercostal neuralgia, and chronic chest wall pain (grade IB).

Tibial metaphyseal bone grafting

The ipsilateral proximal and distal tibia provide adequate amounts of bone graft material for use in foot and ankle surgery. The tibia is easily accessible and can provide large quantities of cancellous and cortical bone. Tibial bone is commonly harvested using an osteotome, curette, or trephine. The main postoperative complications are pain at the donor site, hematoma, deep infection, and stress fracture (grade IB).

Distal radius bone grafting

The distal radius is usually used for nonunion or bone defects in the ipsilateral hand and wrist requiring a small amount of bone graft material. The cancellous or corticocancellous bone can be harvested by fenestration through the dorsal first and second compartments or through the palmar approach. The recurrent branch of the radial artery is anatomically constant, and a vascularized free bone flap can be used to repair scaphoid fracture nonunion and lunate osteonecrosis to obtain mechanical support and improve local blood supply. The main complications are donor site pain, tenosynovitis, infection, fracture, and nerve injury (grade IB).

Greater trochanter bone grafting

The greater trochanter of the femur is mainly composed of cancellous bone, which is suitable for ipsilateral lower limb defects, foot and ankle surgery, femoral neck nonunion, and femoral head necrosis. The greater trochanter free bone graft can be obtained by trephine or fenestration, providing a bone volume of 5–10 cm^3. Common complications are donor site pain and stress fracture of the femoral neck due to excessive bone harvesting (grade IB).

Reamer irrigator aspirator technique

The reamer irrigator aspirator (RIA) is a relatively recent device that is placed in the femoral or tibial medullary canal to harvest a large volume of bone and is supposed to be less invasive than previous methods, allowing the harvest of a greater graft volume. The RIA device allows intramedullary reaming with simultaneous irrigation and aspiration to harvest large amounts of autologous bone from the medullary canal of long bones. The complications of the RIA technique are hemodynamic instability, iatrogenic fracture, pain, hematoma, and deep infection (grade IIIB).

Indications, techniques, and complications of vascularized bone grafting

Free vascularized fibular grafting

Free vascularized fibular grafting (FVFG) is indicated for the reconstruction of upper extremity skeletal defects larger than 6 cm caused by oncologic resection, trauma, osteomyelitis, nonunion, or congenital malformation. Furthermore, FVFG is another important hip-preserving approach for the treatment of osteonecrosis. The most common FVFG technique is Wood's modified method in which the fibula is resected between the peroneus longus and soleus muscles. Complications at the donor site are ipsilateral tibial stress fracture, flexor pollicis longus tendon contracture, peroneal nerve palsy, and compartment syndrome (grade II-B).

Vascularized iliac bone grafting

The vascularized iliac bone graft based on deep circumflex iliac vessels provides a large concave segment of bone suitable for reconstruction of the extremities and spine. Both pedicled iliac bone flap transfer and FVFG are effective methods for the treatment of femoral head necrosis. Several donor site complications are reported after vascularized iliac bone grafting, namely injury to the lateral cutaneous femoral nerve, gait disturbance, bowel obstruction, and herniation (grade III-B).

Vascularized rib bone grafting

The vascularized rib graft is suitable for use in adjacent spinal fusion or long bone defects of the extremities that require strong biomechanical support. Vascularized rib grafting can be used in complex cases with a high risk of nonunion, infection, and pseudoarthrosis of the bone defect. There are few donor site complications, namely pneumothorax and hemothorax (grade IIIB).

Surgical techniques related to autogenous bone grafting

In vitro storage of autogenous bone graft material

The common preservation methods after autologous bone harvesting are dry preservation and solvent preservation. Saline or 5% glucose solution is recommended as it better preserves the osteoinduction and osteogenic ability of autologous bone than dry preservation (grade IIIC).

Antibiotic-impregnated autogenous bone grafts

Antibiotic-impregnated bone grafts have become popular and seem to be effective and safe in the treatment of infected bone and joint defects. Infectious bone defects are common and need to be addressed before a new implant is inserted. A major advantage of antibiotic-impregnated bone grafts is the possibility of impregnating various antibiotics depending on the sensitivity profile of the causative organism (grade IB).

Autogenous cancellous bone grafting using the induced membranes treatment technique

The induced membranes technique is a common clinical technique that comprises a two-stage procedure. The iliac crest is the most common donor site in clinical practice, and bone can be harvested from the anterior or posterior iliac crest in accordance with the surgical position and the patient's condition. The acquisition of autologous bone by the RIA device obtains relatively more bone mass, reduces the time required for bone harvesting, and reduces donor site complications (grade IIIB).

Acknowledgments

We thank Kelly Zammit, BVSc, from Liwen Bianji (Edanz) (www.liwenbianji.cn/), for editing the English text of a draft of this manuscript.

Funding

This work was supported by grants from the Special Project Program of the National Clinical Research Center for Orthopedics, Sports Medicine & Rehabilitation (No. 2022-NCRC-000000) and the Beijing Municipal Natural Science Foundation (No. 7232165).

Conflicts of interest

None.

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How to cite this article: Zhang JZ, Li SG, He HY, Han L, Zhang SM, Yang L, Han WX, Wang XW, Gao J, Zhao JW, Shi WD, Wu Z, Wang H, Zhang ZC, Zhang LC, Chen W, Zhu QT, Sun TS, Tang PF, Zhang YZ. Clinical guidelines for indications, techniques, and complications of autogenous bone grafting. Chin Med J 2024;137:5–7. doi: 10.1097/CM9.0000000000002691