Autogenous Bone Grafting in Clinical Osteomyelitis and Septic Nonunion (The Papineau Technique)

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ABSTRACT: The technique of extensive wound debridement and secondary use of autogenous cancellous bone chips can be used to salvage both septic nonunions and chronic osteomyelitis. The same technique may also be used to bridge large bony defects of traumatic origin. With time, the cancellous bone becomes completely incorporated and strengthened, allowing full use of the limb. There are few complications with the procedure. Nonunion may develop on occasion and require a closed bone graft once the wound is free of infection and closed. The major surgical principles are: 1) adequate debridement with removal of all infected tissue, 2) a viable base to support the graft, 3) the use of autogenous cancellous bone, 4) adequate immobilization, and 5) delayed wound closure.1-6

Introduction
The management of traumatic bony defects, possibly complicated by infection, and the sequelae of chronic infection with or without nonunion, have long plagued the orthopedic surgeon. Even with the advent of newer and stronger antibiotics, these wounds continue to present a formidable challenge. In 1973, Papineau6 reported his experience with more than 80 patients with chronic osteomyelitis treated first by excision of sequestra and fistulous tracts, then delayed bone grafting with later skin coverage. This report supported the previous experience of Coleman,7 Prigge,8 Bickel,9 Hazlett,10 and others who found that even in the face of low grade infection, cancellous bone seemed to exhibit a remarkable resistance to infection. Papineau reported that by establishing a healthy bed of granulation tissue, the chips of cancellous bone were rapidly vascularized and then covered by the granulation tissue. This allowed eventual wound closure with skin grafts or a flap. With time, the bone graft incorporated with the recipient bone and eventually remodelled. This paper will present the details of the open bone grafting technique of Papineau and two illustrative cases.

Technique
The open bone graft technique described by Papineau was recommended for chronic osteomyelitis. The same principles and procedures may also be used for traumatic defects in bone, although some authors recommend its use only for defects under 9 cm. When defects greater than 9 cm are present, the use of a vascularized fibular graft should be considered. Patients with osteomyelitis should have a preoperative workup that includes cultures, a baseline sedimentation rate, tomograms, and fistulograms as indicated. Generally, several doses of preoperative antibiotics are administered unless sepsis has necessitated more vigorous medical treatment. When fistulous areas are present, the preoperative instillation of methylene blue may be helpful in delineating necrotic tissue at the time of surgery.

Fig. 1: Sequence of Papineau technique. A) Chronic osteomyelitis. B) After debridement and development of granulation tissue. C) Open bone graft. D) Blood clot in place.
The initial debridement should be done in a bloodless field whenever possible. The criteria of bony bleeding is used to establish the margins of healthy tissue. All sequestra, fistulae, and foreign bodies should be excised. If it is difficult to tell whether the margin is adequate, a second debridement several days later is preferable to overzealous excision initially. The goal of debridement should be sauceration of the wound, so that the walls of the cavity are gently sloped (Fig. 1B). Following debridement, a moist antibiotic-soaked dressing is applied. If the debridement is extensive enough to cause instability, an external fixator is applied at the first operative sitting. The dressing is changed daily on the ward. When the debridement has been done adequately, healthy granulation tissue will begin to line the surface of the wound within several weeks time (Fig. 1B). Once granulation tissue has completely covered the floor and walls of the wound, the patient is prepared for the bone graft.

In patients with infection, the bone graft donor site should be isolated from the recipient site. The best way to minimize cross contamination is to harvest the bone graft first and close the donor site. The harvested bone graft is kept moist in a physiologic solution with or without antibiotics. Only cancellous bone is used for this procedure, as cortical bone is more slowly vascularized and seems predisposed to the formation of sequestrum. Unless the defect is extensive and a massive amount of bone is required, we feel it is preferable to lay a reasonably thin layer of bone in the wound (Fig. 1C), and to repeat the procedure if needed, as opposed to filling the defect completely with bone. However, the wound may be too small to accept a second bone graft. We have found that an overabundance of bone chips in the wound takes much longer to incorporate and may become secondarily infected with loss of a portion of the graft. At the end of the procedure, the defect should be filled with fresh blood, which then clots over the bone chips. An antibiotic-impregnated gauze is used as a wound dressing. We prefer to use cancellous chips as opposed to the strips of bone reported originally by Papineau. These chips become rapidly adherent to the underlying granulation tissue, and are vascularized more quickly because of their small size.

The surgical dressing is changed carefully on the fourth postoperative day, so as not to dislodge any bone chips. After the first week, when incorporation is well progressed, the dressing changes may be performed by trained nursing staff. Generally, the wound will rapidly fill with granulation tissue, which will completely cover the bone graft chips. Once the tissue is level with the surrounding skin, a split thickness skin graft may be applied. Depending upon the nature and position of the wound, flap coverage may be preferable to skin grafting. It has been our practice to continue parenteral antibiotic coverage throughout the course of the hospitalization until several days after the wound is covered.

The decision as to the type of immobilization that best allows ultimate maturation of the graft is dependent upon the nature, location, and depth of the defect. The use of an external fixator for periods longer than eight weeks demands meticulous care of the pin tracts with adequate and often repeated skin release around the pins. It is usually possible to remove the fixator and place the patient in a cast even before the graft is completely incorporated. Papineau recommended the use of intramedullary fixation, which may be of value in the acute case, especially when infection is not a problem. Intramedullary fixation should be approached with caution in the face of chronic osteomyelitis, but once the wound is clean it may facilitate healing.

Cases

Case 1

This 20-year-old black woman sustained a shotgun blast injury to the left tibia on January 26, 1982. She underwent initial wound debridement and application of a Hoffmann external fixator before transfer to our institution (Fig. 2A). On March 16, 1982, repeat debridement was performed, followed by pulsating lavage of the wound and an open bone graft. The graft incorporated without difficulty. The Hoffmann apparatus was removed on April 23, 1982, and she was placed in a long leg, non-weight-bearing cast. A split thickness skin graft was applied on May 6, 1982. Followup roentgenograms demonstrated maturation and incorporation of the graft both proximally and distally, with hypertrophy of the bone (Fig. 2B). The patient had been walking in a patellar-tendon-bear cast. A nonunion developed in the central part of the graft; she underwent a posterior lateral bone graft procedure with primary wound closure in March of 1984. On May 25, 1984, her wound was healed, the radiolucent line was diminishing, and she had a full range of motion of her knee and ankle (Fig. 2C, D). The patient ambulates without pain and is extremely happy with the result.

Case 2

This 34-year-old black man sustained a gunshot wound in 1979 with a tibia fracture that subsequently developed osteomyelitis (Fig. 3A). In May 1981, spontaneous drainage of an abscess began at the site of original injury. In July 1981, a Hoffmann external fixator was applied after debridement of the right tibia with resection of 7/8 cm of tibia because of infection and ischemia (Fig. 3B). The wound was managed with dressing changes, followed by an open bone graft on August 20, 1981. This wound healed more slowly due to the large amount of cancellous bone used. The Hoffmann apparatus was removed on October 27, 1981, and a split thickness skin graft applied on November 11, 1981. The graft incorporated satisfactorily, and it hypertrophied after the patient began weightbearing (Fig. 3C). A nonunion developed, but for the past two years he has been fully weight-bearing without pain, in a short leg cast initially and then in a brace. The nonunion is currently being treated with a bone stimulator (Fig. 3D).

Discussion

The open bone graft is a useful technique, which is easily mastered, and with patience and attention to detail it can give gratifying results in the management of complicated wounds. The advantages of using only autogenous cancellous bone chips include rapid revascularization, healing with creeping substitution, and complete repair of the graft with time (Burchard[1]). These characteristics of cancellous bone graft healing result in the entire graft being replaced by viable new bone. Initially the grafts are strengthened when new bone is formed on necrotic bone surfaces, then the graft strength returns to normal as the necrotic trabeculae are gradually removed. This process is contrasted with cortical bone, which is slowly revascularized and initially weakened by up to 40% of normal due to the initial osteoclastic activity and decreased osteoblastic activity. These
Fig. 2A: Case 1—six weeks after injury, two days after open bone graft.

Fig. 2B: Case 1—one year after injury, ten months after bone graft.

Fig. 2C: Case 1—26 months after injury, one week after closed bone graft.

Fig. 2D: Case 1—clinical appearance 26 months after injury.
Fig. 3A: Case 2—one month prior to debridement.

Fig. 3B: Case 2—one month after debridement.

Fig. 3C: Case 2—six months after open bone graft.

Fig. 3D: Case 2—30 months after open bone graft.
aspects of bone graft repair, in part, support the clinical observation that cancellous bone can survive in infected wounds provided a suitable bed is prepared. When infection is not a concern, the results of open cancellous bone grafting are even more dramatic.12,13

References