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A Bone Bank for the District Hospital

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ABSTRACT

Autogenous bone grafts are the ideal bone substitutes. Allogenous bone graft substitutes are needed where the autogenous bone is either not available or inadequate. The commonly employed methods of preserving allogenous bone require expensive equipment. We describe here a technique of preserving bone in a dilute solution of formaldehyde for use as an allograft. This requires minimal resources and can be practised even at the district hospital level. These *formalin preserved allografts (FPA)* have been used in 86 patients with bone cavities, non-union and comminuted fractures and have proved to be reliable and safe although we found the incorporation to be delayed as compared to autogenous bone grafts.

Key words: Formalin, allografts, bone bank, non-union, bone cavities, fracture

INTRODUCTION

Bone grafting is a common orthopaedic procedure performed for the management of cavitary lesions and non-union of bone. The bone grafts may be autogenous, that is from the same individual, or, allogenous, that is from another genetically different individual of the same species. Autogenous bone grafts are the gold standard in terms of fast incorporation and lack of immunogenic potential. However, it carries the disadvantages of pain, haematoma, infection, cosmetic problems, neurovascular damage, peritoneal perforation, sacroiliac joint instability and herniation of abdominal contents through the defect in ilium (1). Besides, autologous bone may be inadequate in children and in conditions where quantum of bone required is large. These limitations have necessitated development of suitable alternatives to autologous bone. The techniques recommended for the preservation of such allogenous bone grafts like freeze-drying and deep freezing require expensive equipment and an uninterrupted power supply. We describe a simple, inexpensive technique of preserving bone in formaldehyde, which can be practised with minimal resources and is reliable and safe.

MATERAL AND METHODS

The requirements for setting up a bone bank of formalin preserved allogeneic [FPA]

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bone grafts are – a refrigerator, adequate supply of normal saline and formaldehyde. It can be practised at practically any centre with an operation theatre and a microbiology laboratory for culture.

Donor cancellous bone is obtained from excised femoral heads of patients undergoing hemireplacement or total replacement arthroplasty of the hip and from excised patellae. Donors are routinely screened for human immunodeficiency virus [HIV] and Hepatitis B antigen and to rule out any associated infective or neoplastic pathology. The bone is cut into thin slices, denuded of all soft tissue and articular cartilage and thoroughly washed with saline. A 0.4 percent solution of formaldehyde is prepared by diluting commercially available 40 percent formaldehyde in saline to a proportion of 1 in 100. Bone pieces are kept in sterile glass jars containing the diluted formaldehyde solution between 2 and 6 °C in a dedicated refrigerator. The solution is changed on day 1, day 3 and then two changes are done at weekly intervals. Subsequent changes are done at monthly intervals. Culture of the preserving fluid and the bone pieces is done routinely at the time of change of solution and prior to usage of graft. The graft can be used after a minimum period of one month of preservation. Unused grafts after one year of preservation should be discarded. Three days prior to usage, the bone and the preserving solution are subjected to aerobic and anaerobic culture for infective organisms. Since the temperature used for storage is 2 to 6 °C, the grafts are not adversely affected by lack of power supply for up to 6 hours as the temperature inside a refrigerator is reasonably maintained by insulation.

The cancellous bone grafts are used in the management of patients with bone cavities, non-union and communited fractures.

Patients

Formaldehyde preserved alogeneic bone grafts were used in 86 patients [49 males and 37 females], presenting with lytic lesions of bone, non-union and comminuted fractures at the Department of Orthopaedic Surgery at King George's Medical College, Lucknow. Benign bone cavities included fourteen unicameral bone cysts, six aneurysmal bone cysts, five patients with fibrous dysplasia, and two of enchondroma. Eight patients of unicameral bone cyst had a pathologic fracture through the cyst wall. Malignant bone cavities included five patients with giant cell tumour of lower end of femur and four patients with giant cell tumour of upper end of tibia. None of these had any breach of the cortex or any soft tissue extension. Patients with non-union included seven cases of non-union of tibial diaphysis, seven cases of humeral diaphysis, five cases of non-union of femoral diaphysis and four with non-union of radius and ulna. Bone gap was present in the tibial shaft in six patients and the distal end of femur in one patient. Two of these patients were lost to follow-up and were excluded. Eighteen patients with communited fractures were primarily bone grated at the time of internal fixation.

RESULTS

We have used cancellous bone graft all the cases in this study. Post-operative complications included superficial stitch line infection in 5 patients (6.1%) and a sterile serous discharge in 22 patients (26.8%). The median duration of discharge was 5 days starting on the third post-operative day. No active intervention was required in either event. There was a severe infection in one patient undergoing bone grafting for a non-union of femoral diaphysis. This required opening the wound and debridement followed by suction irrigation. Post-operative mild pyrexia was present for a median duration of six days in 26 patients (31.7%).

The time taken for obliteration of cavity and reconstitution of trabeculae was regarded as the end point for incorporation of the bone graft. The median time taken for incorporation of bone graft was 20 weeks for benign lesions and 24 weeks for malignant lesions. No recurrence of benign or malignant lesions was encountered in any patient during a minimum follow up of 18 months. Fracture union was assessed by the visibility of fracture line in the roentgenogram in either view. In the 23 patients of atrophic non-union, one patient had a partial union at the last follow-up at 24 weeks while the rest had a fully united fracture after a median duration of 27 weeks. Among patients with gap non-union, five had union at a median duration of 40 weeks and two had only partial union at the last follow-up at 24 weeks. Comminuted fractures were fully consolidated in 18 patients after 28 weeks while 4 patients had only a partial obliteration of fracture line at the last follow-up. On comparing the results of FPA bone grafts with autogenous bone grafts, we found the time taken for obliteration of cavitary lesions was comparable between the two groups in 81.4% patients with benign cavities and 55.5% patients of malignant cavities. The remaining patients of FPA bone grafts had a delayed obliteration of cavity. The union of fracture was delayed in 17.3% patients of atrophic non-union, 60% patients of gap non-union and 31.8% patients of comminuted fractures treated by FPA bone grafts. In two patients of gap non-union, the graft was absorbed with no evidence of union of fragments. So, the FPA bone grafts show a delayed incorporation as compared to autogenous bone grafts.

DISCUSSION

The best substitute for bone is bone. Fresh autologous and vascularised autologous bone grafts are the ideal and the most effective bone replacements and these are the gold standard with which any substitute should be compared. Freeze dried bone (2) and deep frozen bone (3) are the most widely used techniques in developed countries but require expensive equipment and an uninterrupted power supply. The limitations in our centres lacking expensive equipment stimulated the search for alternate methods, which could be carried out at the secondary health care level.

To prepare formalin preserved allografts, bone is kept in a low concen-

tration of formaldehyde at 2 to 4 °C (4). This is based on the concept of Lavrishcheva et al (5) that vital processes of tissues are preserved in low concentration of formaldehyde in an inhibited state for up to one year. They observed restoration of the vital processes on restoration of optimal conditions. This is believed to result from protein molecule enlargement due to reaction of formaldehyde with the reactive group of proteins (5).

We have used donor bone from excised femoral heads and patellae as the bone is cancellous, biologically normal and available in plenty at any Orthopaedic centre. The articular cartilage was removed as it cannot be preserved by this technique. Lavrishcheva et al (5) assume a loss of antigenicity after three weeks of preservation. We have used the bone graft after a minimum preservation period of 30 days. No HLA matching was done between donor and recipients. Previous reports on he use of formalin preserved allograft have demonstrated its efficacy in animal models (4,6,7) and in humans (8).

Postoperatively, no evidence of local or systemic immunological reaction was noted. The FPA is believed to be inherently resistant to infection (5) due to local action of formaldehyde. In this study, all the cultures of donor bone and the preserving solution done prior to allografting were negative for bacterial contamination. The occurrence of sterile serous discharge in patients with no preoperative infection may indicate a local reaction to formaldehyde leftover in the graft after washing.

Follow-up of patients is based upon the radiological assessment of fracture union or cavity obliteration. In this study, the healing of malignant cavities was delayed in comparison to benign cavities which could be related to the relatively larger average size of the malignant cavities or an effect of the malignant pathology.

Tuli and Gupta (9) commenting on the use of decalcified bone reported resorption of half the mineral content and removal of cellular and organic debris without affecting the biologic activity of the remaining matrix. Decalcification is believed to enlarge marrow spaces, Haversian canals, Volkmann canals and lacunar spaces. We have not employed decalcification as the cancellous bone is sufficiently porous to facilitate ingrowth of capillaries. We believe decalcification to be of greater use for cortical bone graft.

The chief limitation of this technique lies in its inability to preserve cartilage and consequently whole joints. Furthermore, the efficacy of cortical FPA remains to be demonstrated. FPA is an inexpensive, simple and reliable method of recycling bone. Further clinical trials are needed to document its efficacy in various clinical solutions.

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