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INCORPORATION OF BONE GRAFT COVERED WITH METHYLMETHACRYLATE ONTO ACETABULAR WALL

An Experimental Study

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The acetabular model, as described in the present study, appears to serve as a promising experimental model for grafting procedures since it promotes the acceptance of autogenous grafts and the induction of new bone formation. Further, the biologic and mechanical properties of the femoro-acetabular joint appear permissive to the development of an efficient reparative system even when a foreign material such as methylmethacrylate cement is incorporated into the overall reconstructive procedure. Hence, it is hereby recommended to utilize the biological approach in the frame of replacement arthroplasty of severely damaged acetabulum.

Key words: bone cement; bone grafts; hip arthroplasty, protrusion hip

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Deficiency in the medial wall of the acetabulum represents a serious problem during replacement arthroplasty of the hip, as it may lead to the protrusion of a prosthetic hip into the pelvic cavity. Initially, we have encountered this problem in a case of an old central fracture dislocation of the hip which was followed by a non-union of the acetabulum; and more recently, during revisions of unsuccessful cases of total hip arthroplasty where the acetabulum has been significantly damaged. In order to overcome these kinds of problems, it has been recommended to use mechanical reinforcements such as those of the Eichler-ring or the Harris-Ho protrusion shell (Oh & Harris 1978). It is our belief, though, that a more promising approach to handle such cases of a damaged acetabular wall should encompass primarily a biological mean and that a mechanical reinforcement of any sort may be added. Hence, our laboratory has been recently engaged in investigating the fate of autogenous bone grafts covered with methylmethacrylate cement (Roffman et al. 1982) and our initial findings clearly indicate that such grafts remain viable and retain their osteogenic potential. Consequently, we designed an animal experimental model simulating conditions often encountered in patients. Using such a model we hoped to determine the outcome of bone grafts in deficient acetabular walls when covered with methylmethacrylate cement.

MATERIALS AND METHODS

Eight mongrel dogs weighing between 15 and 21 kg were used in this study. All animals were anesthetized with intravenous Nembutal® (30 mg/kg) and a Girdlestone operation was carried out through the resection of the femoral head. The acetabular cartilage was then stripped off and a bursting fracture of the medial wall of the acetabulum was performed using a 0.5 cm wide gouge. Thereafter, a silastic sheet was placed in between the fracture fragments in order to prevent bony union. At the same time bone grafts com-

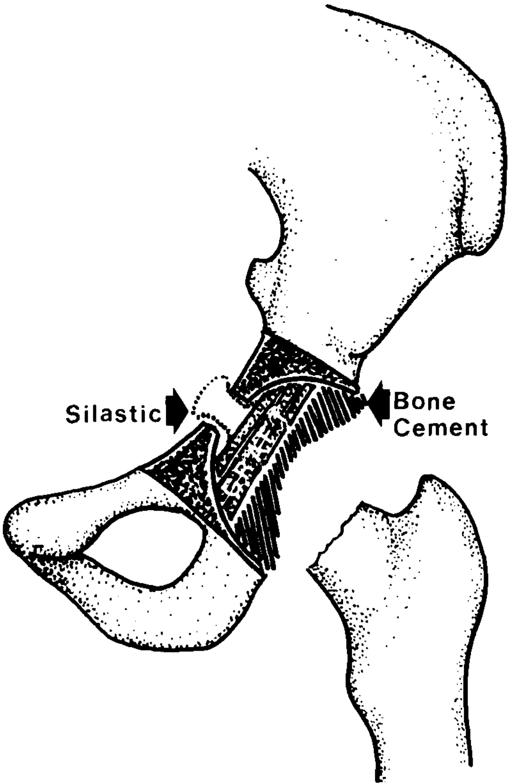

Figure 1. Graphic representation of our experimental design in the dog's hip joint.

prising cortico-cancellous chips were prepared from the resected femoral head and were then placed over the silastic sheet and the adjacent acetabular bone, thus bridging over the fracture site. Thereafter, the acetabulum was filled with polymethylmethacrylate bone cement (CMW) which covered the entire layer of bone grafts (Figure 1). All animals received 1.0 g Penbritin® intramuscularly 2 h prior to surgery and daily thereafter (the same dose) for a duration of 1 week.

The dogs were ambulated soon after surgery and were examined periodically for the range of movement and for the use of the operated limb. Roentgenograms were taken during the second and fourth weeks following surgery and monthly thereafter. Four dogs were killed after 6 months and the remaining four animals after 10 months. At those times the cement was removed, the involved regions dissected out, decalcified, cut into small pieces (each including a piece of the host bone as well as a graft), embedded in paraplast, sectioned serially (6 μm in thickness) and stained with hematoxylin and eosin.

RESULTS

All dogs ambulated soon after surgery and by the second week they could walk bearing their full weight. Their range of motion was close to normal except for one dog that had developed a flexion contracture of the hip secondary to surgery-induced ischial nerve injury. Roentgenographical examinations indicated the development of a bony union between the bone grafts and the acetabular wall 6 months following the implantation of the grafts. Gross inspection of the specimens also suggested a solid union between the host and its grafts, thus leading to the formation of a bony bridge over the fracture site which was inhibited from a primary bony union by the silastic sheet. The above observations obtained further support via our morphological studies, which revealed the existence of a genuine bony union between the grafts and their host. Highly developed strands of new bone were noted to extend from the compact lamellar bone of the acetabulum toward the more spongy bone of the grafts (Figure 2). In addition, the grafts

Figure 2. A section through the acetabular cortical surface (A) showing a sprout (S) of new bone trabecules extending toward the implanted graft. Note the wealth of bone cells in these new trabecules of bone. H&E, ×192.

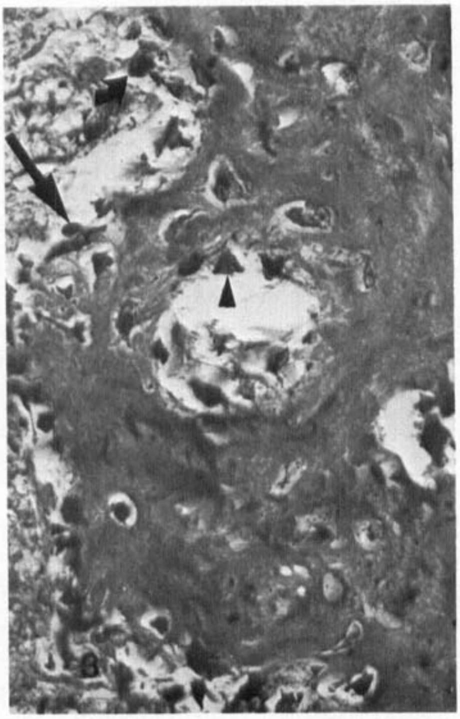

Figure 3. A section through the implanted graft that has been covered with bone cement. Note the immense number of osteoblasts (arrows) lining the peripheral surface of the graft, as well as its internal (marrow) spaces. H&E, ×384.

themselves appeared viable inasmuch as they contained multiple osteocytes, osteoblasts and osteoclasts. Osteocytes containing prominent nuclei were found throughout the grafts while the peripheral surfaces of the grafts as well as their marrow spaces were found to be lined with well developed osteoblasts (Figure 3). Signs of osteoid formation could also be noted underneath these osteoblasts. The presence of osteoclasts was also a consistent feature in these grafts (Figure 4). The most distinctive feature, however, was the grafts' capacity to induce new bone formation along their "free" surface, namely, along that surface adjoining the methylmethacrylate cement. This was manifested by the development of an osseous network within the connective tissue "capsule" that surrounded these implants (Figure 5). While examining specimens that were obtained 10 months following surgery, it became evident that this newly-formed bone replaced larger portions of the dense fibrous tissue which characterized all specimens of the shorter intervals, mainly those that were obtained after 6 months.

DISCUSSION

Sotelo-Garza & Charnley (1978) described the use of bone grafts to reinforce the medial wall of acetabula in patients undergoing a total hip arthroplasty. Oh & Harris (1978), on the other hand, claimed that a mechanical reinforcement is essential when contemplating total hip arthroplasty in cases of a weak medial wall in the acetabulum. It is our feeling that though it is true that mechanical reinforcement might contribute positively in the short run, it might fail later on and thereby allow the protrusion of the joint into the pelvis. Hence, the supplementation of a local biological factor such as bone grafts, even under bone cement, could provide a better long-lasting solution to the above problem. In spite of the fact that good clinical results have been reported using bone grafts in conjunction with arthroplasty (Salvati et al. 1975, Hastings & Parker 1975,

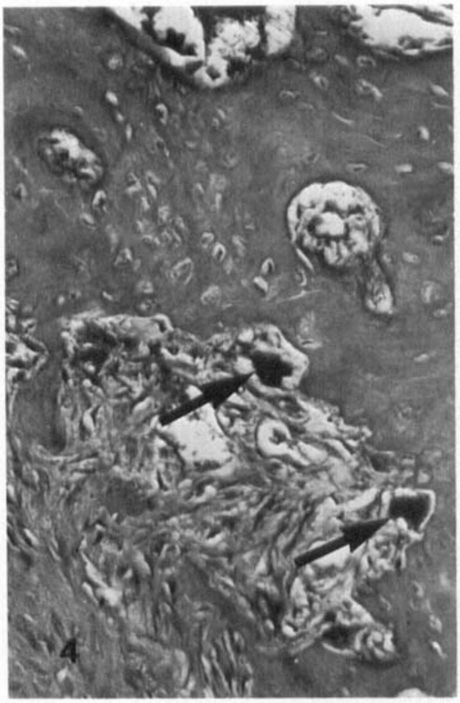

Figure 4. A similar section to that shown in Figure 3 showing a row of osteoclasts (arrows) along the peripheral surface of the graft. H&E, ×192.

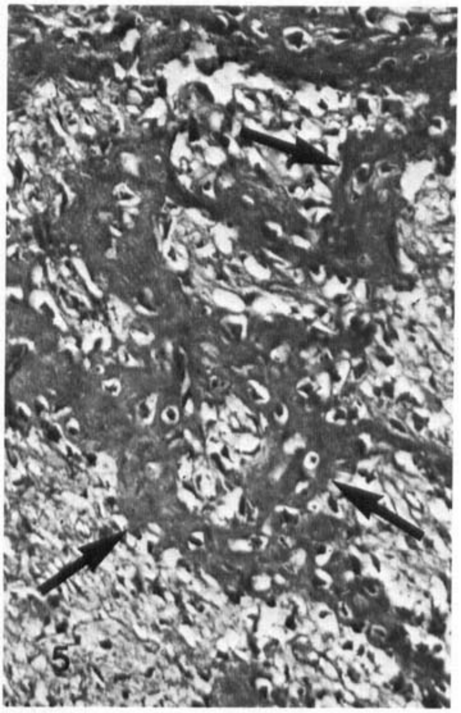

Figure 2. A section through the interface between the host and a graft 10 months after surgery. Note the well-developed network of bone trabecules (arrows), which composes the osseous bridging that contributes to the efficient union and repair of the acetabular defect. Note partial resorption of the graft.

Heywood 1980, McCullum et al. 1980), relatively little is known about the fate of grafts that are covered with methylmethacrylate cement. In view of recent experimental results in our laboratory (Roffman et al. 1982) we were encouraged to design and proceed with this model system which to a great extent resembles similar situations in humans. Our present morphological findings tend to provide important evidence that bone cement *per se* does not necessarily hinder *de novo* osteogenesis, a fact that has been noted also in our femur model. In the latter model, autogenous bone grafts that were coated with methylmethacrylate cement surrounded an osteotomized femur that was stabilized via an intramedullary rod. In contrast to the femur model, which revealed a fibro-osseous union, the acetabulum revealed a more solid bony union possibly due to the fact that in the acetabulum there was no motion between the graft and the host. The lack of inevitable motion appeared to enhance the differentiation of progenitor cells to osteoblasts and thereby the accelerated formation of new bone. One is, therefore, tempted to assume that a similar developmental pattern would take place in humans within a time period ranging from 6 to 10 months. Heywood (1980) has recently reported his experience using bone grafts underneath bone cement in the acetabular socket and McCullum et al. (1980), have reported an autopsy study of one of their patients who had undergone a procedure similar to the one described in this study and indicated the presence of bony union.

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