ALLOGRAFTS OF THE HEMIPELVIS AFTER TUMOUR RESECTION

TECHNICAL ASPECTS OF FOUR CASES

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Four en-bloc resections for malignant tumours of the hip, the peri-acetabular region and the iliac wing were reconstructed using an irradiated hemipelvic allograft together with a total hip prosthesis. Technical aspects include the use of an anterior Enneking approach which excises the previous biopsy site, division and re-attachment of the iliac crest and fixation of the prosthesis using a modified acetabular cup and three polypropylene artificial ligaments to increase the stability of the joint.

Weight-bearing was allowed at three months. The oncological and clinical results were satisfactory after a mean follow-up of 19 months, with walking distances of 500 metres to two kilometres without pain.

Reconstruction after the excision of pelvic tumours involving the acetabulum and the iliac wing poses difficult problems. In four such cases, we performed allograft reconstruction of the hemipelvis using cadaver bone together with a total hip prosthesis rather than a hemipelvectomcy or any other conservative procedure. Follow-up at three, 15, 26 and 33 months in the four cases showed that this operation had a low early morbidity and satisfactory functional results.

CASE REPORTS

All the tumours involved the region of the acetabulum, requiring excision of the joint and the iliac wing. There were two chondrosarcomas and two isolated metastases, one of thyroid and one of renal carcinoma. The four patients were women aged 30, 46, 60 and 67 years, all in good general health. The first case involved also the upper femur but in the three later cases the operative and rehabilitation techniques were as described for Case 2. Case 1. A 30-year-old woman with a pelvic chondrosarcoma associated with multiple exostoses was treated at Caen (Vielpeau and Langlais 1987). The tumour measured 11 by 23 cm, extending from the pelvis to the anterior part of the greater trochanter. A Cochin upper femoral resection prosthesis was used and a pelvic allograft was fixed by two plates to the remaining portions of the pubis and ischium. No ligament reconstruction was used to stabilise the hip.

Case 2. A 46-year-old woman suffering from a pelvic metastasis, was operated on in October 1985. She had received surgical treatment for a carcinoma of the thyroid two years earlier. Radio-isotope scanning and other tests revealed only a solitary metastasis above and around the acetabulum with extension both within and outside the pelvis (Figs 1 and 2). She was first treated with radioactive iodine and then by the pelvic operation after embolisation of the superior gluteal artery. Using an Enneking approach (see Figs 5 and 6) a wide excision was performed with removal of the joint and the upper end of the femur down to the intertrochanteric line. Reconstruction was performed using an irradiated hemipelvis fixed by screws to the sacrum and to the pubis and ischium by large intramedullary cancellous screws (Fig. 3). A standard total hip prosthesis was inserted and stabilised by artificial ligaments (Fig. 4). The limb was kept in balanced traction for three weeks (Fig. 5) and weight-bearing was allowed at the end of the third month. Twenty-four months later there were no signs of recurrence of the disease and there was little pain. Passive flexion of 100° was possible but active flexion was only 40° because of the considerable muscle excision. The patient was able to walk indoors without a stick and out of doors for two kilometres using one stick. Standing on the operated leg was possible without marked pelvic
Case 2. Pre-operative radiograph and CT scan of the solitary metastasis of a thyroid carcinoma in a 46-year-old woman.

Fig. 3
Radiograph at 18 months.

Diagram to show the allograft (stippled), the polypropylene braid holding down the neck of the prosthesis (striped) and the braids controlling rotation without limiting abduction or adduction (black).
tilting, possibly because of a tenodesis effect, since the abductor muscles had not been retained (Fig. 6).

Cases 3 and 4 were treated by the same technique and postoperative management.

RESULTS

Although the operations lasted about 10 hours, no severe complications were seen. There were no infections, no dislocations and no phlebitis. Wound healing was obtained in 15 days in the two younger patients, but an area of skin necrosis measuring about 2 by 7 cm developed at the anterior part of the flap in the two patients over 60 years of age. Healing was obtained in two weeks, after excision and suture in one case and excision, and split-skin grafting in the other.

The time to bony union was difficult to assess, but was probably achieved in three to six months at all the sacro-iliac junctions and at the pubic and ischial rami in the two younger patients. The functional result in the three cases with over one year of follow-up was better than was anticipated after such extensive excision of muscle. On the Merle d'Aubigné scale (1970), pain was mild, scoring 5 out of 6, passive flexion was over 90° and active movement, including flexion of about 40°, scored 3 out of 6. Stability was not severely impaired and was rated at 4 out of 6. The women, all housewives, were able to resume most of their previous activities.

At 17 months Case 3 (a woman of 60 on long-term steroid therapy for rheumatoid arthritis) had sudden severe pain in the hip, with instability and shortening, and some days later, suffered a severe retro-peritoneal haemorrhage. At operation we found no recurrence of infection, but a fracture of the acetabulum with intrapelvic protrusion of the cemented cup, and injury to the iliac artery.

These findings were compatible with a fatigue fracture at the rim of the peri-acetabular "revascularised" bone. After vascular repair, the acetabulum was reconstructed with femoral head allografts. Postoperative recovery was uncomplicated and functional rating at six months was 5–2–2.

DISCUSSION

The rationale of allograft reconstruction. Most pelvic lesions, particularly those of the iliac wing at a distance from the acetabulum, can readily be treated by resection of the iliac wing with or without fusion between the sacrum and the supra-acetabular region. However, CT scans and magnetic resonance imaging show that many malignant tumours extend to the acetabulum and even penetrate the joint. Such tumours require en-bloc resection of the joint and its capsule, the pelvirochanteric muscles and the iliac wing with its covering of gluteus medius, minimus and ilipsoas. Restoration of
function poses difficult problems, and an allograft seems to be one of the possible techniques.

Other solutions include hemipelvectomy, but this gives poor functional results (Michaut et al. 1975). Major prosthetic replacement has a high rate of morbidity, because of the difficulty of attachment to the residue of the pelvic ring, and because muscle re-attachment is impossible. Resection of the pelvis without reconstruction gives only moderate functional results (Nilsonne et al. 1982, Campanacci et al. 1987) as does pelvi-femoral arthrodesis. These options can be retained as back-up procedures if an allograft should fail.

The use of an allograft is therefore valuable. It is not a complex operation, the most demanding part being the excision. The allograft can be regarded as a "prosthesis" which is relatively easy to produce. It can be shaped to the required dimensions, fixed in place and combined with a standard hip prosthesis. It offers the advantage of eventual biological union to the neighbouring bone and makes muscle re-attachment easier. In our bone bank, allografts are removed aseptically from brain-dead patients at the same time as visceral grafts are removed. The bone is stored at -40°C and is irradiated with 1.5 to 2.5 megarads of beta-radiation. This sterilisation combats any contamination which may occur during removal of the graft (Hernigou, Delepine and Goutallier 1986).

Radiological and technetium scanning show that replacement of the allograft by host bone is only partial. A biopsy performed in Case 1 more than one year after grafting did not demonstrate any colonisation by osteocytes. In addition, magnetic resonance examinations performed one year after operation in Cases 2 and 3 showed resonances in the allografts which were characteristic neither of living nor of necrotic bone but rather of fibrous tissue.

**Approach and vascular control.** The Enneking approach (Campanacci et al. 1987) is recommended since it enables the dissection to be made inside and outside the pelvis in good operative conditions and allows an en-bloc excision of the tumour to include the site of the previous biopsy. If a wide excision is planned, this preliminary biopsy should be made through a Heuter-Schede type of anterior approach, using a trophine to collect a supra-acetabular sample.

Although the Enneking approach provides a well-vascularised musculocutaneous flap, some skin necrosis, which is benign if excised early, may be seen in older patients.

In Case 2, to limit bleeding during excision of a very vascular thyroid metastasis, pre-operative embolisation of the superior gluteal artery was used without complications and with an effective reduction of operative blood loss. In other cases, fearing skin necrosis caused by embolisation of terminal cutaneous branches, we preferred to ligate the internal iliac artery (which has a large anastomotic network) and the superior gluteal artery at the sciatic notch.

**Stabilisation of the graft and the prosthesis.** Internal fixation of the allograft does not present any particular difficulty. Both sacro-iliac cartilaginous surfaces are excised and the lengths of the pubic and ischial rami are adjusted. Fixation is accomplished with 7 mm Maconor screws. These screws are 60 or 70 mm long, are self-tapping, cone-shaped and applied over a 2.5 mm guide wire. They produce fixation which has several advantages over plate fixation. It is rigid, does not require removal of the periosteum of the healthy bone and allows the area of fusion to be covered with cancellous autografts.

Sacro-iliac arthrodesis is performed using 5 or 7 mm diameter screws inserted into the posterior iliac mass at an angle oblique both medially and forwards. An upper screw is inserted into the sacral wing and a lower screw emerges between two anterior sacral foramina which can readily be located by palpation. This fixation is not as solid as that at the obturator foramen.

The rim of iliac crest, which has been preserved, is secured to the graft with braided nylon sutures. These sutures transfix the allograft 10 mm below its upper edge and are passed over the remaining iliac crest, thus placing this part of the allograft next to well-vascularised bone. The abdominal muscles and any remaining gluteal muscles are re-attached to the crest to provide good cover of the operation site.

Stabilisation of the prosthesis is important. We used titanium alloy prostheses and fixed them in place using antibiotic-loaded bone cement. Cement fixation appears to be more reliable than bone ingrowth from an allograft, and the presence of antibiotics provides protection from infection. The prosthesis must be self-stabilising during the early weeks since the capsule and all the muscles contributing to the stability have been excised. For this reason, we used a prosthesis with a head diameter of 32 mm rather than a smaller head. The acetabular cup has posterior and superior walls to limit the risk of dislocation in these directions (Langlais et al. 1986). The cup is placed more horizontally than usual, at an angle of 35° with slight anteverision.

In Cases 2, 3 and 4, three Kennedy braided artificial ligaments were used to stabilise the arthroplasty (see Fig. 5). One encircled the neck of the femur at its upper end and was attached to staples inserted into the ilio-pubic and ischiopubic rami, thus limiting the risk of upward dislocation of the prosthesis. The two other artificial ligaments were used to make up for the absence of rotary control of the hip with the risk of dislocation in extreme rotation. One ligament was placed between holes drilled in the anterior edge of the greater trochanter and the anterior part of the pelvis close to the ilio-pubic eminence. It was tightened so that abduction and adduction were not limited but external rotation was. Another ligament was attached in the same way between the ilio-ischial junction and the posterior edge of the greater trochanter to limit internal rotation. The use of
these ligaments improved the stability of the prosthesis, but stress on the posterior ligament may explain the osteolysis at the iliac attachment which was noticed after one year.

Other factors. What is the future of this type of operation from the oncological point of view? The fact that the limb had been preserved and the pelvis reconstructed did not reduce the extensive nature of the excision. The resection would not have been more extensive if hemipelvectomy had been used. Additional treatment was not needed for these patients since histological examination showed that excision had been wide in all cases (Enneking and Dunham 1978). Control scans using iodine markers 12 months after excision of the thyroid metastasis showed no evidence of deposits in the pelvis and none were found in other patients on routine magnetic resonance scans.

What is the future of these allografts? Replacement of the graft by host bone is a hypothetical consideration, though it is possible that the large surface of the iliac bone and its cancellous structure will allow better invasion than the dense cortex of diaphyseal bone. Creeping substitution may possibly increase the risks of loosening or fatigue fractures, though the use of intramedullary screws in the ilio-pubic and ischiopubic rami may reduce this risk.

Conclusions. We report four cases of allograft replacement of the hemipelvis after its resection en-bloc with the upper end of the femur. The prospects of reconstruction did not limit the extent of tumour excision which was wide. There have been no recurrences or metastases, though the follow-up only extends over a maximum of 33 months, with a mean of 19 months. It was surprising to find how straightforward was the postoperative course in these patients after a 10-hour operation. The quality of the functional result was quite good and after six months the patients were able to walk with a stick without pain. A return to normal family life and some leisure activities was possible though one patient required revision at 17 months. Important technical points include: absolute sterility of the allograft, firm fixation using large cancellous screws in the pubic and ischial rami, preservation of the iliac crest as a pedicle graft, and stabilisation of the prosthesis helped by a special acetabular cup and artificial ligaments.

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REFERENCES


