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Pelvic limb-salvage surgery for malignant tumors

Abstract Thirteen patients with primary malignant tumors of the pelvis underwent internal hemipelvectomy. The diagnoses were: Ewing's sarcoma 7, osteosarcoma 4, chondrosarcoma 1, and malignant fibrous histiocytoma 1. No megaprostheses or massive allografts were used for reconstruction. Six patients underwent resection only with no reconstruction, 5 had strut grafts inserted to restore the pelvic ring, 1 had an autoclaved autograft of the acetabulum and 1 had an ilio-femoral arthrodesis. No patients were lost to follow-up. Nine patients died from their disease after an average of 23 months (range 2 to 72 months). The 4 survivors (3 free of disease) have an average follow-up of 84 months (range 60 to 120 months).

Résumé Treize patients porteurs d'une tumeur maligne du bassin ont subis une hémi-pelvectomie interne. Les diagnostics furent: sarcome d'Ewing 7, osteosarcome 4, chondrosarcome 1, et histiocytome fibreux malin 1. Nous n'avons utilisé aucune allogreffe ou mega-prothèse pour la reconstruction. Six patients n'ont eu qu'une résection, cinq ont eu des greffes de peroné non-vascularisé pour reconstituer l'anneau pelvien, un a recu une autogreffe autoclavée, et un a subi une arthrodèse ilio-femorale. Aucun patient n'a été perdu de vue. Neuf patients sont morts de leur maladie après un délai moyen de 23 mois (2–72 mois). Les quatre survivants, dont trois sans signe de leur maladie, ont un suivi moyen de 84 mois (60–120 mois).

Introduction

Limb salvage surgery for malignant tumors of the pelvis is a formidable surgical undertaking, both from the viewpoint of surgical resection and the reconstruction. The

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surgeon's primary goal is local control of the tumor by complete resection and the secondary goal is to preserve a functional limb.

The traditional surgical procedure was a formal hemipelvectomy, but recent advances in effective adjuvant chemotherapy have encouraged surgeons to carry out wide resections with preservation of the limb. Following wide resection, the surgeon's next challenge is reconstruction to restore as much pelvic stability and hip joint function as possible. We report our results in 13 cases following resection only or following reconstruction with autogenous bone grafts without using pelvic allografts or megaprostheses.

Patients and methods

The 13 patients selected for internal hemipelvectomy and included in this study were seen between January 1990 and June 1996 in the combined sarcoma clinic at our institution. All but one of the tumors were classified as stage II B [10]. The preoperative evaluation included routine blood work, radiographs and both computed tomography (CT) and magnetic resonance imaging (MRI) studies of the lesion. A technetium bone scan was done to exclude distant skeletal metastases or multiple lesions, and chest X-ray and chest CT scan to exclude pulmonary metastases.
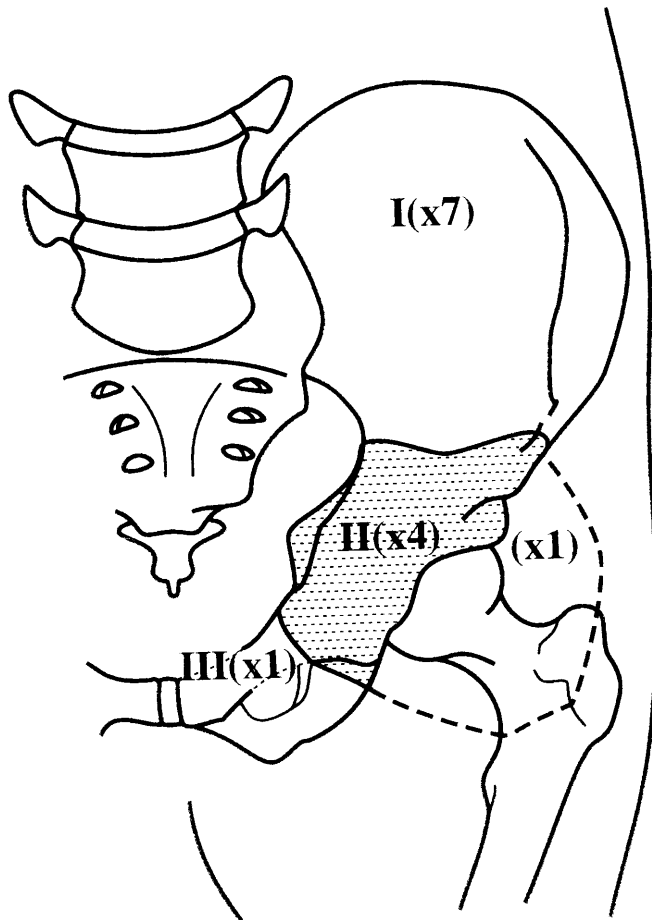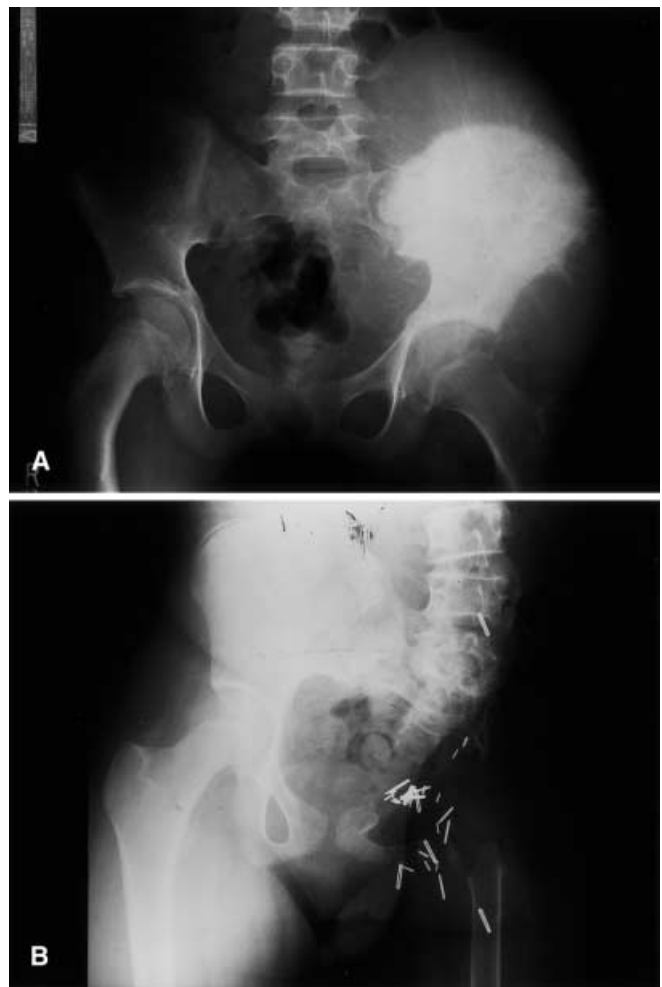
Following preoperative evaluation, surgery was considered if it was felt that a clear margin could be obtained with preservation of the major vessels and nerves. According to the classification of pelvic lesions of Enneking [9] there were 7 P1, 5 P2 and 1 P3 lesions (Fig. 1). One patient with a femoral neck osteosarcoma with intra-articular spread into the hip joint needed a peri-acetabular resection as for a P2 lesion. Table 1 gives a clinical overview of the 13 patients in this study.

Nine of the 11 patients presenting with a diagnosis of either Ewing's sarcoma or osteosarcoma received neo-adjuvant chemotherapy according to protocols being used at that time. The other 2 patients who presented with a pathological fracture proceeded directly to definitive surgery. Adjuvant chemotherapy was given to all 11 patients.

Three of the 7 patients with Ewing's sarcoma received chemotherapy and radiotherapy as the initial treatment, but then required surgery either because of a late recurrence or inadequate response to the initial treatment. Postoperative radiotherapy was limited to patients with contaminated surgical margins.

The surgical approach was often customized for the patient, depending upon the presentation of the tumor and the location of

Fig. 1 Anatomical location – 7 PI, 5 PII and 1 PIII lesions

Fig. 2 A Osteosarcoma (L) Ilium. **B** 10 years post-surgery following a Super-Girdlestone procedure

pre-existing biopsy scars. Access was generally through a modified ilio-inguinal approach or the utilitarian incision as described by Enneking [7]. The basic surgical principle that we followed included excision of previous biopsy tracts aiming for wide resection margins by limiting all dissection to normal tissue outside the "reactive" zone. If a lesion was entered, but still excised as planned, the procedure was considered contaminated. The extent of tumor excision was classified according to the system of Enneking and Dunham [9].

- *Type 1*: Iliac excision – excision of a portion or all of the iliac bone from the sacro-iliac joint to the neck of the ilium but sparing the acetabulum. Reserved for low-grade P1 lesions.
- *Type IA*: Iliac resection – in addition to the above includes resection of the buttock muscles. Generally done for high-grade P1 lesions.
- *Type II*: Peri-acetabular excision – wide excision of the whole acetabulum and adjacent neck of the ilium, ischium and lateral portion of the pubic rami. The femoral head is usually preserved. Done for low-grade P2 lesions.
- *Type IIA*: Peri-acetabular resection – usually necessitates an extra-capsular resection of the hip joint at or below the lesser trochanter and includes the entire acetabulum and peri-acetabular bone. Indicated for high-grade P2 lesions.
- *Type III*: Pubic excision – wide excision of a portion or whole of the pubis from the symphysis to the lateral margin of the obturator foramen but sparing the hip joint. Indicated for low-grade P3 lesions.
- *Type III A*: Pubic resection – in addition to the excision, includes a radical resection of the enveloping muscles and may include the femoral neuro-vascular bundle with preservation of

the hip joint. It is done for high-grade P3 lesions that have not extended intra-pelvically.

Excision margins were defined according to Enneking [6] and the surgical aim was to obtain a "wide" margin as far as possible. The resection was deemed contaminated if there was microscopic evidence of tumor extending to the excision margin or if there was spillage of tumor at surgery. According to these criteria 9 patients had "clear" margins and 4 patients had "contaminated" margins. The contamination in each of these 4 patients was at the sacro-iliac resection margin highlighting the difficulty of obtaining access for wide resection at this location. Adjuvant radiotherapy was given postoperatively to all patients with contaminated surgical margins.

Reconstructive procedures to restore pelvic stability varied according to the type of excision and the resultant osseous defect. In Type I and IA lesions fibular strut grafts were often used to complete the pelvic ring. In patients with a Type IIA resection it was often impossible to restore pelvic stability and these patients were left with what can be described as a "Super Girdlestone" procedure (Fig. 2). Our single patient with a Type III excision had an ilio-femoral arthrodesis.

Table 1 Characteristics of the 13 patients in this study (*MFH* Malignant fibrous histiocytoma, *AFO* ankle/foot arthrosis)

Patient no.	Age (years)/ Sex	Diagnosis, grade and location of tumor	Re-section	Margins	Reconstruction	Complications	Outcome
1	17/male	Ewing's (L) ilium, grade II B. Location PII	IA/IIA	Wide	Super-Girdlestone	Wound infection responded to debridement/ antibiotics	2/12 post-surgery soft tissue metastases to (L) forehead. 9/12 post-surgery had terminal metastatic disease
2	5/male	Ewing's (L) ilium, grade II B. Location P2 (Pathological fracture)	IIA	Wide	Super-Girdlestone	Foot drop	Alive with no disease. Uses AFO splint. 10 year follow up
3	15/male	Osteosarcoma (R) ilium, grade II B, Location P2	IIA	Wide	Super-Girdlestone	Nil significant	6/12 post-surgery chest metastases. 9/12 post-surgery terminal with chest/brain metastases
4	12/female	Chondroblastic osteo-sarcoma, grade II B. Location P2	IA/IIA	Conta-minated	Super-Girdlestone	None to date. Needed post-operative adjuvant treatment for conta-minated margin	Died 6 years post-surgery of metastatic disease
5	35/male	Osteosarcoma (L) superior pubic ramus, grade IIB. Location P3	II/III	Wide	Ilio-femoral arthrodesis	Nil	24/12 post-surgery developed local recurrence. 26/12 post-surgery was terminal with chest metastases.
6	13/male	Ewing's (R) ilium, grade II B. Location P1	IA	Wide	Fibular strut grafts	Supurating wound necrosis responded to debridement and antibiotics. Foot drop	Metastases contralateral hip 4 years post-surgery. 60/12 terminal
7	23/male	Chondrosarcoma (L) ilium, grade IIA. Location P1	I	Wide	Fibular strut grafts	18/12 postoperative eveloped wound infection with osteo-myelitis, required debridement with removal of autograft	Alive with no disease. 8 year follow-up
8	18/male	Ewing's (R) ilium, grade II B. Location P1	IA	Conta-minated	Fibular strut grafts	Nil significant	5/12 post-surgery local recurrence with chest/bone metastasis. Palliative treatment. 27/12 post-surgery was terminal
9	21/male	Ewing's (R) ilium, grade II B. Location P1	IA	Conta-minated	Fibular strut grafts	Nil significant	15/12 post-surgery developed local recurrence with multiple metastases and was terminal at 16/12 post-surgery.
10	30/male	MFH (R) ilium, grade IIB. Location P1	I	Conta-minated	Retained bony bridge	Wound breakdown responded to debridement/ antibiotics	2/12 post-surgery had both local recurrence and multiple metastases and was terminally ill
11	24/male	Osteosarcoma (R) femoral neck. Pathological fracture and intra-articular extension, grade IIB. Location P2	IIA	Wide	Re-implantation of autoclaved acetabulum	Dislocation hip-treated by relocation and pantaloon cast followed by abduction brace	Alive with disease. Chest metastasis 5 years post-surgery. Symptom free at (R) hip but radiological evidence of loosening of acetabular component
12	22/male	Ewing's ilium, grade IIB	1A	Wide	Fibular strut grafts	Nil significant	At 18/12 post-surgery metastasis with terminal disease.
13	15/male	Ewing's (L) ilium, grade IIB. Location P1	IA	Wide	Retained bony bridge	Nil significant	5 years post-surgery alive with no disease
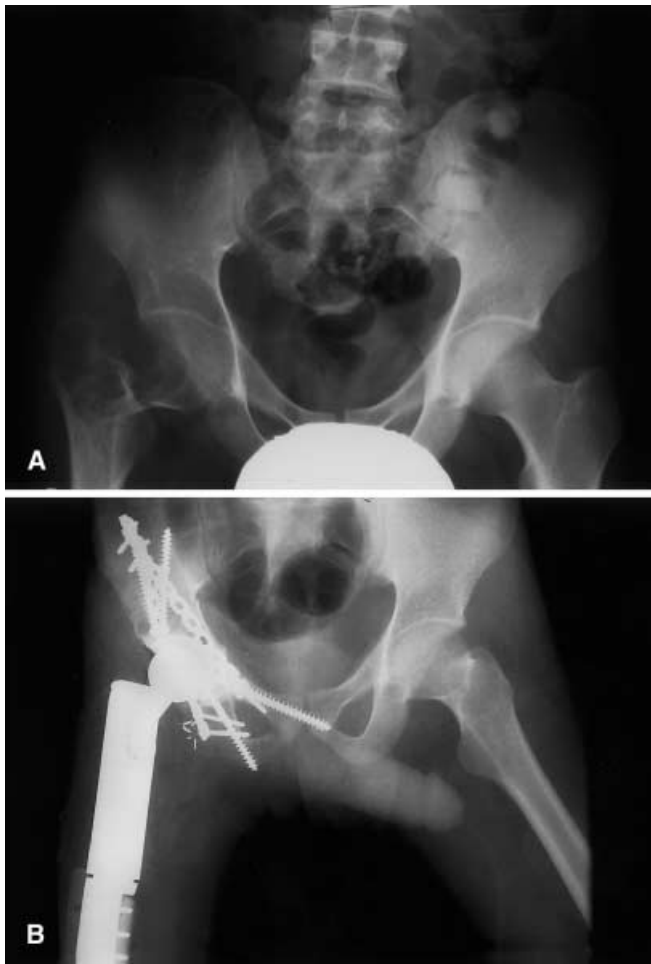
Fig. 3 A Fibrous osteosarcoma hip with a pathological fracture. **B** Composite reconstruction

Results

Significant morbidity may be anticipated for patients undergoing such extensive procedures [1, 4, 9, 13, 16]. Wound infection was the most common complication in our series, with 4 patients requiring additional treatment in the form of local debridement and appropriate multi-drug anti-microbial therapy. All 4 patients went on to heal uneventfully without the need for flap procedures although one patient eventually required removal of fibular strut autograft for chronic osteomyelitis.

Neurological complications in the form of a drop-foot occurred in 2 patients, secondary to a traction lesion of the L4/5 roots in an attempt to gain clearance with adequate margins at the sacro-iliac joint level.

One patient with a P2 lesion had a Type IIA resection and reconstruction with re-implanted autoclaved bone on the acetabular side with a cemented cup and a proximal femoral replacement (Fig. 3). Postoperatively the prosthesis dislocated (the entire abductor mass was removed at surgery) and following closed reduction the patient was treated in a pantaloon cast for 3 months and then in

a brace for a further 6 months. At his 5-year review the patient's hip remained stable and he was mobilizing with full weight bearing. However, on X-ray, loosening was apparent and multiple pulmonary metastases were seen, which were not amenable to surgery.

Three out of 4 patients with contaminated margins developed local recurrence despite postoperative adjuvant radiotherapy, compared with 1 out of 9 patients who had clear resection margins. This latter case was a patient with a highly pleomorphic osteosarcoma in a P3 location that needed a Type II/III resection. The incidence of local recurrence correlated closely with the type of surgical margin, with postoperative adjuvant radiotherapy having only minimal success in prevention.

The mean length of follow-up was 7 years, by which time 3 patients were alive with no evidence of disease. One patient was alive with disease and the remaining 9 patients had died of metastatic disease (4 of them had evidence of local recurrence).

Functional evaluation of the survivors was undertaken according to the Musculo-Skeletal Tumor Society modified system [8]. Out of the 4 survivors 3 had good and 1 had a fair result.

Discussion

Internal hemipelvectomy is the application of the principles of limb-sparing surgery to pelvic tumors. With an increasing demand for limb salvage, it is being performed more often and for more advanced tumors than previously. The critical area in this procedure remains the proximal margin [1, 9, 12, 16] and local control is a measure of successful surgical resection.

In our study the local recurrence rate was 4 out of 13 patients and all 4 cases with inadequate resection had contamination at the proximal resection margin. Other authors have reported similar local recurrence rates from 27 to 30%, [9, 11, 16] although Huth et al. [12] reported a substantially lower local recurrence rate of 7.4% (however, for standard hemipelvectomies his rate was 33%). Clear resection margins should be the goal, as there seems to be no convincing adjuvant treatment modality to prevent local recurrence in the event of contaminated margins. In our study, postoperative adjuvant radiotherapy was not successful in preventing local recurrence in the majority of patients.

Adequate reconstruction following surgery can be difficult, particularly with peri-acetabular resections. The choices are arthrodesis, arthroplasty, or allograft bone usage. Arthrodesis involves co-aptation of the resected bone ends to achieve either a sound fusion or a pseudo-arthrosis [9, 16, 19], e.g., ilio-femoral or ischio-femoral. Arthroplasty options are a pelvic endo-prosthesis, which may include the hip joint, a saddle type of prosthesis or acceptance of a salvage.

In pelvic excision arthroplasty [5, 15, 18], allograft bone can be used either alone or as an allograft/prosthesis composite for major reconstructions [11, 14, 19]. In

our series the Super-Girdlestone resection used in the early part of this study not surprisingly gave inferior functional results. Our 1 patient with an autoclaved autograft-prosthesis composite reconstruction had a good functional result at 5 years, but the long-term prognosis regarding this reconstruction remains guarded as the x-rays showed loosening.

An autogenous primary arthrodesis would certainly give the best long-term result in terms of durability, but this is often not feasible with extensive resections and obtaining sound bony fusion can be difficult [2, 3, 9].

With such major surgical procedures, problems with wound healing and infection are anticipated, and our rate has been roughly comparable to the 22–39% [1, 9, 16] reported in other studies. However, we did not have any major flap necroses. The two neurological complications were L4–5 traction injuries with a resultant permanent foot drop for which the patients required an orthosis. Injury to nerve roots [1, 9, 16] (intentional or inadvertent) in an effort to gain clearance at the proximal resection margin has been well documented and is not a contraindication for limb salvage.

The justification for an internal hemipelvectomy depends upon both achieving at least as good a survival rate as hindquarter amputations and at the same time leaving the patient with a functional level greater than could be achieved by a prosthetic fitting after amputation. It is, of course, difficult to compare two procedures that are not necessarily applied to similar anatomical situations (in that patients undergoing a hindquarter amputation are likely to have more advanced disease) but even so Apffelstaedt et al. [1], among others [12], have shown in their studies that local recurrence rates and mortality after internal hemipelvectomy are, if anything, superior to those obtained in patients undergoing a standard hemipelvectomy (hindquarter) and the former offers better functional results. In our series, the 3 survivors had a good functional outcome and one fair according to the scale of the Musculo-Tumour Society [8].

The survivors included 2 patients with Ewing's sarcoma at 5 and 10 years post-surgery, plus 1 patient with chondrosarcoma at 8 years post-surgery. One patient with osteosarcoma at 5 years post-surgery is alive, but with residual disease. Long-term survival with high-grade non-metastatic tumors in other studies has been shown to be about one third of the cases [17], as in our group.

Pelvic limb salvage for malignant tumors is a formidable surgical undertaking with a high potential for complications. Although more difficult than a formal hemipelvectomy, the survival and recurrence rates are similar. Patients prefer it to formal hemipelvectomy, both for appearance and function. Because of the nature of the malignancies, the long-term survival rate remains around 30%. We preferred resection alone or biologic reconstruction using autogenous bone grafts in the majority of our patients.

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