

# Outcome after pelvic sarcoma resection and reconstruction with a modular hemipelvic prostheses

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## Abstract

**Purpose** The aim of this study was to evaluate the early clinical outcome of reconstruction with modular hemipelvic prostheses after pelvic sarcoma resection.

**Methods** We retrospectively reviewed eight patients between 2004 and 2007 who had periacetabular resections and reconstruction with a modular hemipelvic prosthetic system for pelvic sarcoma with a mean follow-up of 27 (range, 10–54) months. Oncology outcome was assessed with survival rate, local recurrence rate, International Society of Limb Salvage (ISOLS) score and complications. Two patients had types I and II (periacetabular and ilium) pelvic resections, three had types II and III (periacetabular and pubis) pelvic resections and three had type I, II and III (ilium, periacetabular and pubis) pelvic resections. Nobody received chemotherapy or radiotherapy.

**Results** Five patients were free of disease; three patients died of disease. The overall survival rate was 62.5%. None had local recurrence, and 37.5% had metastasis. The mean ISOLS score was 19.5. No one had deep infection or dislocation.

**Conclusions** Reconstruction with a modular hemipelvic prosthetic system after periacetabular resection is a promising method because of the acceptable complication rate and satisfactory functional outcome.

## Introduction

Before the 1980s, hemipelvectomy was the standard surgical treatment for primary pelvic sarcomas. Recently, however, limb salvage surgery in the pelvis is more common due to better function, quality of life and acceptable local recurrence. Though limb salvage surgery remains difficult and challenging, various methods were used to reconstruct the hemipelvis after periacetabular reconstruction resection, including ischiofemoral arthrodesis or pseudarthrosis, iliofemoral arthrodesis or pseudarthrosis [16], massive allograft [6, 23, 27, 30], autoclaved autograft [20], allograft prosthetic composite [21, 35], custom-made endoprosthesis combined with hip arthroplasty [1, 17, 38], modular saddle prosthesis [2, 5, 7] or modular hemipelvic endoprosthesis [37]. However, each method has its limitations, such as high complication or local recurrence rates or poor functional results after hemipelvic resection, etc [31]. In this study, we used a modular hemipelvic endoprosthesis, which was easy to use in surgery and features flexible size [37]. We evaluated the early clinical outcome of the modular hemipelvic prosthesis by survival rate, local recurrence rate, function score and different complication rate.

## Materials and methods

Between 2004 and 2007 at the outpatient department of the West China Hospital, Sichuan University, China, approximately 37% of pelvic tumours were primary bone tumours. From those patients, 30% (eight patients) selected periacetabular resection and reconstruction with a modular hemipelvic prosthetic system. Approximately 26% selected hemipelvectomy or reconstruction with custom-made pros-

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Level of Evidence: Therapeutic study, Level IV-1 (case series without control group). See the Guidelines for Authors for a complete description of levels of evidence.

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thesis; 44% abandoned treatment due to treatment costs, poor physical condition or other reasons. We retrospectively reviewed eight patients treated with tumour resection and reconstruction using modular hemipelvic endoprostheses for primary bone tumours during this period (Fig. 3). Six patients were men and two were women. Age ranged from 25 to 63 years, with a mean of 45 years. The minimum follow-up was ten (mean 27; range 10–54) months.

Diagnoses were chondrosarcoma in four patients (50%), osteosarcoma in one (12.5%), leiomyosarcoma in two (25%) and malignant giant cell tumours in one (12.5%). All patients received no chemotherapy or radiotherapy. Two patients had types I and II (periacetabular and ilium) pelvic resection, three had types II and III (periacetabular and pubis) pelvic resection and three had types I, II and III (ilium, periacetabular and pubis) pelvic resection. Three malignant tumours were high grade with an extraskeletal component (stage IIB) and five were stage IB (Table 1).

We preoperatively staged all tumours according to the staging system of Enneking et al. [13]. Preoperative staging and assessment of tumour resectability were accomplished with chest X-ray, Bone scan and three-dimensional computed tomography (CT) scans or magnetic resonance imaging (MRI) in all patients. The osseous involvement of the tumour was evaluated to ensure that enough iliac bone could be preserved; the extraosseous component of the tumour was assessed for resectability and to address possible pelvic organ involvement. The modular, titanium hemipelvic prosthesis (ChunLi Co, Beijing, China, Fig. 1) was of biomimetic designed according to pelvic radiographs and three-dimensional CT scans. All operations were performed by the senior surgeon (Chongqi Tu). Although the operative details have individual variance, there were common features. The patients were placed in a lateral position on the contralateral side. We used a combination of an ilioinguinal, posterior iliac, and Smith-Petersen approach. We started from the posterior iliac spine – iliac crest – anterior superior iliac spine, inside to the pubic tubercle along the inguinal ligament, which exposed the inner face of the pelvis, iliac vessels, femoral vessels and nerves, bladder and pubis, extended lateral to distal along the sartorius muscle and the outer edge of the rectus femoris muscle, which exposed the outer face of the pelvis, sciatic nerve, acetabulum, ischium and proximal femur. We performed the periacetabular resection according to the tumour extent. The upper boundary reached at least to the lower edge of the sacroiliac joints. However, the auricular plane of the sacral bone or the small auricular plane of the ilium was reserved. The hemipelvic prosthesis was then saddled in the lower edge of the sacroiliac joint or the lower edge of the auricular plane of the sacral bone (Fig. 2) and horizontally fixed with three or four screws. The pubis component of the hemipelvic prosthesis was

fixed with the contralateral pubic bone by a screw plate. After that, we routinely placed the acetabular component in 45° abduction, 15° anteversion and routinely placed the femoral prosthesis. After reconstruction, cancellous bone of the excised autogenous femoral head was grafted into the space between the plate and bone. Then, the muscles were reattached as far as possible and the wound was closed over a suction drainage.

The postoperative limb position was determined by the intraoperative abduction and anteversion angles, commonly in a rotary neutral, 15°~25° abduction, 15° hip-flexion position and 15° knee position. Orthosis devices preventing rotation were used to keep the hip in a rotary neutral position because the limb could adopt external rotation, caused by the missing or weak proximal femoral muscle attachment points after the wide excision.

Postoperative rehabilitation training was strictly undertaken (Figs. 3 and 4). Our patients began exercises eight h after the surgery. Quadriceps relaxation and contraction was executed during the first seven days. Then, patients were encouraged to flex the affected hip actively but <90° in order to reinforce the strength and balance of the internal and external rotation hip muscles. After two weeks, patients could stand with the lumbar pelvic hip brace (Initially, the affected limb weight-bearing was reduced and then gradually increased until equal to that of the contralateral side). Walking with crutches without the protection of the brace began at week four. Three months after reconstruction, patients could walk without crutches and flex the hip >90°.

Oncological outcome was determined using the International Society of Limb Salvage (ISOLS) system [14] at the latest follow-up. The ISOLS score measures patient activity, including pain, function, emotional acceptance, supports, walking ability and gait. Each variable was assessed on a five-point scale, allowing a maximum score of 30 points. Complications, including surgery-related complications and mechanical failures, were determined at the final follow-up.

## Results

The follow-up ranged from 10 to 54 months (27 months on average). Overall survival rate was 62.5%. Two patients with chondrosarcoma and one with osteosarcoma died of metastasis to the lungs. Five patients were free of disease. No patient had local recurrence at the latest follow-up (Table 2). Postoperatively, three patients could walk without support; two patients required a brace; three patients could walk using a crutch. All patients were able to walk outside the house. No patient experienced complications perioperatively or during the follow-up period. Two patients had wound effusion but no patient had infection.

**Table 1** Treatment of implanted modular hemipelvic prosthesis in eight patients

Case	Gender	Age (years)	Diagnosis (stage)	Resection (Enneking stage [13])
1	Male	59	Chondrosarcoma IB	I+II
2	Female	55	Leiomyosarcoma IIB	II+III
3	Male	31	Chondrosarcoma IB	II+III
4	Male	52	Malignant giant cell tumour of bone IB	I+II+III
5	Male	34	Chondrosarcoma IB	I+II+III
6	Male	63	Chondrosarcoma IB	I+II+III
7	Male	25	Osteosarcoma IIB	I+II
8	Female	39	Leiomyosarcoma IIB	II+II

No hip dislocation occurred. Functional assessment of affected limbs of the eight patients resulted in two excellent and six good. The mean score was 19.5. Two cases received a score >25, two cases between 20 and 25 and four between 15 and 20.

## Discussion

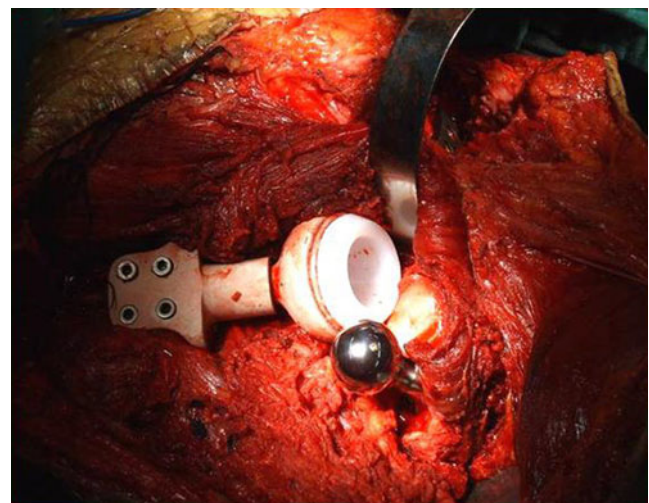
Limb salvage surgery in the pelvis is more favourable compared with other methods because of its worthwhile function and quality of life. Reconstruction after resection of periacetabular tumours is critical and difficult. Numerous reconstruction methods and kinds of differently designed endoprostheses after pelvic tumour resection have been reported (Table 3). Satcher et al. [34] reported 15 patients received a reconstruction method of autoclaved autograft and attained a 60% survival rate at five years. Aljassir et al. [5] reported 27 cases reconstructed with saddle prostheses and 59% survival rate. Ozaki et al. [31] reported a 70% survival rate of 12 custom-made prostheses for resection of pelvic sarcomas at three years. Wei et al. [37] used a modular hemipelvic system to reconstruct the periacetabular bone defect. We applied the modular hemipelvic



**Fig. 1** Components of a typical prostheses are shown. The set typically consists of three components: iliac fixation components with variable-length bush, acetabular component and pubic connection plate. All components are made of titanium

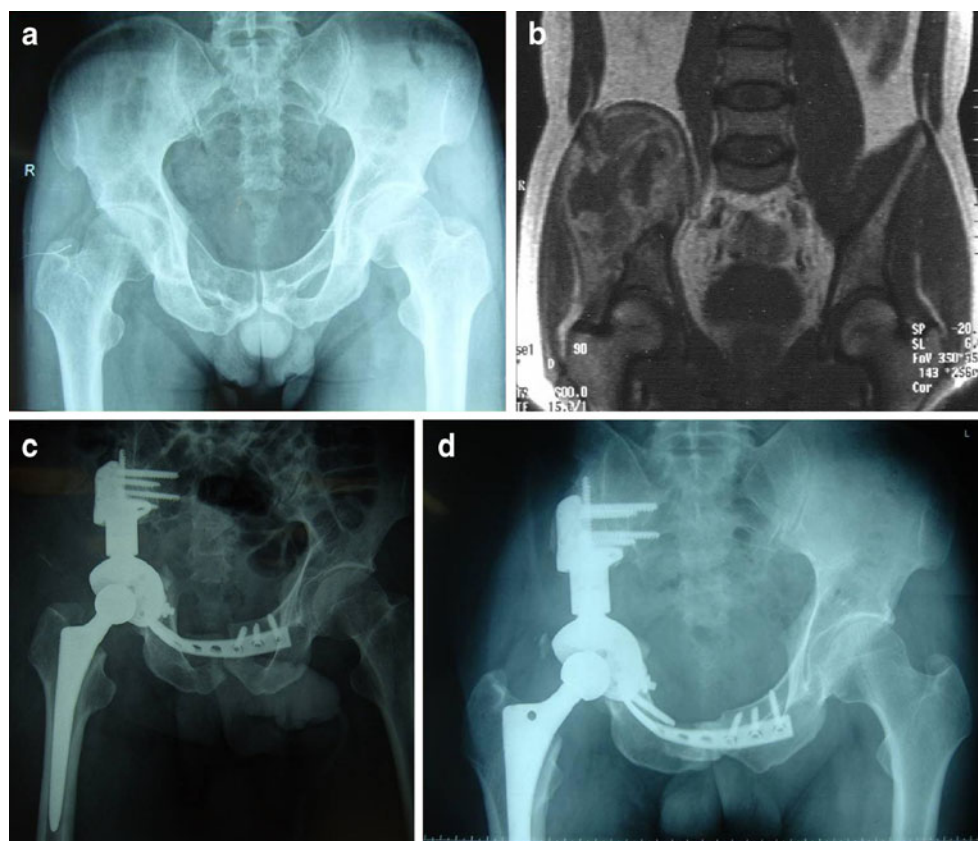
prosthetic system reconstruction in our study. Five patients were free of disease. Three patients died of disease. The survival rate of the eight patients with primary sarcoma in our study was 62.5% compared with 70% at three years in Wei et al. [37]. Local recurrences and infection did not occur in our study, whereas Wei et al. [37] reported a local recurrence of 25%; infection was 32.1%. The rate of local recurrence and infection reported by others varies from 22% to 55.6% and 21.4% to 37%, respectively.

Functional results depend on the extent of resection and the method of reconstruction [37]. Aljassir et al. [5] reported 27 patients reconstructed with saddle prosthesis after resection of pelvic sarcomas and achieved a Musculoskeletal Tumor Society (MSTS) (1987) score of  $15.3 \pm 6.1$  points. Windhager et al. [38] found custom-made pelvic prostheses had better functional results when compared with saddle prostheses and attributed this to the eccentric new hip centre position of the saddle prosthesis, which allows only limited motion. Ozaki et al. [31] reported the MSTS (1987) score of 12 custom-made prostheses after resection of pelvic sarcomas was 37%. Wei et al. [37]



**Fig. 2** Assembly process of the acetabular component and pubic connection plate

**Fig. 3 a–d** Modular hemipelvic prosthesis reconstruction after types I, II and III resection. The patient was a 63-year-old man with a chondrosarcoma of the right pelvis. **a** Radiograph shows the lytic lesion around the acetabulum. **b** Magnetic resonance imaging shows tumour involvement of the acetabulum with an extensive soft tissue mass. **c** Postoperative radiograph shows limb salvage reconstruction of the left hemipelvis achieved with implantation of a modular hemipelvic prosthesis. **d** Twelve months after reconstruction



reported the MSTS (1993) score of 28 for modular hemipelvic prosthesis following resection of pelvic sarcomas was  $60 \pm 17.3\%$ . We used the ISOLS system [14] at the latest follow-up and the score was 19.5.

It is critical that osseointegration is achieved after the surgery because failure in the osseointegration process is a significant cause of implant loss [28]. Osseointegration implies a firm, direct and lasting connection between vital bone and the titanium implants [3, 26]. It was defined by Brånemark that an implant is regarded as osseointegrated when there is no progressive relative movement between the implant and the bone with which it has direct contact [8, 9]. Montes considered that living and functional bone tissue formation around the implants results in osseointegration [25, 28]. Success of osseointegration depends on certain factors [33], such as implant biomaterial and superficial properties (topography and surface roughness) [4, 10, 11, 18, 19, 22], appropriate bone quantity and quality [15], systemic factors and no surgical complications, such as bone overheating and contamination [4, 24], and peri-implantitis [32, 36]. In our study, osseointegration of all cases was attained from the clinical aspect. That may be because few complications occurred, and we grafted cancellous bone from the cutting autogenous femoral head into the adjointer between the plate and bone, particularly in stress-concentration areas (Fig. 5).

Neither breakage nor loosening of the prosthesis occurred in our study. Aljassir et al. [5] reported fractures occurred in six (22%) and saddle dislocation occurred in six (22%) of 27 patients. Furthermore, progressive erosion of bone and upward migration of the saddle resulting from the direct application of load and movement between metal and bone have been frequently reported [5, 12, 29]. In our opinion, the force area between hemipelvic saddle prosthesis and sacroiliac joint have a parallel with the pelvic ring, which causes a significant shear force perpendicular to the fixed screws, greatly increasing the risk of implant loosening, even implant fracture. Windhager et al. [38] reported a dislocation rate of 7% and attributed the better functional results of custom-made pelvic prostheses compared with saddle prostheses to the eccentric new hip centre position of the saddle prosthesis, which allows only limited motion [5, 38]. Ozaki et al. [31] reported one patient with a custom-made prosthesis had a fracture of the sacral screws which might have been attributable to failure of hardware or failure of screw selection for fixation. Wei et al. [37] reported two cases (7.2%) of pubic fixation breakage and one case (3.6%) dislocation in 28 patients and suggested that pubic fixation may be inadequate. We developed finite element (FE) models of the pelvis reconstructed with modular prostheses and found that areas in axis of iliac fixation components and pubic connection plate were the



**Fig. 4 a–d** Postoperative rehabilitation training. Quadriceps **a** relaxation and **b** contraction before getting out of bed. **c** Standing with the lumbar pelvic hip brace 2 weeks after surgery. **d** Four weeks later, walking with crutches



stress concentration points (Fig. 5) (paper in preparation). Because the axis of iliac fixation components was designed to bear far more stress than it actually needed to, until now, no fracture has been reported in this area. Wei et al. [37] reported two that cases of breakage occurred in the pubic fixation connection area, showing that pubic fixation possibly needs some improvements. Such events did not

occur in our study, possibly because of the short-term follow-up, success of osseointegration, small modular prostheses eccentricity and high stress intensity of modular prostheses.

The postoperative rehabilitation exercises are very important because of the large surgical trauma and quantities of muscles involved. Until now, there was still

**Table 2** Follow-up of implanted modular hemipelvic prosthesis in eight patients

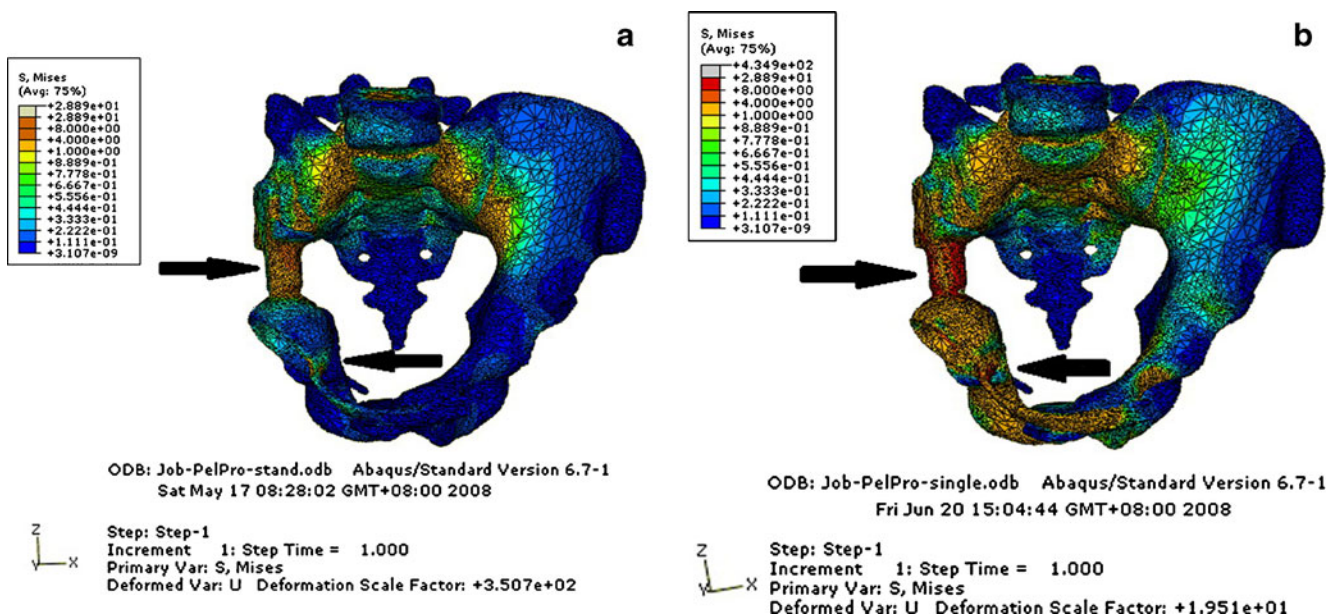
Case	Follow-up (months)	Results	Recurrence and metastasis	Complication	Function evaluation	ISOLS scores
1	54	Survived	None	None	Good	21
2	36	Survived	None	None	Good	20
3	16	Died	Metastasis in both lungs	None	Good	16
4	34	Survived	None	Wound effusion, no infection	Good	18
5	10	Died	Metastasis in both lungs	None	Good	15
6	33	Survived	None	None	Excellent	26
7	12	Died	Metastasis in both lungs	None	Excellent	25
8	24	Survived	None	Wound effusion, no infection	Good	15

**Table 3** Comparison of complication rate and functional scores of various periacetabular reconstruction studies

Study (year)	Number of patients	Reconstruction method	Mean follow-up (months)	Number of patients alive/dead	Major complication	Functional outcome
This study	8	Modular hemipelvic prosthesis	27	5/3	Infection 0%; local recurrence 0%; metastatic 37.5%; dislocation 0%	ISOLS score was 19.5; excellent to good 100%
Wei et al. [37] (2007)	28	Modular hemipelvic prosthesis	30	20/8	Infection 32.1%; deep infection 14.3%; local recurrence 25%; metastatic 21.4%; dislocation 3.6%	MSTS (1993) 60.0%±17.3% <sup>a</sup> ; excellent to good 62.3%
Aljassir et al. [5] (2005)	27	Saddle prosthesis	45	16/11	Infection 37%; local recurrence 22%; metastatic 22%; dislocation 22%	MSTS (1993) 50.8%±21.7% <sup>a</sup> ; MSTS (1987) 15.3 points±6.1 points <sup>a</sup> ; TESS 64.4%±17.2% <sup>a</sup>
Ozaki et al. [31] (2002)	12	Custom-made prosthesis	57	9/3	Deep infection 25%; dislocation 8.3%; local recurrence 33%	MSTS (1987) 37%
Wirbel et al. [39] (1999)	39	Megaprosthetic replacement	58	19/20	Infection 25.6%; dislocation 15.4%; metastatic 41.0%; local recurrence 23.1%	Excellent to good 76.5%
Abudu et al. [1] (1997)	35	Prosthesis	84	21/14	60% in all: local recurrence 24%; deep infection 26%; dislocation 17%	MSTS (1993) 70%
Windhager et al. [38] (1996)	21	Mainly saddle prosthesis and custom-made prosthesis	41	14/7	57% in all: infection 21.4%; dislocation 7%	MSTS (1987) 15.5 points
Aboulafia et al. [2] (1995)	17	Saddle prosthesis	33.4	8/9	53% in all: wound complication 17.7%; dislocation 11.8%	Excellent to good 52.9%
Gradinger et al. [17] (1991)	9	Cementless, adaptable prosthetic system	27	5/4	Local recurrence 55.6%; metastatic 33.3%; infection 22.2%; dislocation 11%	Good 55.6%

MSTS Musculoskeletal Tumor Society, TESS Toronto Extremity Salvage Score

<sup>a</sup> Mean±standard deviation



**Fig. 5 a, b** Finite element models of the pelvis reconstructed with modular prostheses shows the areas in axis of iliac fixation components and pubic connection plate are the stress-concentration

points. **a** Stress distribution when standing with both limbs. **b** Stress distribution when stand with affected limb

no uniform exercise protocol for the postoperative hemipelvic prosthesis. Few reports on the subject can be found. In our opinion, functional exercise should be based on the extent of resection, the hip stability after construction with the hemipelvic prosthesis and the balance of reconstruction of the periacetabular muscles. How rehabilitation exercises are carried out is critical. Because progressive erosion of bone and upward migration of the saddle as a result of the direct application of load and movement between metal and bone have been frequently reported [5, 12, 30], Cottias et al. [12] reported that their patients were postoperatively immobilised using transtibial traction for two weeks and a hip spica cast for six weeks in order to obtain immediate postoperative stability of the saddle. Early rehabilitation exercises were limited, and the out-of-bed training usually began several weeks after reconstruction. That may lead to slow and poor functional limb recovery. Modular hemipelvic prosthesis reconstruction reduced the shear force through the perpendicular pelvic ring and the contact face between hemipelvic saddle prosthesis and sacroiliac joint. That also reduces the risk of implant loosening and fracture. In our study, patients began exercise eight hours after hemipelvic prosthesis reconstruction and out-of-bed training two weeks after reconstruction.

The early results are promising. Although our study was limited by the short-term follow-up, for large and highly malignant periacetabular primary sarcomas or solitary metastatic cancer, reconstruction with the modular hemipelvic prosthesis seems to be an alternative method with satisfactory functional outcomes.

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