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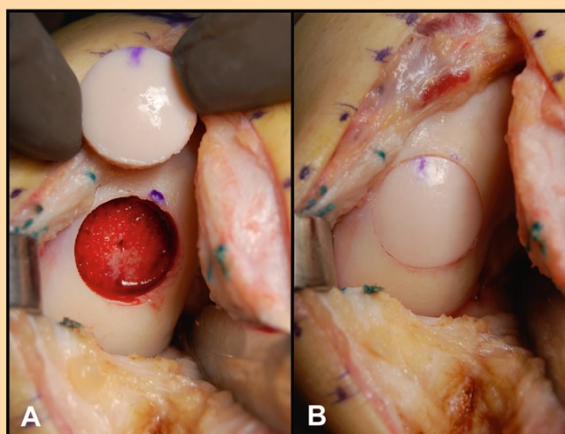
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Abstract

Background The saddle prosthesis originally was developed to reconstruct large acetabular defects in revision hip arthroplasty and was used primarily for hip reconstruction after periacetabular tumor resections. The long-term survival of these reconstructions is unclear.

Questions/purpose We therefore examined the long-term function, complications, and survival in patients treated with saddle prostheses after periacetabular tumor resection.

Patients and Methods Between 1987 and 2003 we treated 17 patients with a saddle prosthesis after periacetabular tumor resection (12 chondrosarcomas, three osteosarcomas, one malignant fibrous histiocytoma, one metastasis). During followup, 11 patients died, resulting in a median overall survival of 49 months (95% CI, 30–68 months). The remaining six patients were alive without disease

(mean followup, 12.1 years; range, 8.3–16.8 years). In one patient the saddle prosthesis was removed after 3 months owing to dislocation and infection. We obtained SF-36 questionnaires, Toronto Extremity Salvage Scores (TESS), and Musculoskeletal Tumor Society (MSTS) scores.

Results Thirteen of 17 patients used walking assists for mobilization at last followup: eight patients required two crutches, five needed one crutch, and one did not use any walking aids. The other three patients were not able to mobilize independently and only made bed to chair transfers. The mean hip flexion in the six surviving patients was 60° (range, 40°–100°) at last followup. Local complications were seen in 14 of the 17 patients: nine wound infections, seven dislocations, and two leg-length discrepancies requiring additional surgery. In the five surviving patients with their index prosthesis still in situ, the mean MSTS score at long-term followup was 47% (range, 20%–77%), the mean TESS score was 53% (range, 41%–67%), and the mean composite SF-36 physical and mental component summaries were 43.9 and 50.6, respectively.

Conclusion Reconstruction with saddle prostheses after periacetabular tumor surgery has a high risk of complications and poor long-term function with limited hip flexion; therefore, we no longer use the saddle prosthesis for reconstruction after periacetabular tumor resections.

Level of Evidence Level IV, retrospective case series. See the Guideline for Authors for a complete description of levels of evidence.

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Introduction

The pelvis accounts for 5% to 15% of primary sarcomas and is the third most frequent site for occurrence of bone metastasis. As tumor surgery evolved in the first half of the

20th century, the standard surgical treatment for primary pelvic sarcomas was hemipelvectomy, which is a mutilating procedure to a vital extremity to achieve local tumor control at the cranial margin. Furthermore this disfiguring procedure has a reported range of major morbidity in more than 53% of patients [3, 4] and is disabling. With the development of better imaging, chemotherapy, and surgical techniques there has been increased interest in internal hemipelvectomy with partial resection of the innominate bone [11, 21, 27]. With this procedure local tumor control can be obtained in patients with pelvic sarcomas without the necessity for amputation. Ideally a periacetabular reconstruction achieves tumor resection with adequate margins and minimal complications and results in the ability to mobilize without the use of walking aids [3, 4, 10, 17, 18].

Pelvic resections were classified by Enneking et al. [12–14] into three types by the portion of bone removed. Type 1 involves resection of the ilium, Type 2 involves the acetabulum, and Type 3 involves the pubic rami. The reconstructive procedure is challenging with a reported incidence of mechanical, infectious, and neurovascular complications of 33% to 56% after Type 2 internal hemipelvectomy of a periacetabular tumor [1, 8, 16, 20, 21, 23].

The saddle prosthesis (Link, Hamburg, Germany) initially was designed by Nieder et al. [23] in 1979 for large acetabular defects in revision hip arthroplasty. Since the 1980s the saddle prosthesis also was used for reconstruction after periacetabular tumor resection [5, 8]. Partly owing to the design of the saddle prosthesis, several long-term complications have been described [16, 20, 23, 26] in which iliac wing destruction and proximalization of the prosthesis resulting in leg-length discrepancy and dislocations were most prominent. Other major complications are wound-healing problems, deep infection, nerve deficits, fractures, and heterotopic ossification [1, 2, 5, 8, 29].

Advancements in radiographic imaging, adjuvant chemotherapy and radiotherapy, and surgical techniques have facilitated the resectability of periacetabular tumors with a subsequent increase in the number of pelvic reconstructions [10]. Owing to increased patient survival after internal hemipelvectomy, improvement of long-term hip function after pelvic reconstruction is required to make mobilization without walking aids possible. Although several other reconstructive procedures have been reported including pelvic prosthesis arthroplasty [1, 2, 8, 16, 20, 23, 28], allograft reconstruction (with or without a total hip prosthesis) [19, 27], arthrodesis [16, 24], and pseudarthrosis [16], a gold standard has yet to be established owing to poor postoperative function and major complication rates ranging from 33% to 56% [1, 2, 7, 8, 16, 19, 20, 23, 24, 28].

We therefore evaluated the long-term function and complications in patients with a saddle prosthesis after reconstruction of a periacetabular tumor resection.

Patients and Methods

From 1987 to 2003, a total of 17 patients were treated with a saddle prostheses after a Type 2 resection of periacetabular tumors. The indications for a saddle prosthesis were: (1) pelvic tumors localized in the periacetabular region with clear surgical margins, (2) no signs of metastatic disease, (3) sufficient residual bone stock of the ilium after planned resection for creation of a stable notch for the saddle, and (4) otherwise good physical status and life expectancy. The contraindications were: (1) tumor extension across the sacroiliac joint and iliacus muscle or extensive soft tissue infiltration into the pelvis or thigh, (2) involvement of sacral nerves or sciatic nerve, (3) metastatic disease from the primary periacetabular tumor, (4) lack of residual bone stock of the ilium after planned resection, and (5) poor life expectancy and physical status. There were 10 men and seven women with a mean age of 48 years at diagnosis (range, 24–65 years). Twelve patients had chondrosarcomas, three had osteosarcomas, one had a malignant fibrous histiocytoma, and one had periacetabular metastasis of a Grawitz tumor (Table 1). No patients were lost to followup. At last followup, 11 patients had died (median survival, 36 months; range, 2–58 months), and six were still alive (median followup, 94 months; range, 2–204 months). Of this last group one patient had the saddle prosthesis removed 3 months postoperatively owing to chronic infection. No evidence of disease was found in the six patients who were still alive (Fig. 1). No patients were recalled specifically for this study; all data were obtained from medical records and radiographs, and functional scores were taken of the surviving patients at latest followup.

During surgery the patient was positioned supine and access to the acetabulum and sciatic notch was gained by an extended ilioinguinal approach. The gluteal and abdominal muscles were spared as much as possible to restore abductor strength, hip stability, and soft tissue coverage postoperatively. The periacetabular tumors were resected en bloc and usually some iliac muscle was sacrificed to achieve a wide tumor margin. After preparation of the femoral stem a notch was engraved in the medial part of the iliac wing remnant. In the majority of patients an iliac wing augmentation was performed in standard fashion to create more stable bone stock for the saddle to articulate with. In these patients the remnant iliac wing was split between the internal and external tables, augmented with autograft femoral bone from the patients' own resected femoral head, and if necessary with an allograft donor femoral head (Table 1, Patients 2–3, 8, 13–17). In case of insufficient bone stock for creation of a stable notch a massive fibular allograft also was used for iliac wing augmentation, which was fixated on the iliac wing by plate and screws (Table 1, Patients 5, 6, 10, 11). In seven

Table 1. Baseline data for 17 patients treated with a saddle prosthesis

Patient	Sex and age (years)	Type of tumor and grade	Enneking, side	Year of surgery	Graft type	Graft technique	Cerclage fixation	Surgery time (minutes)	Post-operative plaster	Adjuvant therapy
1	M 44	Chondrosarcoma grade 2	Zones 2/3, L	1987	None	None	No	450	Yes	RT
2	M 49	Chondrosarcoma grade 2	Zones 1/2/3, R	1987	Auto + allograft femur	Standard	Not documented	Not documented	Yes	RT
3	F 63	Chondrosarcoma grade 2	Zone 2, R	1988	Auto + allograft femur	Standard	Yes	540	Yes	RT
4	M 61	Chondrosarcoma grades 2–3	Zone s1/2, L	1988	Not documented	Not documented	Not documented	240	Not documented	RT
5	M 51	Chondrosarcoma grade 2 (dedifferentiated)	Zone 2, R	1989	Auto + massive allograft	Standard + osteo-synthesis iliac wing	No	480	Yes	ChT
6	F 43	Osteosarcoma	Zones 1/2, R	1990	Auto + massive allograft	Standard + osteo-synthesis iliac wing	No	Not documented	No	RT + ChT
7	M 50	Metastatic renal cell carcinoma	Zone 2, R	1992	Not documented	Not documented	Not documented	Not documented	Not documented	RT + ChT + embolization
8	M 65	Chondrosarcoma grade 2	Zone 2, L	1992	Auto + allograft femur	Standard	Yes	370	Yes	None
9	M 24	Chondrosarcoma grades 2–3	Zones 1/2, R	1994	Not documented	Not documented	Not documented	540	Yes	Not documented
10	F 26	Chondrosarcoma grade 1	Zone 2, L	1995	Auto + massive allograft	Standard + osteo-synthesis iliac wing	No	360	Yes	None
11	F 53	Chondrosarcoma grades 2–3 (dedifferentiated)	Zone 2, L	1995	Auto + massive allograft	Standard + osteo-synthesis iliac wing	No	660	Yes	ChT
12	M 34	Chondrosarcoma grades 2–3 (dedifferentiated)	Zone 2, L	1998	Autograft femur	Standard	Yes	370	Yes	RT
13	M 27	Malignant fibrous histiocytoma	Zones 1/2, R	1999	Auto + allograft femur	Standard	Yes	300	Yes	ChT
14	F 50	Osteosarcoma	Zone 2, R	1999	Auto + allograft femur	Standard	Yes	390	Yes	RT + ChT
15	F 54	Chondrosarcoma grade 2 (dedifferentiated)	Zone 2, L	2001	Auto + allograft femur	Standard	Yes	420	Yes	None
16	M 57	Chondrosarcoma grades 2–3 (myxoid)	Zone 2, R	2001	Auto + allograft femur	Standard	No	300	Yes	ChT
17	F 59	Osteosarcoma	Zones 2/3, R	2003	Autograft femur	Standard	Yes	330	Yes	RT + ChT

RT = radiotherapy; ChT = chemotherapy.

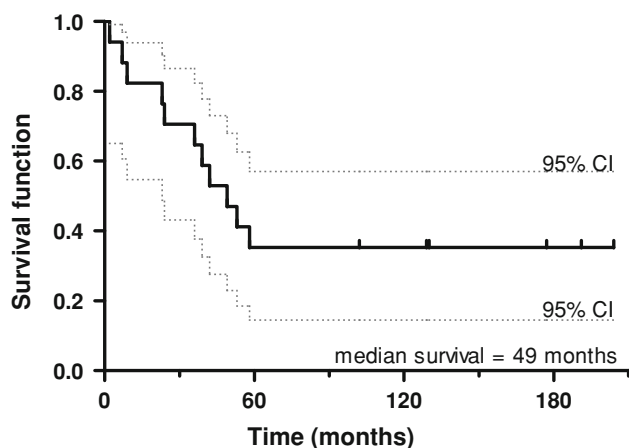


Fig. 1 The Kaplan-Meier curve of implant survivorship shows a major decrease in survival of the saddle prosthesis for the first 5 years owing to removal of the prostheses because of infection and death. The patients who survived after pelvic reconstruction require good long-term hip function from the saddle prosthesis.

patients a cerclage with Dacron tape also was used to further reinforce the bond between the saddle and the notch in the augmented iliac wing (Table 1, Patients 3, 8, 12–15, 17). After selection of the required saddle prosthesis length, hip stability and achieved leg length were tested perioperatively and adjusted when necessary. At the end of the procedure sufficient soft tissue coverage was achieved in all patients primarily.

The postoperative rehabilitation protocol included nonweightbearing for wound healing the first 2 weeks followed by 6 weeks of gradually increasing mobilization to partial weightbearing with two crutches and a pelvic plaster cast. Full weightbearing was allowed after 8 weeks. No braces or casts were used routinely for mobilization after the first 3 months [22]. Postoperative radiotherapy and/or chemotherapy were administered on indication guided by the specific tumor characteristics after histologic examination (Table 1).

During the first 2 years after surgery the patients were seen for clinical followup in the outpatient department three to four times a year, and on an annual basis afterwards. All patients were screened annually at our outpatient clinic with pelvic radiographs and thoracic CT for pulmonary metastatic disease. CT of the pelvis was done only if there was suspicion of local recurrence. All postoperative complications, maximal hip flexion, and use of walking aids were retrieved from the medical records. Of the remaining six surviving patients, function also was assessed by maximal hip flexion at followup, the SF-36 questionnaire [6], Toronto Extremity Salvage Score (TESS) [9], and Musculoskeletal Tumor Society score (MSTS) [13]. The TESS is a questionnaire that is being used for functional assessment in patients who have had limb surgery for bone and soft tissue tumors. The questionnaire consists of 30 activities and the

result is converted to a percentage. The MSTS limb salvage scoring system consists of six factors (pain, function, emotional acceptance, support, walking, and gait). The highest possible MSTS score is 30, and the points are converted to a percentage.

Results

Eight of the 17 patients required two crutches or a walker for general mobilization. At last followup one patient was able to ambulate without walking aids, while five used one elbow crutch or cane. Three other patients were not able to mobilize even with support and only made bed to chair transfers. The mean maximal postoperative hip flexion for the five surviving patients was 60°, with a range of 40° to 100°. For the surviving patients the MSTS score at a mean followup of 12.1 years (range, 8.3–16.8 years) was 47% (range, 20%–77%), the mean TESS score was 53% (range, 41%–67%), and the mean composite SF-36 physical and mental scores were 43.9 and 50.6 respectively. Infection and delayed wound healing formed the majority of all documented postoperative complications. Nine early postoperative wound infections were diagnosed within 3 months postoperatively; all were treated with antibiotics. Three patients eventually had their saddle prosthesis removed because of ongoing infections. Two of the nine patients required débridement of necrotic wounds, one patient had a fistula excised, and in one patient the saddle prosthesis could be retained only after multiple débridements and treatment with gentamicin beads. Seven of the 17 patients had dislocations of their saddle prostheses, all of which initially were treated with reduction and casting. Three of these patients required subsequent revision surgery because of recurrent dislocations (Table 2, Patients 8, 9, 16). The mechanism of dislocation was usually a combined flexion and rotational force when getting out of bed or a chair during the early mobilization period (within 3 months after surgery). Two patients had developed leg length differences greater than 5 cm and both had revision of the modular components of the saddle prosthesis with restoration of leg length and stability (Table 2, Patients 1, 15). During surgery proximalization of the saddle prosthesis at the iliac wing was noted with decreased soft tissue tension. Seven patients had revision surgery owing to infection, dislocation, or leg length difference. One patient had a femoral artery thrombosis and one had an iatrogenic lumbosacral plexus lesion at the level of the L2-S1 nerve root that was permanent and probably attributable to extensive soft tissue excision necessary to achieve safe surgical margins. Fourteen of all the 17 patients had a postoperative complication that was documented (Table 2). Length of the surgical procedure was documented in 14

Table 2. Clinical outcome data for 17 patients

Patient number	Complications	Recurrent disease	Died of disease	Patient survival (months)	Revision, removal	Survival of prosthesis (months)	Hip flexion (degrees)	Mobilization
1	Plexus lesion, length difference	Yes	Yes	36	Yes, no	36	60	Two crutches
2	None	Yes	Yes	58	No	58	Not documented	Two crutches
3	Dislocation	Yes	Yes	53	No	53	60	Two crutches
4	Infection, wound necrosis	Yes	Yes	9	No	9	80	Bedridden
5	Infection, dislocation	Yes	Yes	2	No	2	Not documented	Bedridden
6	Infection	Yes	Yes	42	No	42	Not documented	One crutch
7	Infection	Yes	Yes	49	Yes, yes	40	100	Two crutches
8	Dislocation, length difference	No	No	204	Yes, no	204	40	Two crutches
9	Infection, thrombosis, dislocation	No	No	191	Yes, yes	2	Not documented	Bedridden
10	None	Yes	No	177	No	177	40	One crutch
11	Wound necrosis	Yes	Yes	24	No	24	90	One crutch
12	Infection	Yes	Yes	23	Yes, yes	3	Not documented	Two crutches
13	Dislocation	No	No	130	No	130	80	No walking aids
14	None	No	No	129	No	129	50	One crutch
15	Infection, length difference	No	No	102	Yes, no	102	90	One crutch
16	Infection, dislocation	Yes	Yes	39	Yes, yes	12	80	Two crutches
17	Infection, dislocation, wound fistula	Yes	Yes	7	No	7	90	Two crutches

patients. Median time of surgery was 380 minutes (range, 240–660 minutes). Owing to death from disease, followup was limited in three patients to 2, 7, and 9 months, respectively (Table 2, Patients 4, 5, 17).

Discussion

The saddle prosthesis initially was designed for reconstruction of large acetabular defects in revision hip arthroplasty, but it has been used primarily for hip reconstruction after periacetabular tumor resections. For periacetabular reconstruction with the saddle prosthesis a notch is created in the iliac remnant [23], and in the event of large resections the remaining iliac wing can be augmented additionally with a cortical allograft to create a more stable notch. The saddle articulates with the iliac notch and does not require an exact anatomic fit. The saddle design has no formal constraint, but does have four modular interpositional components to build an optimal offset and length for soft tissue tensioning. The goals of surgical treatment of periacetabular tumors are wide resection providing local control and optimal chance for

survival, preservation of limb function, and quality of life. Previous reports have been published on the surgical and functional outcomes of saddle prostheses [1, 2, 5, 8, 20, 23, 25, 28], but functional outcome in long-term survivors with these reconstructions remains unclear. Therefore we examined the long-term functional results and complications in patients treated with a saddle prosthesis after periacetabular tumor resection.

We recognize some limitations to our study. First, it is a retrospective case series, which makes comparison with a concurrent control group impossible. Therefore the exact influence of the extensive exposure needed for excision of periacetabular tumors with safe margins remains unclear. Second, the group of long-term survivors is relatively small and functional scoring has not been documented on an annual basis for all patients. Third, the operative time was not documented for all patients, therefore, it is not clear whether surgical technique or a learning curve could have influenced the high rate of complications. Fourth, only 17 patients have undergone surgery during a 16-year period. Although the operation rate was approximately one saddle prosthesis per year, the senior surgeons had extensive experience in this surgical field with different types of

orthopaedic oncology surgery and arthroplasty during this period. The Leiden University Medical Centre has been a national referral center for orthopaedic oncology for more than 25 years. In the same 5-year period as in this study 24 pelvic reconstructions of other types were performed after periacetabular Stages P1 through 3 tumor resections. Compared with other studies the mean length of surgery also was shorter (Table 3). For these reasons we believe the limited number of procedures did not influence the complication rate.

In comparison to previous short-term followup series, the mean followup of 12.1 years in our study (with minimal followup of 8.3 years) of the surviving patients for whom functional scores with TESS and MSTS were measured, is substantially longer. Cottias et al. [8] reported a series of patients with a mean followup of 42 months. Functional scoring for nine patients showed a mean MSTS score of 57% and a mean TESS score of 58%. Kitagawa et al. [20] reported functional scores for a group of seven patients with a mean followup of 21 months. They reported a mean MSTS score of 45% for the seven patients, and six patients had a mean TESS score of 61%. Aljassir et al. [2] had a group of 16 patients with mean followup of 45 months, a mean MSTS score of 51%, and mean TESS score of 64%. Renard et al. [25] measured functional outcome at 1 and 2 years after a saddle prosthesis in 11 and six surviving patients respectively, and reported mean MSTS scores of 53% and 51%. Aboulafia et al. [1] described the results of patients treated with saddle prostheses by a grading system depending on oncologic outcome, ambulatory function, and use of pain medication. Of the nine patients still alive after an average of 33 months, the overall results were reported as “excellent” in seven patients and “good” in two patients. The functional outcome scores for our patients with long-term followup are

slightly less (mean MSTS score, 47%; mean TESS score, 53%) than reported by other authors with substantially shorter followups. The functional results after pelvic reconstruction with the saddle prosthesis, and especially the poor hip flexion, are related to the eccentric position of the new rotational center of the hip that allows only limited ROM [29]. However, the extended resection has a negative effect on patient function [3–5].

Major complications after periacetabular reconstructions are common (ranging from 33%–65%) and can be related to the surgical procedure, tumor extension, the implant, and comorbidities of the patient [1, 8, 16, 20]. The type and incidence of complications after saddle prosthesis reconstruction in our patients are comparable to those reported by others. Wound complications, occurring in 18% to 37% of patients [1, 2, 8, 23, 25], are wound dehiscence, skin necrosis, and superficial and deep infections. Risk factors for the high incidence of wound problems are the long operating time, large surgical exposure, high volume of blood loss, lack of muscular and soft tissue coverage, large dead space after resection, and the patients' immune system compromised by chemotherapy and radiotherapy. Reported neurologic complications are transient peroneal nerve paresis and neurapraxia of the sciatic and femoral nerves attributable to manipulation of the femur. The bony complications that frequently are described are fractures of the remaining iliac wing and proximal migration of the saddle component (range, 0%–7%), which causes leg length difference and dislocations (range, 0%–18%) [1, 8, 16, 20]. When large resection of the iliac wing is required, more proximal migration has been reported [1, 25]. In cases where continuous cranial migration of the saddle prosthesis is observed (Fig. 2), the patient is likely to have a deep wound infection [23]. We used nonresorbable sutures around the iliac wing and the saddle to prevent

Table 3. Literature comparison of long-term functional outcome of saddle prostheses

Study	Year published	Patients with long-term followup	Mean length of long-term followup (months)	MSTS score	TESS score	Other outcome data
Kitagawa et al. [20]	2006	7	21	45%	61%	Operation time mean, 391 minutes
Aljassir et al. [2]	2005	16	45	51%	64%	Operation time mean, 600 minutes
Cottias et al. [8]	2001	9	42	57%	58%	Operation time range, 300–480 minutes
Renard et al. [25]	2000	11	12	53%	–	Operation time median, 420 minutes
		6	24	51%		
Aboulafia et al. [1]	1995	9	33	–	–	Operation time mean, 466 minutes 7 patients “excellent” 2 patients “good”
Current study	2012	6	146	47%	53%	Operation time mean, 380 minutes 1 patient no crutches 3 patients one crutch 1 patient two crutches 1 patient only transfers>

MSTS = Musculoskeletal Tumor Society; TESS = Toronto Extremity Salvage Score.

dislocation, and bone grafting of the iliac notch was used in case of a narrow remnant iliac wing, as described by others [8, 20]. Heterotopic ossifications can be seen growing from the iliac remnant several months postoperatively, which can have a negative effect on functional outcome. Oncologic complications are local recurrence and systemic progressive disease [16, 25, 26, 28].

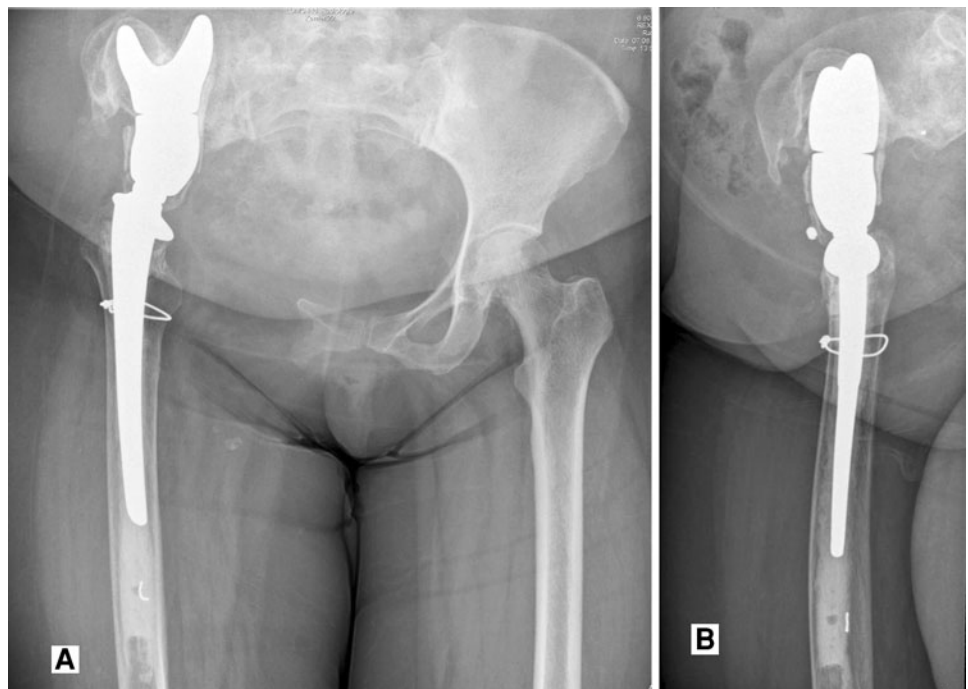
The Mark II saddle prosthesis (Link, Hamburg, Germany) used in our series is a second-generation design that offers better mobility and stability because of its modular design compared with the first-generation nonmodular Mark I design [23]. It still requires additional bone resection to create an iliac notch and provides an unstable articulation causing a high risk of mechanical failure at the ilium-to-saddle interface. Furthermore, the postoperative function based on the MSTS and TESS scores of the patients after saddle prosthesis reconstruction was not superior to other reconstructions with pelvic prostheses, allograft reconstruction, arthrodesis, or pseudarthrosis [20]. To address the mechanical complications of the saddle prosthesis, the periacetabular reconstruction (PAR) endoprosthesis was developed, which is a third-generation modular design consisting of an iliac wing component fixed to the ilium with screws and cement [15]. The modular femoral stem articulates with a constrained socket joint, which is embedded in the iliac wing component. Menendez et al. [21] reported results for 25 patients treated with the PAR endoprosthesis with a mean followup of 29 months and an average MSTS score of 67%. Although this third-generation saddle design did provide some functional improvement, major

complications still occurred in 56% of the patients and implant survivorship after 5 years was reported at 60% [21]. In the study by Menendez et al. [21], 14 of 25 patients had at least one major complication: there were eight infections, five reoccurrences, three dislocations, two fractures, one malposition, one necrosis, and one heterotopic ossification.

Some authors prefer pelvic reconstruction by pseudarthrosis [16] instead of reconstruction with allografts [24] or an endoprosthesis [30], because of difficulty in providing a firm long-lasting reconstruction and high complication rates. However, in addition to limited motion and inconvenient leg length discrepancy, failure of fusion often occurs, resulting in a painful pseudarthrosis with unsatisfactory functional outcome [7, 9, 29].

To improve outcome after reconstruction of large defects after periacetabular resection new custom implants and ball and socket-type implants with pedestal-based cups have been developed. These newer types of tumor prostheses consist of a socket with a cone-shaped pedestal attached, which is inserted into the remaining iliac body toward the superior border of the sacroiliac joint for stable fixation. Some designs offer a modular cup for restoration of anatomic inclination and anteversion, which articulates with a large ceramic or tripolar head potentially offering more stability. Because no iliac notch has to be created less bone resection and soft tissue exposure is required, but complications otherwise related to the challenges of periacetabular tumor resections probably will remain unchanged. Although these new pedestal-based designs theoretically may offer improved function, no long-term followup data are available yet.

Fig. 2A–B This patient had a periacetabular osteosarcoma induced by radiotherapy, for which a Type 2 internal hemipelvectomy was performed, with pelvic reconstruction using the saddle prosthesis. (A) AP and (B) lateral view radiographs obtained 6 years after the initial reconstruction show signs of cranial migration of the saddle prosthesis attributable to osteolysis at the narrow iliac wing remnant proximally.



Reconstruction with saddle prostheses after periacetabular tumor surgery has a high risk of complications and poor long-term functional outcome with limited hip flexion. Based on our study with limited patient numbers but long-term followup the saddle prosthesis cannot be recommended for pelvic reconstruction after internal hemipelvectomy. Therefore in our center we no longer use the saddle prosthesis for reconstruction after periacetabular tumor resections. New more anatomic modular designs for pelvic reconstruction may offer better stability and mobility with cone-shaped, pedestal-based designs, but long-term followup is required to assess survivorship and functional outcome.

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