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Reconstructive techniques in musculoskeletal tumor surgery : management of pelvic and extremity bone tumors

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Chapter 3

Clinical Outcome of Pedestal Cup Endoprosthetic Reconstruction After Resection of a Periacetabular Tumor

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Abstract

Periacetabular tumor resections and their subsequent reconstruction are among the most challenging procedures in orthopaedic oncology. Despite the fact that a number of different pelvic endoprostheses have been introduced, rates of complication remain high and long-term results are mostly lacking.

In this retrospective study, we aimed to evaluate the outcome of reconstructing a periacetabular defect with a pedestal cup endoprosthesis after a type 2 or type 2/3 internal hemipelvectomy.

A total of 19 patients (11 male, 8 female) with a mean age of 48 years (14 to 72) were included, most of whom had been treated for a primary bone tumor (n = 16) between 2003 and 2009. After a mean follow-up of 39 months (28 days to 8.7 years), seven patients had died. After a mean follow-up of 7.9 years (4.3 to 10.5), 12 patients were alive, of whom 11 were disease-free. Complications occurred in 15 patients. Three had recurrent dislocations and three experienced aseptic loosening. There were no mechanical failures. Infection occurred in nine patients, six of whom required removal of the prosthesis. Two patients underwent hindquarter amputation for local recurrence.

The implant survival rate at five years was 50% for all reasons, and 61% for non-oncological reasons. The mean Musculoskeletal Tumor Society score at final follow-up was 49% (13% to 87%).

Based on these poor results, we advise caution if using the pedestal cup for reconstruction of a periacetabular tumor resection.

Introduction

Primary sarcomas of the pelvis commonly involve periacetabular bone. Traditionally these were treated by hindquarter amputation with a poor functional outcome and quality of life¹. Because of the advances in chemotherapy, preoperative imaging and surgical techniques, limb-salvage surgery has become increasingly popular. At present, most patients are treated with a type 2 or type 2/3² internal hemipelvectomy, followed by reconstruction of the defect³. These are some of the most challenging procedures in orthopaedic oncology. First, it is often difficult to achieve adequate margins due to the complex anatomy, size of the tumor and proximity of major neurovascular structures⁴. Second, reconstruction of a functional and painless limb is demanding, because of the complex biomechanics and extent of the resection. Third, infection is of major concern, with reported rates of up to 40% whichever method of reconstruction is used.⁵⁻⁸

A number of techniques have been described for the reconstruction of a periacetabular defect. Although associated with a significant reduction in range of movement, some authors prefer to perform an iliofemoral arthrodesis or pseudarthrosis. However, failure to obtain a solid fusion is a frequent occurrence and results in a painful reconstruction with poor function⁹. Others have attempted to reconstruct the defect using allografts, irradiated autografts or an allograft-prosthetic composite^{6,7,10}. However, allografts are associated with a high rate of failure because of nonunion, fracture and graft resorption^{6,7,10,11}. If an allograft becomes infected it is difficult to treat and often has to be removed¹². An alternative technique, hip transposition, causes significant shortening of the limb but may result in reasonable function. It tends to be used as a salvage procedure after failure of other forms of reconstruction¹³.

Much thought has also been given to endoprosthetic reconstruction of pelvic defects and a number of different types of endoprostheses have been employed. Although encouraging results have been reported, mechanical complications are frequent^{5,8,14,15}. Dislocation is reported to occur in 12% to 22%, while 3% to 12% experience aseptic loosening. Reoperations are often needed: secondary rotationplasty, hip transposition or hindquarter amputation may be needed^{3,4,8,16-18}.

Musculoskeletal oncologists generally agree that reconstructing a pelvic defect with an endoprosthesis has the greatest potential to achieve a well-functioning limb^{3,4,19}. Nevertheless, long-term results are limited and little is known about the durability of these reconstructions. Meanwhile, the search continues for new, more successful prostheses.

We have used the titanium pedestal cup prosthesis (Zimmer, Freiburg, Germany) to reconstruct type 2 and type 2/3 defects of the pelvis. The prosthesis was originally designed for use after the extensive revision of a total hip replacement (figure 1). To the best of our knowledge, we are the first to describe its use in a consecutive series of patients with a pelvic malignancy. In this two-center retrospective study, our aims were to evaluate the mid- to long-term survival of the implant, its complications and the patient's resulting functional outcome and quality of life.

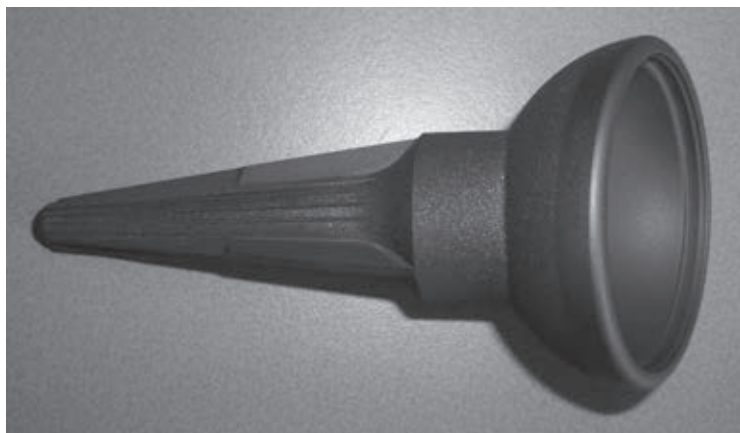


Figure 1: Photograph showing the pedestal cup prosthesis.

Patients and Methods

After obtaining institutional ethics board approval, we assessed all consecutive patients in whom a pedestal cup had been used to reconstruct the defect created by a type 2 or type 2/3² internal hemipelvectomy for pelvic malignancy between 2003 and 2009.

There were 19 patients (11 male, 8 female) with a mean age of 48 years (14 to 72) at the time of surgery. The principal diagnosis was chondrosarcoma in 13, Ewing's sarcoma in three and metastatic carcinoma in three. All lesions involved the acetabulum and were Enneking stage 2B²⁰. A total of four patients had undergone previous surgery, including three total hip replacements and one allograft-prosthetic reconstruction which failed due to resorption of the allograft.

The implant consists of a hemispherical acetabular component and a porous-coated, one-size titanium 70 mm stem, with an 11-mm maximum core diameter. The stem is ribbed and carries two 5 mm wings to secure rotational stability. A cylindrical segment (available in 0 mm, 10 mm and 20 mm lengths) connects the acetabular component with the stem. A standard polyethylene liner was used. Triplanar CT images were obtained for pre-operative templating (figure 2). Computer-navigated techniques were not routinely used.

Cephalosporins were given intravenously prior to surgery and were usually continued for five days postoperatively. Patients were placed in the lateral decubitus position which allowed them to be rotated almost prone or supine. The incision started posteriorly and was extended superiorly across the iliac crest to the anterior superior iliac spine and then angled distally along the line of the femoral artery, to a point approximately 10 cm distal to the greater trochanter. After *en bloc* tumor resection, a Kirschner (K-) wire was inserted in the medial part of the remaining ilium, adjacent to the sacroiliac joint, to guide implantation of the stem. This part of the ilium (part 1A according to a modified version of Enneking's classification)⁸, (figure 3) allows a prosthesis to be seated well between the anterior and posterior cortices because of its shape.



Figure 2A.



Figure 2B.



Figure 2C.

Figures 2A-C. Clinical images taken 3.5 years post-operatively of patient 3. Figure 2a – anteroposterior radiograph showing the position of the pedestal cup in the ilium. Figure 2b and 2c – CT images in the frontal plane, (b) through the pedestal cup and (c) in the sagittal plane, through the pedestal cup.

The ilium was prepared by drilling over the K-wire and this was followed by gradual reaming. Two grooves were created for the anti-rotation wings and a trial stem was introduced. After checking anteversion and inclination, the definitive stem was implanted with its tip close to the sacroiliac joint. When necessary, a

MUTARS attachment tube (implantcast, Buxtehude, Germany) was used to prevent dislocation (figure 4)²¹.

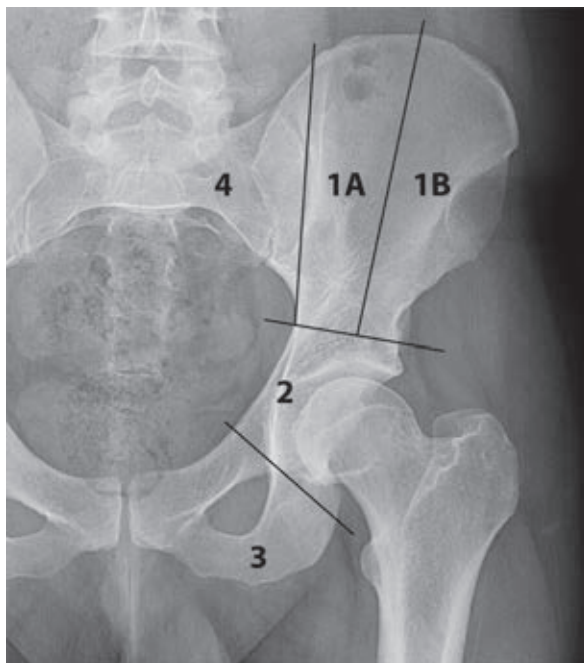


Figure 3. Modified version of Enneking's classification² of pelvic resections. Resections of the ilium (type 1) are further subdivided into type 1A (those involving the medial part of the ilium) and type 1B (those confined to the lateral portion of the iliac wing). The pedestal cup is inserted in the medial part of the ilium, where the cortices have a straight shape and hence provide a good fit for the implant.



Figure 4A.



Figure 4B.



Figure 4C.

Figures 4A-C. Photographs of the surgical procedure of reconstructing the pelvic defect with the pedestal cup showing a) after drilling over the Kirschner wire, the ilium is reamed, b) situation after implantation of the pedestal cup and placement of the polyethylene insert and c) soft-tissue reconstruction with the MUTARS attachment tube.

The medical records of each patient were used to obtain demographic details, the indication for surgery, adjuvant therapies, details of the reconstruction, surgical margins, complications and reoperations. Radiological images were used to assess for signs of loosening, dislocation and fracture. Failure was defined as (partial) removal of the construct, with the exception of revision of the acetabular component. Complications were classified according to Henderson *et al*²². The Musculoskeletal Tumor Society (MSTS) score²³ and the Dutch language version of the Short Form (SF)-36²⁴ questionnaires were used to evaluate functional outcome and quality of life. For quality of life, norm-based outcome scores are presented on the physical and mental component scales²⁵.

Survival is presented as Kaplan–Meier curves and compared between groups with log-rank tests. Factors of influence on functional outcome were compared with Mann–Whitney U tests. SPSS v20.0 software (IBM Corp., Armonk, New York) was used for statistical analysis, with the level of significance at a p-value < 0.05.

Results

At final review, seven patients had died (one due to an acute cardiovascular event), after a mean of 39 months (28 days to 8.7 years). The 12 surviving patients (11 free of disease) had a mean follow-up of 7.9 years (4.3 to 10.5). Most patients had undergone type 2/3 resections (n = 14): the medial part of the ilium was preserved in every patient. In one patient, a two-stage procedure had been performed. Adequate surgical margins were obtained in 14 patients (ten wide, four marginal). Two patients, both with a chondrosarcoma, had focally contaminated margins (one of whom was continuously disease-free at 10.5 years follow-up). Three patients, all with metastatic carcinoma, had intended intralesional excisions.

A variety of femoral components were used. Most had standard total hip prostheses, either cemented (n = 6) or uncemented (n = 6). Five patients (four of whom had undergone previous surgery) had a MUTARS proximal femoral replacement (implantcast) and two patients had a CUT femoral neck prosthesis (Orthodynamics, Lübeck, Germany). MUTARS attachment tubes were used in 15 patients. The iliac stem was cemented in two patients because of extensive cortical destruction. Partial resection of the iliopsoas muscle was required in three patients. One patient had permanent loss of function of the lateral femoral cutaneous nerve, in three patients the obturator nerve was sacrificed.

One or more complications occurred in 15 patients. There were seven mechanical and 11 non-mechanical complications. We were unable to identify any risk factor which was significantly associated with the occurrence of complications.

Type I complications²² (dislocation) occurred in five patients, after a mean of 18.5 months (17 days to 8.5 years). Three patients experienced recurrent dislocations. Of these, two had type 2/3 resections and two had MUTARS attachment tubes in place. Two patients required open reduction, one of whom subsequently underwent revision of the acetabular component.

Type II complications²² (aseptic loosening) were diagnosed in three patients, after a mean of 19 months (16 to 24). The construct was reinforced by percutaneous bone cement injection in one patient. No attempt was made to reinforce or revise the other constructs, either because of a poor prognosis or because of a lack of remaining bone stock.

Type III complications²² (structural) occurred in four patients; they had undisplaced crack fractures of the remaining ilium during implantation of the stem. All healed uneventfully.

Type IV complications²² (infection) occurred in nine patients, six of whom required removal of the pedestal cup. The final outcomes of these patients included revision to a LUMiC prosthesis (implantcast) in two, a type BII rotationplasty²⁶ in one and a hindquarter amputation in one. In the remaining patients, no attempts were made to reconstruct the defect, either because of a lack of remaining bone stock or poor prognosis.

Type V complications²² (tumor progression) occurred in four patients: local recurrence and lung metastases were each diagnosed three times. Two local recurrences resulted in hindquarter amputation.

The prosthesis was removed in eight patients after a mean of 19 months (29 days to 4.2 years). None failed for mechanical (type I/II/III) reasons. For all reasons, the estimated two- and five-year survival rates were 72% and 50%. For non-oncological reasons, these were 78% and 61%, respectively (figure 5). Survival of the prosthesis was significantly worse for patients with an infection (log rank, $p = 0.008$).

The median postoperative hospital stay was 13 days (IQR 11 days to 6.6 weeks); all patients were able to walk postoperatively. A total of 13 patients had one or more further operations: the total number of secondary procedures was 85. In all, 59 reoperations (69%) were performed in the first postoperative year, 69 (82%) for infection or wound problems. Four patients, all with a deep infection, underwent ten or more reoperations and accounted for 59 (69%) of all reoperations.

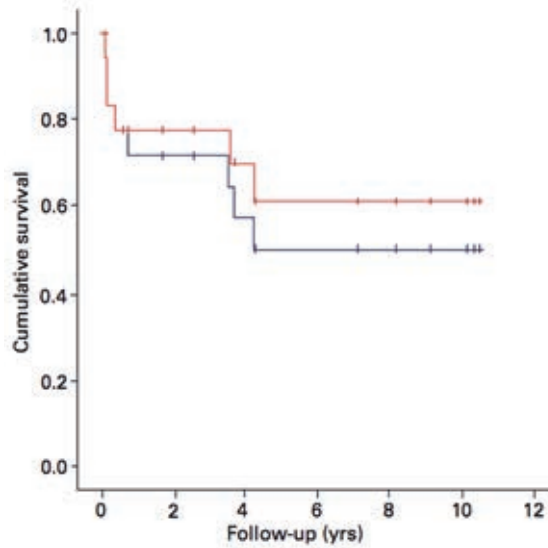


Figure 5. Kaplan–Meier curve for survival of the implant, displaying survival of the construct for all reasons (blue line) and survival for non-oncological reasons (red line).

We obtained MSTS and SF-36 scores for the ten patients who were alive at final follow-up. Their mean MSTS score was 49% (13 to 87) and was significantly worse for patients in whom complications occurred (Mann–Whitney, $p = 0.02$). The mean physical and mental component scale scores of the SF-36 were 56 (39 to 68) and 47 (23 to 62), respectively. One patient used codeine as an analgesic on a daily basis, nine years after the index procedure.

Discussion

Reconstructing a functional, pain-free limb after periacetabular resection is demanding. Although experiences with the pedestal cup in both revision hip arthroplasty and orthopaedic oncology have previously been described²⁷⁻²⁹, this is the first study which reports its use in a consecutive series of patients with a pelvic malignancy.

The complication rate was high with 15 patients (79%) affected. Seven had mechanical complications, none of which required removal of the prosthesis. Failure of the reconstruction occurred in eight patients, six owing to infection and two to recurrent disease. With failure for non-oncological reasons as the end-point,

implant survival at two and five years was 78% and 61%. At final follow-up, limb salvage had been achieved in 15 patients, of whom 13 had a functional limb.

Adequate margins were obtained in most of the patients treated for a primary tumour. Three patients (16%) had a local recurrence and 12 (75%) were alive at final review. This is in accordance with other reports¹⁶.

Recurrent dislocations occurred in three patients (16%). This is in line with previous studies which report dislocations in 12% to 22%. Aseptic loosening also occurred in three patients (16%). This compares unfavorably with other reports, in which loosening of the pelvic component occurred in 3% to 15%^{3,4,8,16,17,19}. None of our reconstructions failed for mechanical reasons. However, for two patients with loosening of the stem we elected to undertake no further treatment.

Our overall complication rate (79%, including type V²²) compares unfavorably with previous reports on endoprosthetic reconstruction of periacetabular defects which describe complications in 37% to 75% of patients (table 1). Unfortunately, there are difficulties when comparing studies of periacetabular endoprostheses, one of which is the limited number of patients. More important is the lack of sufficient (long-term) follow-up in nearly all series (table 1). Major complications of pelvic resection and subsequent reconstruction (including aseptic loosening, dislocation and local recurrences), can occur years after surgery. As these complications may need extensive treatment, the published short-term measurements may not only misjudge the long-term rates of complication, but also the functional outcome. Hence, caution is urged when comparing different devices based on short-term results.

We suggest that modification of the implant could help to improve clinical results. Rates of mechanical complication may be reduced in various ways. First, the acetabular shell-stem angle is fixed in the pedestal cup prosthesis, and the implant lacks the option to adjust the orientation of the acetabular component after the stem has been inserted. We believe that the position of the acetabular component is an important determinant for the risk of dislocation and for functional outcome. Second, because of its size, the pedestal cup is unsuitable for reconstruction of the pelvis when only a small portion of the ilium remains. Therefore, a modular device with different sizes and the ability to adjust the orientation of the component seems desirable. Thirdly, hydroxyapatite coating of the stem may enhance bone ingrowth and reduce the risk of loosening.³⁰

Infection remains of major concern in orthopaedic oncology, despite taking numerous precautions including the routine administration of systemic antibiotics. Possible reasons for the high rate of infection include the duration of surgery, the

presence of malignant disease, the anatomical region involved and, in some cases, age and pre-existing implants³¹. It seems that most risk factors are unalterable and it is therefore conceivable that the rate of infection will remain high.

Modifications of the device, and changes in reconstructive technique, may help reduce the rate of infection. Favorable reports on the silver coating of endoprostheses have been presented by Gosheger *et al*³², who described a lower rate of infection for silver-coated prostheses in a rabbit study. In another study, they reported that no toxicological side-effects occurred in 20 patients, but long-term results are still lacking³³. Fisher *et al*⁴ reported on 27 patients with cemented 'ice-cream cone' endoprosthetic reconstructions after resection of a periacetabular tumor. Although follow-up was limited, only three infections were seen, and all were successfully treated by surgical debridement and the administration of systemic antibiotics. The authors stated that one of the key features was the large volume of antibiotic-laden (gentamicin, vancomycin) bone cement applied around the prosthesis. This was believed to result in a high concentration of antibiotics around the prosthesis, thus not only minimising the risk of infection, but also allowing effective control if it occurs.

The functional outcome scores for reconstruction of a periacetabular defect show considerable variation. Our functional outcome scores are comparable with some previous reports^{8,19,34}, but compare unfavorably with those of more recently published studies³⁴. However, in the latter studies, follow-up was rather short. Only one of our patients used analgesics on a daily basis. Most authors have not reported analgesic usage, but Aljassir *et al*⁸ noted that 27 of their patients with a saddle prosthesis (Waldemar-Link, Hamburg, Germany) used narcotics on a daily basis.

Despite the rather poor functional results, the SF-36 physical component scores were higher than those of age- and gender-matched controls. This might be explained by the fact that it reflects patients' perception of function, rather than their real function. It suggests that patients with an orthopaedic pelvic malignancy cope relatively well with impaired function after this type of extensive surgery. The mental component scores seem to confirm this.

Our study has a number of limitations including the limited number of patients. There was a wide range in follow-up, mainly due to rapid progression of disease which could mean that presented rates of complication underestimate the genuine long-term rates. This is however inherent to retrospective studies on patients with aggressive malignancies.

In conclusion, we report high rates of complication in the mid- to long-term for pelvic reconstructions using the pedestal cup. Based on these results, we advise caution in the use of this implant for reconstruction of a periacetabular defect after resection of a pelvic tumor. Most published data on endoprosthetic reconstruction of periacetabular defects are derived from small studies with limited follow-up. This makes it difficult to compare different techniques. Nevertheless, promising results have been presented in more recent literature, suggesting that other prostheses may be more successful but these too require long-term surveillance to be confident of the outcome.

Table I. Details of previous reports on endoprosthetic reconstruction of peri-acetabular defects.

Author (year)	No. of patients	Follow-up*	Prosthesis used	Indications	Overall complications	Infection	Dislocation	Aseptic loosening (as a reason for revision)	Local recurrence	Functional outcome
Jaiswal et al (2008) ¹⁶	98	survivors 91 months (3 months to 33.5 years); deceased 33 months (2 months to 11.6 years)	Custom made (Stanmore Implants Worldwide Ltd, Stanmore, United Kingdom)	93% primary 7% metastatic	58% (including type V)	18%	20% recurrent	3%	31%	59% (17 to 100) [†]
Witte et al (2009) ¹⁹	40	24 months (1 to 61)	MUTARS hemipelvic endoprosthesis (implantcast, Buxtehude, Germany)	73% primary 28% metastatic	75% (including type V)	30%	3%	15%	18%	50% (SD 19) [†]
Guo et al (2007) ³⁴	28	30 months (10 to 59)	Modular hemipelvic endoprosthesis	86% primary 14% metastatic	39%	32%	4%	-	25%	62% (30 to 83) [†]
Fisher et al (2011) ⁴	27	survivors 39 months (18 to 80) deceased mean 12 months (4 to 27)	Ice-cream cone coned hemi-pelvis (Stanmore Implants Worldwide Ltd, Stanmore, United Kingdom)	70% primary 7% metastatic 22% failure of previous reconstruction	37% (including type V)	11%	15%	-	7%	69% (52 to 90) [†]
Aljassir et al (2005) ⁸	27	45 months (3 weeks to 10 years)	Saddle prosthesis (Link, Hamburg, Germany)	100% primary	-	37%	22%	-	22%	51% (SD 22) [‡] 64% (SD 17) [‡]
Menendez et al (2009) ⁷	25	29 months (13 to 108)	Periacetabular Reconstruction (PAR) prosthesis (Stryker Howmedica, New Jersey, United States)	32% primary 68% metastatic	56% (including type V)	24%	12%	-	20%	70% (37 to 90) [‡]
Abouafia et al (1995) ¹⁷	17	33 months (15 to 62)	Saddle prosthesis (Link, Hamburg, Germany)	47% primary 53% metastatic or systemic	53%	18%	12%	12%	-	59% 'excellent' 12% 'good' 6% 'fair' 24% 'poor' 47% (20 to 77) [‡] 53% (41 to 67) [‡]
Jansen (van de Sande and Dijkstra, 2013) ⁵	17	survivors median 94 months (2 to 204) deceased median 36 months (2 to 58)	Saddle prosthesis (Link, Hamburg, Germany)	94% primary 6% metastatic	82% (not including type V)	53% (as a reason for failure: 18%)	18% recurrent, 24% single	-	71%	49% (13 to 87) [‡]
Current study	19	survivors 95 months (51 months to 105 years) deceased 39 months (28 days to 87 years)	Pedestal Cup (Zimmer, Freiburg, Germany)	84% primary 16% metastatic	79% (including type V)	47% (as a reason for failure: 32%)	16% recurrent, 11% single	16%	16%	

* Mean values, unless stated otherwise, with minimum and maximum or standard deviation (SD) in parentheses

[†]TESS, Toronto extremity salvage score[‡]MSTS, Musculoskeletal Tumor Society Score

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