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ORIGINAL ARTICLE

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Revisions of endoprosthetic reconstructions after limb salvage in musculoskeletal oncology

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Abstract Of 91 limb-salvage procedures using prosthetic reconstructions because of primary or metastatic bone and soft-tissue tumors 26 revisions were performed in 16 patients. Revision was due to polyethylene wear (9 cases), aseptic loosening (8 cases), recurrent hip dislocation (3 cases), prosthetic stem fracture (2 cases), infection (2 cases), leg length discrepancy (1 case), and traumatic dislocation of a saddle prosthesis (1 case). The follow-up period for tumor control varied from 1.5 to 22 years with a median of 13.5 years. The follow-up period after the last revision operation varied from 0.5 to 12 years with a median of 3 years. At the last follow-up, the functional results had deteriorated compared with after the primary operation in 5 patients and had improved in 2 patients. In the remaining patients, the results did not change.

Introduction

Limb-saving surgery has developed during the past 20 years into a widely accepted mode of treatment of malignant bone and soft-tissue tumors. Studies have shown that survival and local recurrence rates after limb salvage are comparable to those after amputation [7, 9, 11–14]. Functional results appear to be better than after amputation [12, 13].

The incidence of immediate and delayed complications, however, was found to be higher than after amputation at the appropriate level [12, 13]. Since limb-salvage procedures are mainly performed in young people and the long-term survival rates have increased considerably during the last decades, revision operations may be expected to be necessary more frequently in the future [9].

We were particularly interested in the impact of the revision operation on the primary functional outcome, as determined by the functional evaluation scoring system of Enneking [4]. The causes of and functional outcomes in 26 revision operations performed at the University Hospitals of Groningen and Nijmegen, The Netherlands, are described in this paper.

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Patients and methods

From 1973 to 1993 91 limb-saving procedures using prosthetic reconstructions were performed at the University Hospitals of Nijmegen and Groningen, The Netherlands, because of primary or metastatic bone and soft-tissue tumors. Up to 1995 26 revisions had been performed in 16 patients. In 9 patients one revision was performed, in 5 patients two, in 1 patient three, and in 1 patient four. At the International Society Of Limb Salvage (ISOLS) meeting in Singapore in 1993, 14 revisions in 8 of these patients were reported [17].

The primary tumor, the stage of the tumor according to Enneking's staging system, and the type of the primary operation in these 16 patients are outlined in Table 1 [3]. The special type of primary reconstruction in patient 3 has been described previously [10] (Fig. 1). In patient 4 the hemipelvis was reconstructed with a transposed proximal part of the ipsilateral femur, a megaprosthesis and a snap-fit acetabular cup; this reconstruction has also been described previously [18] (Fig. 2).

Radiographs of the endoprostheses before and after the revision operation in patients 8 and 11 are shown in Fig. 3 and 4.

The age at the time of the primary operation varied from 10 to 67 years, with a median of 26 years. The duration between the primary operation and the revision varied from 2 months to 18 years. The follow-up period for tumor control varied from 1.5 to 22 years, with a median of 13.5 years at the time of follow-up.

Details of the revision operations performed are summarized in Table 2. Three revisions were related to an accident (patients 1, 4, 5). Five revisions had been performed in two stages: in patient 4 twice because of infection, in patients 6 and 14 because of loosening, and in patient 5 in order to allow a fracture of the iliac wing to heal before a saddle prosthesis was reinserted.

All patients received antithrombotic therapy until full ambulation was achieved.

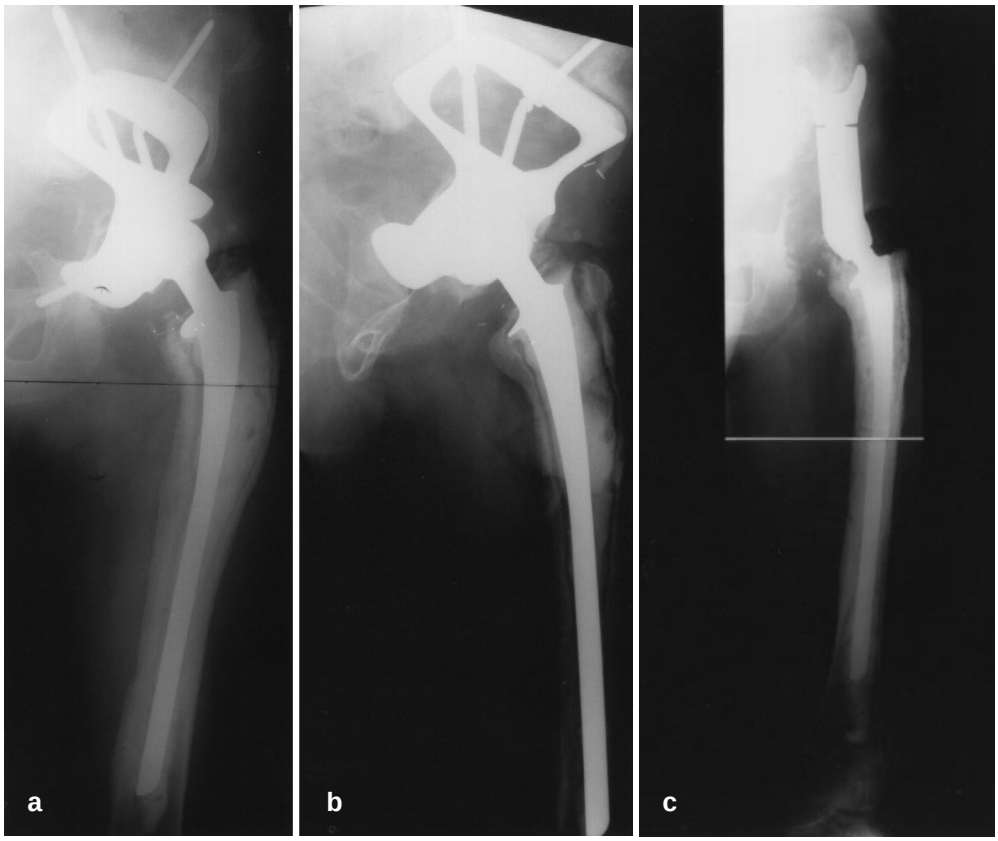

Fig. 1 a, b Anteroposterior (AP) and lateral radiographs of the hemipelvic-proximal femur prosthesis in a 44-year-old man (patient 3) 13 years after the primary operation and 5 years after a previous revision showing loosening of both the pelvic and the femoral components. **c** AP radiograph of a saddle/femur prosthesis after a conversion of a hemipelvic-proximal femur prosthesis in a 44-year-old man (patient 3) 13 years after the primary operation and 5 years after a previous revision

Results

All 16 patients were alive and without evidence of disease at the time of follow-up. The follow-up period after the last revision operation varied from 0.5 to 12 years, with a median of 3 years.

Functional results are summarized in Tables 1 and 2. In two patients (nos. 1, 15), the functional results according to the MSTS functional evaluation system deteriorated after the last revision as compared with the primary operation [9]. In three patients (nos. 3, 4, 14) the functional results after the last revision operation remained unchanged until late complications produced deterioration in the results. In two patients (nos. 6, 7), the functional results were better after the revision compared with the primary operation.

In our series eight revisions were performed because of aseptic loosening, in wo cases (nos. 3, 14) the functional results deteriorated following late complications after the revision operation. Polyethylene wear necessitated revision of the prosthesis in nine cases. In none of these cases did the functional results deteriorate after the revision. Revision because of recurrent dislocation of the hip component was performed in two patients, in one of them twice. In one patient, the functional results deteriorated after the revision (no. 15). In the other patient, the recurrent dislocation persisted until the femoral prosthesis, which was too short, was exchanged for a longer one (no. 6). Two revisions were performed because of infection (no. 4).

Discussion

The major late complication after limb-salvage endoprosthetic replacement is aseptic loosening. Unwin et al. found in a series of 668 massive femoral implants a probability of the proximal femoral implant surviving a prosthetic-associated failure for 10 years of 82% and surviving a loosening failure for 10 years of 92.5%; these figures for distal femoral implants were 61% and 72%, respectively [15]. The incidence of prosthetic-associated complications in proximal femoral implants, distal femoral implants, and proximal tibial implants increases in that order [1]. In active, young individuals, in heavy patients, in patients in whom more bone was removed, and in patients with limited joint motion, the incidence of loosening was higher due to increased mechanical stress on the implant causing motion of the implant and formation of particulate debris [15, 20]. Particulate debris mediating osteolysis caused loss of bone stock, resulting in more difficult revision operations [8]. In our series bone resorption was often present but not extensive. Good functional results have been obtained following revision after aseptic loosening which allows for early revision before much bone stock is lost [9, 11]. Ward et al., however, found in five patients that the functional results decreased

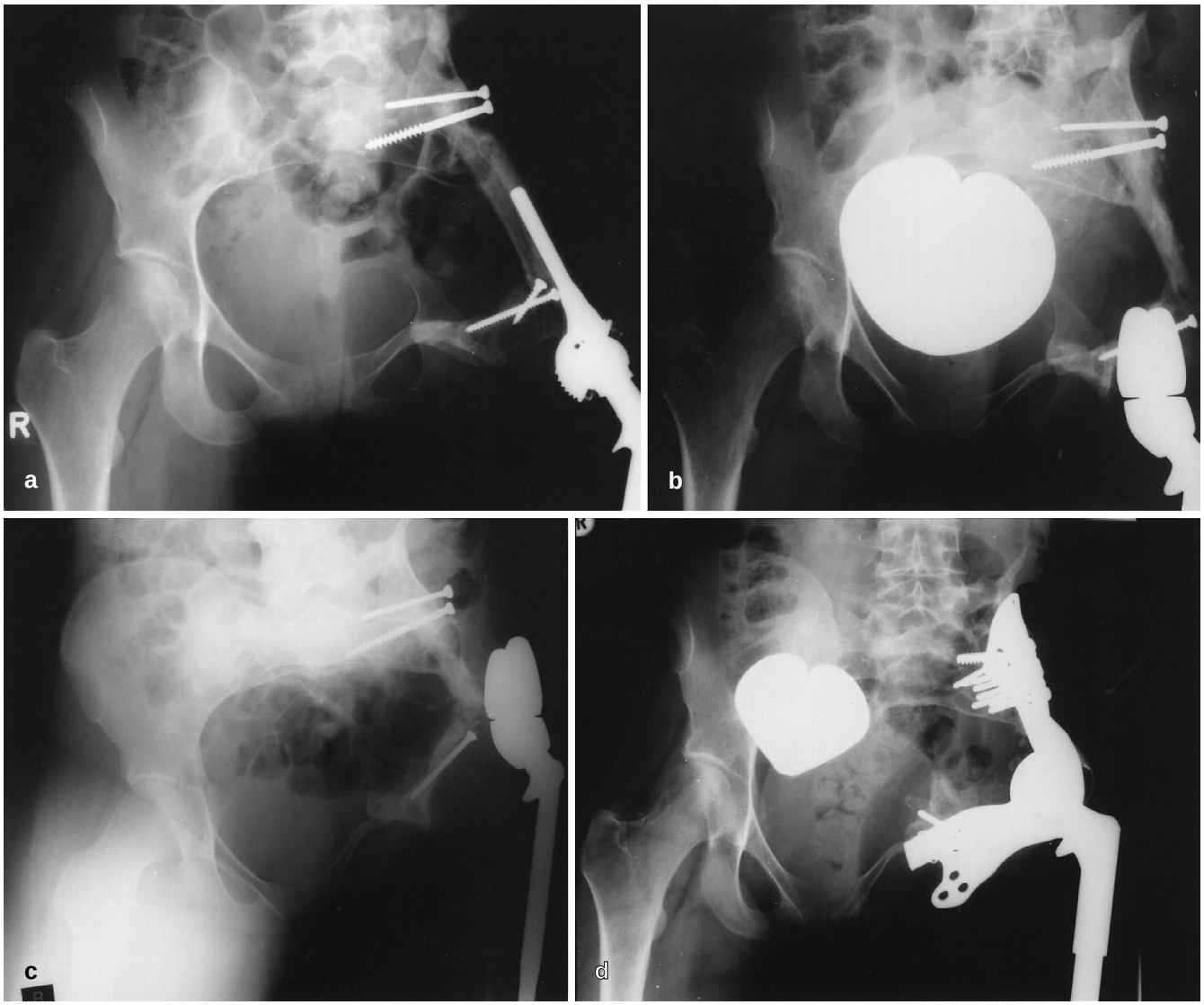

Fig. 2 **a** AP radiograph of the reconstruction of a hemipelvis consisting of the transposed proximal part of the ipsilateral femur, a megaprosthesis, and a custom-made acetabular cup, in an 18-year-old woman (patient 4). **b** AP radiograph of a saddle/femur prosthesis in a 20-year-old woman (patient 4), shortly after exchange of the acetabular component for a saddle prosthesis after a low-grade infection 2.5 years after the primary operation. **c** AP radiograph of a saddle/femur prosthesis in a 22-year-old woman (patient 4) 4 years after the primary operation, showing lateral dislocation of both the pelvic and femoral components and a fracture of the transposed bone. **d** AP radiograph of a custom-made pelvic prosthesis and a proximal femoral prosthesis after revision in a 23-year-old woman (patient 4), 5 years after the primary operation

1 grade in the MSTS rating [20]. As is known for revisions of conventional prostheses, the interface between cement and bone is poorer than in primary prostheses. In our series including eight revisions because of loosening, the functional results deteriorated in two cases because of late complications.

Another frequent complication is wear of the polyethylene components, often resulting in joint instability. Capanna et al. found wear of the polyethylene bushings in 42 of 257 patients with a cementless megaprosthesis in the lower extremity [1]. In another series, they observed polyethylene wear in 42% of cementless distal femur-knee replacements. Revisions after this complication proved to be easy without compromising limb function [2]. In our series including nine revisions because of polyethylene wear, the functional results did not deteriorate in any of the cases.

Dislocation is a frequent complication with proximal femoral megaprostheses, the rate varies in the literature between 5% and 21% [7, 19]. Dislocation is thought to be mainly due to decreased abductor strength. In our series, dislocation could be managed satisfactorily after revision of the bipolar head of the acetabular cup.

Infection is the worst complication after endoprosthetic replacement. Infection causes resorption of bone and subsequently loss of bone stock. Revision operations after infection are more difficult and often less successful than after aseptic loosening [1, 11]. Capanna et al. reported a postoperative infection rate of 43% for revisions of previously infected megaprostheses, whereas these

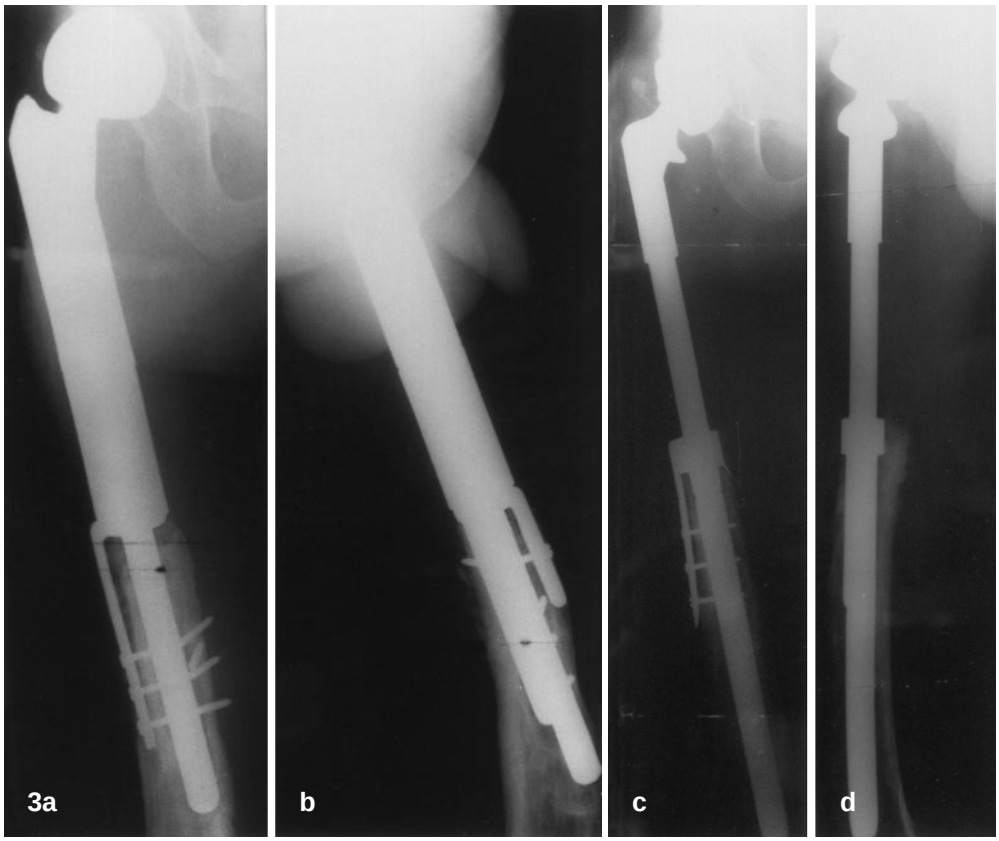

Fig. 3 **a, b** AP and lateral radiographs of the proximal femur-hip prosthesis in a 20-year-old man (patient 8) 5 years after the primary operation, showing loosening and valgus migration of the prosthetic stem. **c, d** AP and lateral radiographs of the proximal femur-hip prosthesis after revision in a 20-year-old man (patient 8) 5 years after the primary operation

Fig. 4 **a, b** AP and lateral radiographs of the distal femur-knee prosthesis in a 27-year-old man (patient 11) 12 years after the primary operation showing fracture of the prosthetic stem and of some of the transverse screws. **c, d** AP and lateral radiographs of the distal femur-knee prosthesis after revision in a 27-year-old man (patient 11) 12 years after the primary operation

Table 1 Details of diagnosis and primary treatment in 16 patients undergoing limb-salvage surgery

Patient no.	Sex/age (years)	Primary tumor	Stage MSTS {3}	Site	Surgical margin	Type of reconstruction	Function MSTS [4]
1	M/33	Giant cell tumor	3	Proximal humerus R	Wide	Resection + proximal humerus--shoulder endoprosthesis	Fair
2	M/35	Giant cell tumor	2	Proximal humerus L	Wide	Resection + proximal humerus--shoulder endoprosthesis	Fair
3	M/32	Chondrosarcoma	IIb	Pelvis L	Wide	Internal hemipelvectomy + hemi-pelvic-prox.femur-prosthesis	Fair
4	F/17	Synovial cell sarcoma	IIb	Pelvis L	Wide	Internal hemipelvectomy + reconstruction	Fair
5	F/67	Metastasis of breast carcinoma		Acetabulum R	Intra-lesional	Internal hemipelvectomy + saddle-prosthesis	Fair
6	F/20	Ewing sarcoma	IIb	Proximal femur L	Wide	Resection + proximal femur-hip--endoprosthesis	Fair
7	M/41	Ewing sarcoma	IIb	Proximal femur R	Wide	Resection + proximal femur-hip--endoprosthesis	Fair
8	M/14	Ewing sarcoma	IIb	Proximal femur R	Wide	Resection + proximal femur-hip -endoprosthesis	Good
9	M/14	Osteosarcoma	IIb	Distal femur L	Wide	Resection + distal femur-knee--endoprosthesis	Good
10	M/10	Osteosarcoma	IIIb	Distal femur L	Wide	Resection + distal femur-knee--endoprosthesis	Good
11	M/15	Osteosarcoma	IIb	Distal femur L	Wide	Resection + distal femur-knee--endoprosthesis	Fair
12	F/41	Chondrosarcoma	IIb	Distal femur R	Wide	Resection + distal femur-knee--endoprosthesis	Fair
13	M/12	Osteosarcoma	IIb	Distal femur L	Wide	Resection + distal femur-knee--endoprosthesis	Fair
14	M/50	Giant cell tumor	3	Distal femur L	Wide	Resection + distal femur-knee--endoprosthesis	Fair
15	M/59	Chondrosarcoma	IIb	Proximal femur L	Wide	Resection + total femur-hip--knee-endoprosthesis	Fair
16	F/17	Osteosarcoma	IIb	Distal femur R	Wide	Resection + total femur-hip -knee-endoprosthesis	Fair

Table 2 Details of revisions in16 patients undergoing limb-salvage surgery

Patient no.	Complication	Type of revision	Bone stock deficiency	Function MSTS [3]	Complication
1	Prosthetic stem fracture	Exchange prosthesis	+ autograft	Poor	–
2	Loosening glenoid cup	removalcup + Tikhoff-Linberg procedure	–	Fair	–
3	1. Loosening femoral component	1. Exchange femoral component	1. –	1. fair	
	2. Loosening femoral + pelvic component	2. Saddle + femoral prosthesis	2. + allograft	2. fair[a]	2. Loosening → hemipelvectomy
4	1. Low-grade infection	1. Saddle prosthesis + exchange acetabular cup	1. –	1. Fair[a]	
	2. Low-grade infection + loosening	2. Pelvic + proximal femoral prosthesis	2. + allograft + titanium mesh	2. ?	2. –
5	Fracture ilium + dislocation saddle prosthesis	saddle prosthesis temporarily removed	–	Fair	–
6	1. Recurrent dislocation	1. Exchange cup	1. –		
	2. Recurrent dislocation	2. Exchange cup	2. –		
	3. Loosening femoral prosthesis	3. Exchange femoral prosthesis	3. + autograft	3. Good	3. –
7	Loosening acetabular cup	Exchange cup	+ allograft	Good	–
8	1. limb-length inequality	1. Elongation of prosthesis	1. + allograft + allograft		
	2. Loosening + valgus migration	2. Exchange cup + femoral component repositioning	2. + autograft + allograft	2. good	–

Table 2 (continued)

Patient no.	Complication	Type of revision	Bone stock deficiency	Function MSTS [3]	Complication
9	1–3. Recurrent dislocation "knee"	1–3. Exchange polyethylene connecting device	1–3. –		
	4. "Knee"-instability	4. Exchange	4. + allograft	4. Good	4. –
10	Polyethylene wear	Exchange polyethylene connecting device	–	Good	–
11	1. Polyethylene wear	1. Exchange polyethylene connecting device	1. –		
	2. Prosthetic stem fracture	2. Exchange prosthesis	2. + allograft	Fair	–
12	Polyethylene wear	Exchange modular axial rotating hinge knee system	–	Fair	–
13	Dislocation "knee"	Exchange modular axial rotating hinge knee system	–	Fair	Polyethylene wear
14	Loosening prosthesis	Exchange prosthesis	+ allograft	Fair[a]	Loosening → midthigh amputation
15	Recurrent dislocation "hip"	Exchange acetabular cup	–	Poor	–
16	1. Polyethylene wear cup	Exchange acetabular cup	–		
	2. Loosening prosthesis	Exchange prosthesis	+ allograft	Fair	–

[a] Functional results deteriorated from fair to poor after late complications

rates for primary operations and revisions of noninfected prostheses were 5% and 6% respectively [2]. Grimer et al. reported other results of staged revision operations after deep infection of megaprostheses in 12 patients; all revisions were successful without functional loss [6]. In our series, infection of a prosthesis was encountered three times. In one patient a staged revision procedure had to be performed twice; in another patient a hemipelvectomy had to be performed.

At revision, bone stock deficiencies at the acetabular, proximal femoral and proximal tibial site were encountered frequently in our series and were managed successfully with the allograft bone chip technique described by Slooff and Ling [5].

Several new developments are being evaluated. The new modular systems have disadvantages such as fracture at the junction sites and excessive formation of particulate debris [7, 8]. An advantage, however, is that one component may be easily exchanged for another in case of failure [16]. In our series, complete exchange of modular endoprostheses was done.

Since long-term survival rates after malignant bone tumors have increased dramatically due to better planned surgery, new chemotherapy and radiotherapy protocols, limb-salvage procedures are successful in appropriate patients. Therefore, a new challenge is to maintain a maximally functional limb as long as possible. Because of the fact that many malignant primary bone and soft-tissue tumors occur in young people, this means that the affected limb may be needed for many decades. If we take into consideration that in adults a 15 year longevity of a conventional joint replacement is considered a good result, it is clear that the goal of maintaining a large endoprosthetic replacement in an active young individual for a long time necessitates the development of new materials and prosthetic designs that will survive longer and in case of failure allow for easy revision. Infection, however, remains the biggest threat to long-term successful limbsalvage.

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