Evaluation of endoprosthetic reconstruction after distal femoral bone-tumor resection

Sherif A. Eltregy, Sayed M. Bayoumy

Department of Orthopedic, Faculty of Medicine, Benha University, Benha, Egypt

Correspondence to Sherif A. Eltregy, MD, Department of Orthopedic, Faculty of Medicine, Benha University, Benha, Egypt
e-mail: shareefaltraigy@fmed.bu.edu.eg

Received: 27 July 2021
Revised: 19 October 2021
Accepted: 14 January 2022
Published: 14 April 2023

The Egyptian Orthopaedic Journal 2023, 57:259–264

Background
Endoprosthetic reconstruction is considered a reliable reconstructive option after periarticular tumor resection as it provides component modularity, improved fixation, near-anatomic appearance, and good functional outcomes. This study aimed at evaluation of the outcomes of the cemented modular distal femoral tumor prosthesis after wide intra-articular resection of aggressive or malignant bone tumors.
Patients and methods
The mean age of the patients was 29.77 years. There were 12 males and six females. The final diagnosis was osteosarcoma in 13 patients, giant-cell tumor in three patients, and chondrosarcoma in two patients. All patients with osteosarcoma received neoadjuvant chemotherapy. Wide intra-articular tumor resection was done through the anteromedial approach of the femur with reconstruction by cemented modular endoprosthesis.
Results
One patient died with pulmonary metastasis. The 5-year cumulative patient-survival rate was 88.88% and 5-year cumulative implant-survival rate was 93.65%. Local recurrence occurred in one (5.5%) patient, while distant metastasis occurred in another. Both of those patients died and were consequently excluded from further statistical work. The mean functional score, the modified Musculoskeletal Tumor Society rating scale, was 73.7%. Complications occurred in five (27.7%) patients. One (5.5%) patient had had a deep infection with failure of reconstruction requiring two-staged revision. There were four cases of superficial wound infection that were successfully treated conservatively. There was no aseptic loosening, periprosthetic fracture or dislocation, soft-tissue problem, or vascular impairment in the operated limb till the final follow-up.
Conclusion
Modular prosthetic reconstruction after wide resection of aggressive and malignant bone tumors of distal femur offers satisfactory clinical and functional outcomes as it allows immediate postoperative stability, early mobilization, and rehabilitation, with reasonable complication rate. Level of evidence: IV case series.

Keywords:
distal femoral bone tumors, modular prosthesis, wide resection

Egypt Orthop J 2023, 57:259–264

1110-1148

Introduction

The life expectancy of patients' malignant bone tumors had increased after improvements in the advances in diagnostic abilities, adjuvant treatment modalities, and surgical techniques [1]. When compared with amputation, limb-salvage surgery offers better clinical and functional outcomes and quality of life without a reduction in survival or an increase in morbidity rates [2]. The endoprosthesis, biological reconstructions, and allograft-prosthetic composite offer good options for reconstruction of the bone defects after bone-tumor resection [3–5]. Endoprosthetic reconstruction is considered a reliable option, especially in periarticular tumor resections as it provides component modularity, improved fixation, near-anatomic appearance, and good functional outcomes [6–11].

The aim of the study was to evaluate the clinical and functional outcomes of a cemented modular tumor-prosthesis system in patients undergoing wide resection of distal femoral aggressive or malignant bone tumors.

Patients and methods

This is a prospective case-series study that was conducted between October 2012 and April 2016 in my university hospital, and comprised 18 patients with aggressive and malignant bone tumors of the distal femur. All cases were treated by wide intra-articular

resection and endoprosthetic reconstruction by cemented modular distal femoral prosthesis (Zimmer *n*=16, Baumer *n*=2). This study was approved by the ethical committee of the university. All patients signed the approval consent after explaining the procedure and the possible complications.

There were 12 males and six females. The mean age of the patients was 29.77 years (range, 17–55 years). There was different presentation of the patients: 14 patients presented with pain and swelling, and four patients presented with only pain.

All the patients included in the study were subjected to history, physical examination, and investigations [plain radiograph, computed tomography (CT) scan, MRI of the whole femur and knee, CT scan on the chest, and bone scan) for staging of the bone tumor. Closed percutaneous CT-guided core biopsy was done in all cases. The final diagnosis in order of frequency was osteosarcoma in 13 patients, giant-cell tumor (GCT) in three patients, and chondrosarcoma in two patients. After completion of the investigations, staging of the tumor was done (according to Enneking classification system [12]) and identified two patients with stage-IA disease, one with stage-IB disease, one with stage-IIA disease, 10 with stage-IIB disease, and one patient with stage-III disease. The three cases of GCT were grade III. All patients with osteosarcoma received neoadjuvant chemotherapy and all of them were good responders as tumor-necrosis percentage exceeded 90% in each patient (range, 90–100%; mean, 93.5). None of the patients received local radiation. Table 1 outlines the patients' demographics.

Surgical technique

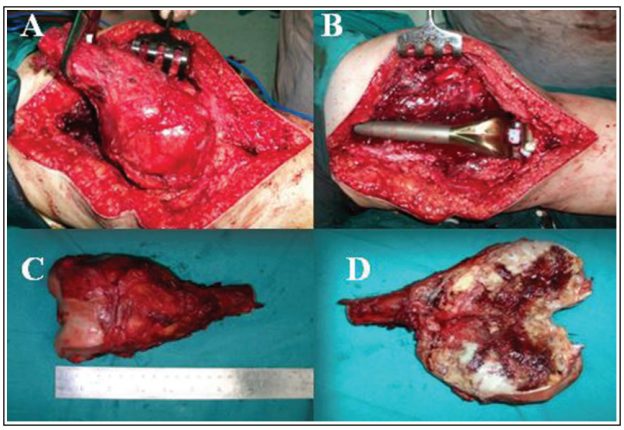
Under spinal or epidural anesthesia, the patients lied supine and the affected limb was draped as a routine from the groin to the foot. Wide intra-articular tumor resection was done through the anteromedial approach of the femur. The femoral and popliteal blood vessels were dissected along their courses in the thigh and behind the knee. The interval between the rectus femoris and vastus medialis muscle was identified and opened, exposing the underlying vastus intermedius muscle that must remain intact around the femoral shaft and the extraosseous tumor component. The entire capsular insertion onto the tibia was completely released keeping the popliteal vessels on direct vision. Detachment of the soft tissue from the distal femur was performed prior to osteotomy. The level of bone resection was preoperatively determined and confirmed intraoperatively. Drill holes were done in the proximal femur and upper tibia as a marker to avoid malrotation during prosthesis insertion. The average size of resection was 15.4 cm and ranged from 12 to 17 cm. Last, insertion of the cemented femoral and then tibial components was done with testing the knee range of motion and stability of the prosthesis. The knee ligaments and the remnant of the capsule were sutured, and the sartorius muscle was sutured to vastus medialis. The wound was then closed in layers over a suction drain after meticulous hemostasis. The resected specimen was sent for histopathological assessment (Fig. 1).

Table 1 The patients' demographic data and outcomes

No	Age (years)	Sex	Side	Diagnosis	Presentation	Staging	Adjuvant TTT	Complications	F up (months)
1	17	M	RT	OS	Pain+swelling	IIB	Chemo.	–	70
2	38	F	RT	GCT	Pain+swelling	III(Câ °)	–	Deep infection	60
3	50	M	LT	CS	Pain+swelling	IIIA	–	Death(pulmonary metastasis)	–
4	17	M	LT	OS	Pain+swelling	IIB	Chemo.	–	71
5	20	M	LT	OS	Pain+swelling	IIB	Chemo.	–	62
6	45	M	RT	GCT	Pain	III(C°)	–	Superficial infection	63
7	52	F	RT	OS	Pain+swelling	IB	–	Superficial infection	69
8	20	M	RT	OS	Pain	IIB	Chemo.	–	65
9	50	F	RT	OS	Pain	IA	–	Superficial infection	63
10	18	M	LT	OS	Pain+swelling	IIA	Chemo.	Local recurrence	60
11	18	M	LT	OS	Pain+swelling	IIB	Chemo.	Superficial infection	76
12	20	F	RT	OS	Pain+swelling	IIB	Chemo.	–	65
13	19	F	RT	OS	Pain+swelling	IIB	Chemo.	–	67
14	55	M	RT	CS	Pain	IIB	–	–	60
15	40	M	LT	GCT	Pain+swelling	III(Câ °)	–	–	62
16	20	F	RT	OS	Pain+swelling	IIB	Chemo.	–	70
17	19	M	LT	OS	Pain+swelling	IIB	Chemo.	–	69
18	18	M	LT	OS	Pain+swelling	IA	Chemo.	–	68

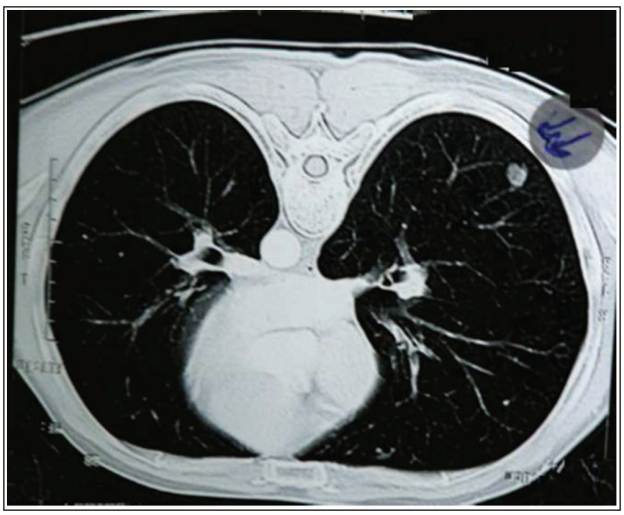
Câ °, campanacci staging; Chemo., chemotherapy; CS, chondrosarcoma; F, female; f, follow; GCT, giant-cell tumor; LT, left; M, male; No, number; OS, osteosarcoma; RT, right; TTT, treatment.

Figure 1



(a–d) Intraoperative steps: (a) wide resection of the tumor through the anteromedial approach of the distal femur. (b) Insertion of the cemented modular distal femoral prosthesis. The resected specimen was ready for histopathological assessment: closed (c) and bisected (d).

Figure 2

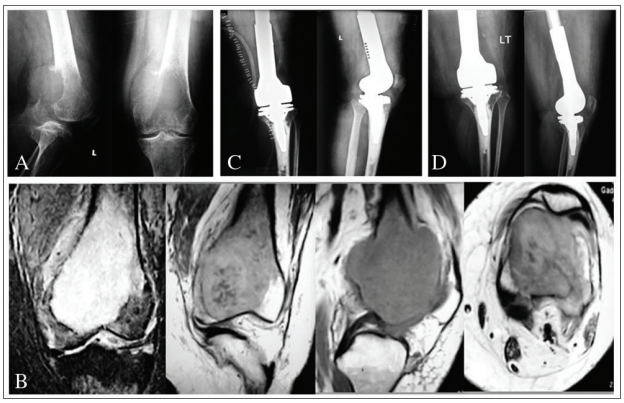


CT chest showing pulmonary nodules (marked by arrow) denoting pulmonary metastasis. CT, computed tomography.

Postoperative protocol and follow-up

Immediately postoperative, continuous passive-motion knee exercises were initiated and full weight-bearing was allowed. The patients were followed up weekly in the first month, monthly for the first 6 months, every 2 months for the next 6 months, and then every 3 months till the last follow-up. Radiographs were taken routinely at each visit to assess the implant position and any early or late implant loosening. All the patients included in this study were evaluated during the follow-up period for patient and prosthesis survivals, oncological and functional outcomes, and complications. The functional outcome was evaluated by the revised Musculoskeletal Tumor Society (MSTS) rating scale for the lower limb [13]. This scale assesses pain, functional limitation, walking distance, the use of a support, emotional acceptance, and gait. Each variable was assessed on a five-point scale with a maximum of 30 points.

Figure 3



(a–d) Male patient complaining from painful swelling of the left knee with painful limitation of knee movements. (a) Plain radiograph was done and showed osteolytic lesion affecting the distal femur, reaching to the subchondral bone (aggressive GCT). (b) MRI was done and showed the soft-tissue extension of the tumor. Intra-articular wide resection of the tumor was done with reconstruction by cemented modular distal femoral prosthesis. (c) The immediate postoperative radiograph. (d) Plain radiograph at the final follow-up. GCT, giant-cell tumor.

Results

The average follow-up period was 65.8 months (range, 60–76 months). Although later-on visits continued by some patients while editing this study, the author chosen includes the data only available before starting the process of publishing, for the sake of establishing biostatistical work.

Survival analysis

One patient died due to respiratory failure 10 months postoperatively. This patient was male, 50 years old, who was diagnosed with chondrosarcoma of the left distal femur. Pulmonary metastasis was detected 5 months postoperatively (Fig. 2). While another patient died after local recurrence. At the final follow-up, there were 16 patients alive and the endoprosthesis was uncomplicated in 15 patients (out of 18) as one patient, of those who survived the study period, developed deep infection that mandated extraction of the prosthesis (Figs 3 and 4). So, the 5-year cumulative patient-survival rate was 88.88% (16/18), and 5-year cumulative implant-survival rate was 83.33% (15/18) when considering the whole number of patients who were included in the study, while excluding the two patients who died (as their death occurred before reaching the 5-year limit of the measure) makes this value to reach 93.75%.

Oncological outcome

In all cases, the histopathological assessment had revealed that the surgical margins were tumor free.

Figure 4

(a–d) Male patient complaining from pain and swelling in the distal part of the left thigh with painful limitation of knee motion. (a) Plain radiograph showed a mixed osteolytic and osteoblastic lesion occupying the distal one-third of left femur with soft-tissue shadow (osteosarcoma). (b) MRI confirmed the presence of an intraosseous mass with an extraosseous component. Wide resection of the tumor was done with reconstruction by cemented modular distal femoral prosthesis. (c) The immediate postoperative radiograph. (d) Plain radiograph at the final follow-up.

However, local recurrence or distant metastasis occurred in two patients. One (5.55%) patient developed local recurrence of the tumor 13 months postoperatively in the local soft tissue (Henderson type 5A). This patient was 17 years old with osteosarcoma of the left distal femur. This patient preferred to be treated with chemotherapy rather than amputation. He died after 4 months of commencing chemotherapy. The other patient was the aforementioned case that developed pulmonary metastasis who was 50 years old with chondrosarcoma of the left distal femur.

Functional outcome (Table 2): using the standard system of the Musculoskeletal Society scoring system (MSTS), the mean functional score of the (16) patients was 73.7% (22.1 points) ranging from 53.3 to 83.3% (16–25 points).

Complications

Complications occurred in five (27.7%) patients. One patient had failure of reconstruction requiring revision. This patient (female, 38 years old, GCT right distal femur) had a deep infection that was failed to be treated conservatively. Two-staged revision surgery was done 13 months postoperatively. Removal of the implant with debridement and application of antibiotic cement spacer were done. Three months later, modular distal femoral prosthesis was implanted. This patient was infection free at the final follow-up with no signs of loosening. There were four cases of superficial wound infection (according to criteria defined by Centers of Disease Control and Prevention as infections affecting only skin and subcutaneous tissue) that were successfully treated by repeated dressings and intravenous antibiotics at early stages after organism isolation by culture and sensitivity tests (Staphylococcus epidermidis in two cases and Staphylococcus aureus in two). In all cases, there was no aseptic loosening, periprosthetic fracture, dislocation, soft-tissue problem, or vascular impairment in the operated limb till the final follow-up.

Table 2 The functional outcome of the patients

Measure	Mean
Pain	4.5
Function	4.3
Supports	3.7
Walking ability	3.5
Gait	3.1
Emotional acceptance	3
Total score (%)	73.7

Discussion

Over the past 25 years, limb salvage has become the preferred method of treatment of malignant bone tumors because of improvements in imaging modalities, chemotherapeutic agents, surgical techniques, and the design of prostheses [14–18]. Endoprosthetic reconstruction was considered as a 'turning point' in managing bone tumors [19]. Improvement of the endoprosthetic survival occurred dramatically due to the advances in the adjuvant therapies, prosthetic design and manufacturing, surgical techniques, and better surgeon familiarity with increased experience in using these implants [20].

Furthermore, it offers a considerable intraoperative flexibility and allows reconstruction of massive defects. The rotating-hinge designs of these prostheses allow stability and flexibility at the knee as the ligaments are removed during surgery [1,7]. Rotational alignment of the prosthesis and restoration of the joint line are very important to achieve a favorable outcome [21]. However, there are certain disadvantages with prosthetic reconstruction, as there was no reduction in the rate of deep infection in recent years, aseptic loosening remains a major threat and the high cost is a problem, especially in the developing countries [7,16].

The aim of the study was to evaluate the functional outcome, the rate of local recurrence, complication rate, and the survival of a cemented modular distal femoral prosthesis after a wide intra-articular resection of aggressive or malignant bone tumor.

Local recurrence after wide resection of the tumor is not an implant-related complication, as it reflects the aggressiveness of the tumor and adequacy of the surgical margin rather than the quality of the implant [7]. After reviewing the literature, the rate of local recurrence was reported as being between 4 and 9% [1,7,22–24]. In the current study, local recurrence occurred in one (5.55%) case. Bekmez *et al*. [1] reported a local recurrence rate of 5.76% in 52 patients treated by limb salvage with endoprosthetic replacement. Guo *et al*. [7] – in their retrospective study on 104 patients treated by limb-salvage surgery using locally designed stainless-steel endoprosthesis – reported local recurrence in nine (8.7%) cases. In the study done by Torbert *et al*. [24] on 74 patients with primary malignant bone tumors, the rate of local recurrence rate was 6.8%.

With the modern treatment modalities, life expectancy has increased in patients with malignant bone tumors. Therefore, the functional outcome became more important to provide a better quality of life for the patients in their remaining life [1]. Modular prosthetic replacement after tumor-wide resection offers good functional outcomes [25,26]. In the current study, the mean functional score was 73.7%, which is comparable to those in previous reports. Bekmez *et al*. [1] reported that the mean overall MSTS score of their cases was 72.7%. In the study done by Guo *et al*. [7], the mean MSTS score of the cases of the distal femur was 77%.

The anatomical location of an implant had a direct effect on survival of the endoprosthesis. The 5-year survival rates for distal femoral prostheses after tumor resection have been reported to range between 88 and 93% [7]. In the current study, the 5-year cumulative implant-survival rate was 83.33%.The modular prostheses for distal femoral tumors have satisfactory outcomes and are easy to assemble [27]. However, failure could occur due to infection, loosening, periprosthetic fractures, malalignment, or instability [28].

Infection is considered a major concern in prosthetic reconstruction after tumor resection [29,30]. Several studies reported that the rate of deep infection after modular prosthesis ranged from 5 to 15% [7,31]. In the current study, the rate of deep infection was 5.5%. Guo *et al*. [7] reported 6.7% rate of deep infection. Periprosthetic infection occurred in seven patients, two of them underwent an amputation. In their case series, Bekmez *et al*. [1] reported that the infection was the most common cause of implant failure. The infection rate was 13%. In a comprehensive study of Henderson *et al*. [32], an infection rate of 8.4% in 2174 patients was reported for various anatomical locations. None of our patients had aseptic loosening presumably due to proper technique together with emphasizing the necessity of activity management to the patients for the sake of enhancing prosthesis longevity.

One of the limitations of this current study is the small number of the cases. In addition, lack of homogeneity in the study population, especially in terms of final diagnosis, and the use of neoadjuvant chemotherapy might have an impact on the outcomes. Moreover, a relatively short follow-up period, and single-center results add to these limitations.

Conclusion

Modular prosthetic reconstruction after wide resection of aggressive and malignant bone tumors of distal femur offers satisfactory clinical and functional outcomes as it allows immediate postoperative stability, early mobilization, and rehabilitation, with reasonable complication rate.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Bekmez S, Ayvaz M, Yucekul A, Tokgozoglu M. Modular cementless prosthetic reconstruction after resection of lower extremity malignant tumor. Acta Orthop Traumatol Turc 2016; 50:674–680.

2 Mavrogenis AF, Abati CN, Romagnoli C, Ruggieri P. Similar survival but better function for patients after limb salvage versus amputation for distal tibia osteosarcoma. Clin Orthop Relat Res 2012; 470:1735–1748.

3 Donati D, Giacomini S, Gozzi E, Mercuri M. Proximal femur reconstruction by an allograft prosthesis composite. Clin Orthop 2002; 304:192–200.

4 Gibbs CPJr, Weber K, Scarborough MT. Malignant bone tumors. J Bone Joint Surg (Am) 2001; 83:1728–1745.

5 Manfrini M, Innocenti M, Ceruso M, Mercuri M. Original biological reconstruction of the hip in a 4-year-old girl. Lancet 2003; 361:140–142.

6 Zeegen EN, Aponte-Tinao LA, Hornicek FJ, Gebhardt MC, Mankin HJ. Survivorship analysis of 141 modular metallic endoprostheses at early followup. Clin Orthop Relat Res 2004; 420:239–250.

7 Guo W, Ji T, Yang R, Tang X, Yang Y. Endoprosthetic replacement for primary tumours around the knee: experience from Peking University. J Bone Jt Surg Br 2008; 90:1084–1089.

8 Bischel OE, Nadorf J, Klein SB, Gantz S, Jakubowitz, Kretzer JP, *et al*. Modular tumor prostheses: are current stem designs suitable for distal femoral reconstruction? A biomechanical implant stability analysis in Sawbones. Arch Orthop Trauma Surg 2019; 139:843–849.

9 Bernthal NM, Greenberg M, Heberer K, Eckardt JJ, Fowler EG. What are the functional outcomes of endoprosthestic reconstructions after tumor resection?. Clin Orthop Relat Res 2015; 473:812–819.

10 Capanna R, Scoccianti G, Frenos F, Vilardi A, Beltrami G, Campanacci DA. What was the survival of megaprostheses in lower limb reconstructions after tumor resections?. Clin Orthop Relat Res 2015; 473:820–830.

11 Nadorf J, Klein SB, Gantz S, Jakubowitz E, Kretzer JP, Bischel OE. Influence of implant length and bone defect situation on primary stability after distal femoral replacement in vitro. Knee 2017; 24:1016–1024.

12 Enneking WF. A system of staging musculoskeletal neoplasms. Clin Orthop 1986; 204:9–24.

13 Enneking WF, Dunham W, Gebhardt MC, Malawer M, Pritchard DJ. A system for the functional evaluation of reconstructive procedures after surgical treatment of tumors of the musculoskeletal system. Clin Orthop 1993; 286:241–246.

14 Biau D, Faure F, Katsahian S, Jeanrot C, Tomeno B, Anract P. Survival of total knee replacement with a megaprosthesis after bone tumor resection. J Bone Joint Surg [Am] 2006; 88:1285–1293.

15 Sharma S, Turcotte RE, Isler MH, Wong C. Cemented rotating hinge endoprosthesis for limb salvage of distal femur tumors. Clin Orthop 2006; 450:28–32.

16 Myers GJ, Abudu AT, Carter SR, Tillman RM, Grimer RJ. Endoprosthetic replacement of the distal femur for bone tumours: long-term results. J Bone Joint Surg 2007; 89: 521–526.

17 Henshaw RM, Malawer MM. Advances in modular endoprosthetic reconstruction of osseous defects. Curr Opin Orthop 2003; 14:429–437.

18 Myers GJC, Abudu AT, Carter SR, Tillman RM, Grimer RJ. The long-term results of endoprosthetic replacement of the proximal tibia for bone tumours. J Bone Joint Surg 2007; 89:1632–1637.

19 Kotz R, Dominkus M, Zettl T, Ritschl P, Windhager R, Gadner H, *et al*. Advances in bone tumor treatment in 30 years with respect to survival and limb salvage. A single institution experience. Int Orthop 2002; 26:197–202.

20 Wirganowicz PZ, Eckardt JJ, Dorey FJ, Eilber FR, Kabo JM. Etiology and results of tumor endoprosthesis revision surgery in 64 patients. Clin Orthop Relat Res 1999; 358:64–67.

21 Rajasekaran RB, Palanisami1 DR, Natesan R, Jayaramaraju D, Rajasekaran S. Megaprosthesis in distal femur nonunions in elderly patients—experience from twenty four cases. Int Orthop 2020; 44:677–684.

22 Plötz W, Rechl H, Burgkart R, Messmer C, Schelter R, Hipp E, *et al*. Limb salvage with tumor endoprostheses for malignant tumors of the knee. Clin Orthop 2002; 405:207–215.

23 Mittermayer F, Krepler P, Dominkus M, Schwameis E, Sluga M, Heinzl H, *et al*. Long-term follow-up of uncemented tumor endoprostheses for the lower extremity. Clin Orthop 2001; 388:167–177.

24 Torbert JT, Fox EJ, Hosalkar HS, Ogilvie CM, Lackman RD. Endoprosthetic reconstructions: results of long-term followup of 139 patients. Clin Orthop 2005; 438:51–59.

25 Mavrogenis AF, Mitsiokapa EA, Sakellariou VI, Tzanos G, Papagelopoulos PJ. Functional and radiographic outcome after tumor limb salvage surgery using STANMORE megaprostheses. J BUON 2011; 16:353–360.

26 Qadir I, Umer M, Baloch N. Functional outcome of limb salvage surgery with mega-endoprosthetic reconstruction for bone tumors. Arch Orthop Trauma Surg 2012; 132:1227–1232.

27 Ilyas I, Kurar A, Moreau PG, Younge DA. Modular megaprosthesis for distal femoral tumors. Int Orthop 2001; 25.6:375–377.

28 Supriadi S, Ardianov MF, Rahyussalim AJ, Whulanza Y, Prabowo Y, Saragih AS. Evaluating internal forces of new design modular MegaProsthesis distal femur. AIP Conf Proc 2019; 2193:050025.

29 Galasso O, Mariconda M, Brando A, Ianno B. Disassembly of a distal femur modular prosthesis after tumor resection. J Arthroplasty 2010; 25:334.e5–e9.

30 Mavrogenis AF, Pala E, Angelini A, Calabro T, Romagnoli C, Romantini M, Drago G, Ruggieri P. Infected prostheses after lower extremity bone tumor resection: clinical outcomes of 100 patients. Surg Infect (Larchmt) 2015; 16:267–275.

31 Blunn GW, Briggs WR, Cannon SR, Walker S, Unwin PS, Culligan S, Cobb JP. Cementless fixation for primary segmental bone tumor endoprostheses. Clin Orthop 2000; 372:223–230.

32 Henderson ER, Groundland JS, Pala E, Dennis JA, Wooten A, Cheong D, *et al*. Failure mode classification for tumor endoprostheses: Retrospective review of five institutions and a literature review. J Bone Jt Surg Am 2011; 93:418–429.