**Evaluation of Endoprosthetic Reconstruction after Distal Femoral Bone Tumors Resection**

**Abstract**

**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.

**Methods:** The mean age of the patients was 29.77 years. There were 12 males and 6 females. The final diagnosis was osteosarcoma in 13 patients, giant cell tumor in 3 patients, and chondrosarcoma in 2 patients. All patients with osteosarcoma received neo-adjuvant chemotherapy. Wide intra-articular tumor resection was done through the antero-medial approach of the femur with reconstruction by cemented modular endoprosthesis.

**Results:** One patient died with pulmonary metastasis. The five-year cumulative patient survival rate was 88.88 % and five-year cumulative implant survival rate was 93.65%. Local recurrence occurred in one patient (5.5%) 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 (MSTS) rating scale, was 73.7%. Complications occurred in five patients (27.7%). One patient (5.5%) 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.

**Key words**: Distal femoral bone tumors, Wide resection, Modular prosthesis.

**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 to 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 6 females. The mean age of the patients was 29.77 years (ranged from 17 to 55 years). There were different presentation of the patients; 14 patients presented with pain and swelling, 4 patients presented with only pain.

All the patients included in the study were subjected to history, physical examination and investigations (Plain X ray, Computed Tomography (CT) scan, Magnetic Resonance Imaging 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 3 patients, and chondrosarcoma in 2 patients. After completion of the investigations, staging of the tumour was done (according to Ennekingclassification 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 neo-adjuvant 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 antero-medial 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 pre-operatively determined and confirmed intra-operatively. Drill holes were done in the proximal femur and upper tibia as a marker to avoid mal-rotation during prosthesis insertion. The average size of resection was 15.4 cm and ranged from 12-17cm. Lastly, insertion of the cemented femoral then tibial components were 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 (Figure 1).

**Postoperative protocol and follow up:**

Immediately postoperative, continuous passive motion knee (CPM) exercises were initiated and full weight-bearing was allowed. The patients were followed up weekly in the first month, monthly for the first six months, every two months for the next six months, and then every three 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 witha maximum of 30 points.

**Results:**

Average follow-up period was 65.8 months (ranged from 60 to 76 months). Although later on visits continued by some patients while editing this study, the author chose include 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 postoperative. This patient was male, 50 years old who was diagnosed with chondrosarcoma of left distal femur. Pulmonary metastasis was detected 5 months postoperatively (Figure 2). While another died after local recurrence. At the final follow-up, there were 16 patients alive and the endoprosthesis were uncomplicated in 16 patients (out of 17) (Figures. 3&4). So, the five-year cumulative patient survival rate was 88.88%, and five-year cumulative implant survival rate was 93.75%.

*Oncological outcome*: In all cases, the histopathological assessment had revealed that the surgical margins were tumor free. However, local recurrence or distant metastasis occurred in two patients. One patient (5.55%) 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 to 25 points).

*Complications*: Complications occurred in five patients (27.7%). 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 (CDC) 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 2 cases and Aureus in 2). 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.

**Discussion:**

Over the past twenty five 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 by Koltz [19] et al in 2002 while Wirganowicz et al. in 1999 [20] and Zeegen et al. [6] in 2004 indicated that surgeons, by those times, have had already accepted modern modular endoprosthesis systems as a state-of-the-art.

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, complications 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 case (5.55%). Bekmez et al reported a local recurrence rate of 5.76% in 52 patients treated by limb salvage with endoprosthetic replacement [1]. Guo et al -in their retrospective study on 104 patients treated by limb salvage surgery using locally designed stainless-steel endoprosthesis-reported local recurrence in nine cases (8.7%) [7]. In the study done by Torbert et al on 74 patients with primary malignant bone tumors, the rate of local recurrence rate was 6.8% [24].

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 of was 73.7% which is comparable to those in previous reports. Bekmez et al reported that the mean overall MSTS score of their cases was 72.7% [1]. In the study done by Guo et al, the mean MSTS score of the cases of the distal femur was 77% [7].

The anatomical location of an implant had a direct effect on survival of the endoprosthesis. The five-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 five-year cumulative implant survival rate was 93.75%.

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, mal-alignment, 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 was ranged from 5% to 15% [7, 31]. In the current study, the rate of deep infection was 5.5%. Guo et al reported 6.7% rate of deep infection. Periprosthetic infection occurred in seven patients, two of them underwent an amputation [7]. In their case series, Bekmez et al reported that the infection was the most common cause of implant failure.The infection rate was 13% [1]. In a comprehensive study of Henderson et al, an infection rate of 8.4 % in 2174 patients was reported for various anatomical locations [32]. 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 homogenecity in the study population, especially in terms of final diagnosis and the use of neo-adjuvant chemotherapy might have an impact on the outcomes. Moreover, relatively short follow-up period, and single centre 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.

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**Figure legends:**

**Fig.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).

**Fig.2:** CT chest showing pulmonary nodules (marked by arrow) denoting pulmonary metastasis.

**Fig.3 (A-D):** Male patient complaining from painful swelling of left knee with painful limitation of knee movements. A-Plain X-Ray 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 tumour. Intra-articular wide resection of the tumour was done with reconstruction by cemented modular distal femoral prosthesis. C: The immediate postoperative x-ray. D: plain x-ray at the final follow up.

**Fig.4 (A-D):** Male patient complaining from pain and swelling in the distal part of left thigh with painful limitation of knee motion. A: Plain X-Ray 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 intra-osseous mass with an extra-osseous component. Wide resection of the tumour was done with reconstruction by cemented modular distal femoral prosthesis. C: The immediate postoperative x-ray. D: plain x-ray at the final follow up.

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**Ethical approval:** The study was approved by ethical committee of the University and was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed consent**: Informed consent was obtained from all individual participants included in the study.

**Consent to participate**: Written informed consent was obtained from all patients regarding study participation.

**Consent for publication:** patients signed informed consent regarding publishing their data and photographs.