Cerrahpaşa Med J 2024; 48(1): 55-58 **ORIGINAL ARTICLE**

Clinical Results of Total Knee Megaprosthesis for Bone Tumors Around the Knee

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Abstract

Objective: Bone and soft tissue tumors have high mortality and morbidity rates. With new improvements in adjuvant–neoadjuvant therapies and new endoprosthesis designs, limb salvage surgery methods became more popular than amputations. The aim of our study was to evaluate the clinical and radiological results of patients who underwent surgery due to tumors around the knee with megaprosthesis. We also compared hinged and rotational hinged megaprosthesis to determine if they have advantages over each other.

Methods: This study has a cohort design. Thirty-one patients who had been operated between 2000 and 2018 by a single surgeon with knee megaprosthesis were evaluated using International Limb Salvage Symposium criteria (ISOLS score).

Results: The 5-year survival rate for the prostheses was 46.2%. The overall Musculoskeletal Tumor Society (MSTS) score was 84.65% ± 9.94% (range: 54%-97%) (fair-excellent), and the ISOLS score was 86.60% ± 10.47% (range: 45%-100%) (poor-excellent). There were no significant differences between the scores according to prosthesis types. As the strength of straight leg lift increased, so did the emotional acceptance for both types of prostheses.

Conclusion: Megaprosthesis is a good choice of treatment for tumors around the knee without decreasing life expectancy. Both hinged and rotational hinged prostheses can be used according to clinical needs.

Keywords: Megaprosthesis, bone and soft tissue tumors, Musculoskeletal Tumor Society, International Society of Limb Salvage

Introduction

The distal femur and proximal tibia are the most common areas for primary and metastatic bone tumors. Developments in chemotherapy and radiotherapy protocols, new improved surgical and diagnostic techniques, and multidisciplinary approaches increased the success rates of the limb salvage procedures.[1-4]

Megaprosthesis, compared to other limb salvage methods (osteoarticular allografts, allograft arthrodesis, rotationplasty, etc.), has earlier mobilization time, better extremity function and cosmetic results, and better emotional acceptance. Therefore, megaprostheses are commonly used for limb salvage procedures.[5,6] Even though early prostheses were only custom made, today modular prosthesis options are available.

Although prosthesis designs and materials have improved, megaprostheses have higher complication and failure rates compared to primary total knee prostheses. Therefore, the need for revision is more common in megaprosthesis patients.[5,7-9] Long-term results, compared to primary knee prostheses, were bad because of the patient's immunosuppressive conditions due to adjuvant therapy, massive soft tissue and bone resections, long surgical time, and the poor health conditions of the patients.[11-12]

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In this study, we aimed to evaluate the complication rates and 5-year survival of the megaprostheses used for bone tumors around the knee. We also compared rotational hinged and hinged prostheses to determine if they have advantages over each other. We used Musculoskeletal Tumor Society (MSTS) scores to evaluate clinical results and International Society of Limb Salvage (ISOLS) scores to evaluate radiological results of the patients.

Methods

After obtaining ethical board approval from İstanbul University-Cerrahpaşa, Cerrahpaşa Faculty of Medicine (Approval No: 83045809-604.01.02, Date: October 19, 2017), we conducted a retrospective review of our institution's database, focusing on patients who underwent a surgical procedure involving bone resection and reconstruction with a megaprosthesis for tumors around the knee area between 2000 and 2018. Written informed consent was obtained from all the patients who participated in this study. Initially, 55 patients were identified, but 24 patients were excluded from the study. The reasons for exclusion included 6 patients who had deceased during their follow-up due to metastasis, 1 patient who required amputation due to chronic infection, and 18 patients with insufficient follow-up data. Ultimately, a total of 31 patients were included in the study.

Among the included patients, there were 19 female (61.3%) and 12 male (38.7%) patients, and mean age was 44.4 ± 20.4 (9-79). Histologically, 8 osteosarcoma, 6 giant cell bone tumor, 1 cyst hydatid, 1 needle cell mesenchymal tumor, 1 hereditary exocytosis, 1 adamantinoma, 1 clear cell carcinoma, 1 malignant fibrous histiocytoma, and 1 lymphoma patient were evaluated.

All patients were graded with the Enneking grading system.[10] For diagnosis and surgical planning, all patients had anteroposterior and lateral knee x-rays, contrast-enhanced magnetic resonance imaging, scintigraphy, and/or positron emission tomography imaging. Additionally, all patients had bloodwork evaluated prior to surgery. For histopathological diagnosis, fine needle biopsy performed.

Necessary adjuvant and radiotherapy treatments were administered before and after the surgeries. All operations performed by the same surgeon, and the same brand of prosthesis system were used (METS modular distal femur prosthesis (Stanmore)) (Table 1). In total, 19 (61.3%) of the patients had bone tumor at their femur distal, and 12 (38.7%) of the patients had bone tumor at their tibia proximal region. Prior to surgery, all patients received 2 g of intravenous cephalosporin for prophylaxis, which was continued after the surgery until surgical drainages were removed. General anesthesia and a pneumatic tourniquet were used for all patients. The mean femoral resection length was 11.2 ± 4.96 (6-25) cm, and the mean tibia resection length was 10.3 ± 3.42 (9-18) cm. The mean operation time was 109.7 ± 18.76 (80-160) minutes. Surgical drainage was applied to all patients and removed after the 3rd day. For deep vein prophylaxis, low molecular weight heparin was used for 30 days.

Following tumor resection, rotational hinged prostheses were applied to 26 patients, hinged prostheses to 4 patients, and 1 custom-made prosthesis was utilized. Due to complications such as aseptic loosening, infection, and periprosthetic fracture, revision surgery was performed, and the final study group comprised 18 rotational, 12 hinged, and 1 custom-made prosthesis. For clinical evaluation, the MSTS score was used, assessing 7 different parameters:

- Range of motion
- Pain
- Stability
- Deformity
- Strength
- Activity
- Emotional acceptance.

Each parameter was scored between 0 and 5, with scores of 2 and 4 used for the intermediate values. The final score was converted to percentiles, with percentiles grouped as follows: 80%-100% excellent, 60%-80% good, 40%-60% fair, 20%-40% poor, and 0%-20% very poor.

Radiological evaluation was conducted using the International Society of Limb Salvage (ISOLS) score, which utilized 6 criteria:

- Bone remodelization
- Interface
- Anchorage
- Implant body problems
- Implant articulation problems
- Extracortical bone bridging.

Table 1. Brand, Model, and Number of implants

Manufacturer	Brand	Number of Prostheses
Stanmore	METS modular distal femur prosthesis, Fixed Hinged System	4
Stanmore	METS modular distal femur prosthesis, Rotational Hinged System	26
Stanmore	METS modular custom made distal femur prosthesis, Rotational Hinged System	1

Each parameter was evaluated based on anteroposterior and lateral views, with the worst-scored view considered for the actual evaluation. Every parameter scored between 1 and 4 and then converted to percentiles. Percentiles were grouped as follows: 80%-100% excellent, 60%-80% good, 40%-60% fair, 20%-40% poor, and 0%-20% very poor.

Statistical Analysis

The statistical analysis was performed using the Number Cruncher Statistical System (NCSS 2007) program from Kaysville, Utah, USA. Descriptive statistics, such as mean, standard deviation, median, frequency, minimum value, and maximum value, were calculated for the variables. When comparing 3 or more groups, the one-way ANOVA test was used. For post hoc evaluation, the Bonferroni test was applied. Pearson correlation analysis and Spearman's correlation analysis were used to assess the correlation between groups. A P-value less than .05 was considered statistically significant. Kaplan–Meier analysis was used for the 5-year survival rate calculation.

Discussion

Megaprosthesis has been the most common method of reconstruction for the past 3 decades. In this study, we aimed to evaluate the clinical and radiological outcomes of megaprosthesis and compare the results between hinged and rotational hinged prostheses.

In our study, the revision rate was 45.2%, with aseptic loosening being the most common complication, followed by infection. The 5-year survival rate was found to be 46.2%. When comparing the survival rates between hinged and rotational hinged prostheses, no significant difference was observed ($P = .526$, $P > .05$). The mean range of motion was 97° (ranging from 30° to 120°). At the last examination, 11 patients reported no pain, 16 patients experienced minimal pain from time to time, 2 patients had moderate pain, and 1 patient had severe pain. All prostheses were stable, and 1 prosthesis exhibited a 5° valgus deformity. In comparison to the unaffected limb, 64.5% of the patients had weaker strength in the operated limb. Quadriceps strengthening exercises were initiated for these patients. Minimal limitations in daily activities were reported by 50% of the patients. Emotionally, 29% of patients (9) were happy, 58% of the patients were satisfied (18), and 9.6% of the patients accepted (3) their condition. Overall, the MSTS scores were 74% (23) excellent, 16% (5) good, and 3.2% (1) fair. Radiologically, the ISOLS scores were 77.4% (24) excellent, 19.3% (6) good, and 3.2% (1) poor.

In limb salvage procedures, emotional acceptance is also crucial for patients' recovery. In our study, we also examined the correlation between the MSTS score parameter and emotional acceptance. We found that as the strength of the extremity increased, emotional acceptance also increased (62.9% correlation, $r = .629$, $P = .001$, $P < .01$).

When comparing the MSTS scores between the hinged and rotational hinged groups, no significant difference was observed (hinged: 83.3% excellent MSTS scores, rotational hinged: 61.5% excellent MSTS scores) ($P > .05$). However, the hinged prosthesis group had slightly higher pain scores. The rotational hinged group had 77.7% excellent scores, while the hinged group had 76.9% excellent scores ($P > .05$).

Conclusion

Large resection is the primary treatment for bone and soft tissue malignancies. Histopathological specifics, anatomical position, and size vary from tumor to tumor, making it difficult to obtain a sufficient surgical margin. Additionally, the relationship of the tumor with joint, vascular, and neurological structures makes surgical planning even more challenging. With the improvements in neoadjuvant and adjuvant therapies, limb salvage procedures have become possible alternatives to amputation.[2,13]

During surgical planning, the surgeon must consider patients' activity levels, age, grade, histopathological specifics of the tumor, surgical margin, and its relation to other structures such as vascular and neurological elements. Prostheses are usually chosen for adults or young adults with closed physes, but today, manual and magnetically extendable prostheses can also be applied for children.[14]

The main goal of surgery is tumor control and prolonging the patients' life span. Functional gain should never be the primary goal for the reconstruction. It is crucial to evaluate soft tissue invasion when selecting the reconstruction method.

Today, limb salvage surgery methods can be used for 85%-95% of patients without affecting the oncological outcome,[1] and the most commonly used surgical method is the megaprosthesis.[3,4,8] There are many types of megaprostheses (hinged, rotational hinged, custom-made, etc.), all with similar complications such as aseptic loosening, infection, prosthesis fracture, and periprosthetic fractures. In the literature, the complication rate of megaprostheses ranges from 40% to 75%.[15-18] For this reason, we aimed to evaluate the survival, revision rates, clinical, and radiological results of our clinic using the MSTS and ISOLS scores. We also compared the results of hinged and rotational hinged prosthesis types.

It is known that hinged prostheses, due to their inability to distribute force evenly, have high rates of mechanical complications.[19] Studies with rotational hinged prosthesis types have shown lower mechanical complication rates because their design allows not only flexion and extension but also external and internal rotation, which provides better weight distribution.[10,20-22] Studies have shown that the 10-year survival rate for rotational hinged prostheses was 78%, while for hinged prostheses, it was 48%.[10,21,23]

Additionally, there was a significant difference in the number of patients between the rotational hinged and hinged prosthesis groups when evaluating the revision rate. To minimize biased patient selection, we included all patients with megaprosthesis between 2000 and 2018 who were operated on by a single surgeon.

In studies, the 5-year survival rate for megaprostheses ranged from 60% to 70%.[2,17,18,24] In our study, the 5-year survival rate was 46.2%. The survival rate for the rotational hinged group was 44.4%, while for the hinged group, it was 50%.

It is common knowledge that the revision rate of megaprostheses is higher than that of primary total knee prostheses. Factors such as longer operation time, chemotherapy and radiotherapy-induced immunodeficiency, larger bone and soft tissue resection, increase the rates of mechanical and biological complications.[25] In the literature, revision rates vary from 25% to 92%.[3-8,25] However, due to the different evaluation systems used, it is challenging to compare these studies. In our study, we classified revision reasons as mechanical (aseptic loosening, periprosthetic fracture, etc.) and biological (infection, recurrence, etc.).

In studies, the incidence of aseptic loosening ranged from 2.4% to 15.4%.[5,8,26,27] In our study, aseptic loosening was the most common reason for revision, with a rate of 69.5%. Aseptic loosening in the rotational hinged group was 54.1%, while in the hinged group, it was 25%. In studies, aseptic loosening of rotational hinged prostheses ranged from 4.8% to 0.7%-27% for hinged prostheses.[3-10,23,28] Bikets reported that aseptic loosening of rotational prosthesis was 5.4% and Fink reported 9.4%.[17] There were no significant differences between the groups ($P = .10$).[19] In contrast, our study showed that the rotational hinged group had higher rates of aseptic loosening. We believe that this result may be due to the difference in the number of patients between the groups.

In our study, the second most common complication was infection (26.08%). In the literature, the risk of infection ranges from 5% to 40%, and it has been reported as the most common reason for revision.[5,15] The patients' immunosuppressed state, long surgical time, and larger resected tissue are thought to be the reasons for this.[28] Another study reported that hinged prosthesis groups had higher infection rates than rotational hinged prosthesis groups (8.9% and 6.6%).[19] However, there were no significant differences ($P = .23$, $P > .05$). In our study, the hinged prosthesis group had an infection rate of 8.3%, while the rotational hinged group had a rate of 20.8%. To decrease the risk of infection, better hygienic precautions, new antibiotic prophylaxis, hydrophilic materials, etc., have been designed. Recently, silver-coated prostheses have been considered to further decrease the infection risk, with in vivo studies showing reduced infection rates.

In our study, periprosthetic fracture was only seen in 1 patient (4.3%). In a meta-analysis, the periprosthetic fracture rate was reported to be between 2% and 12%.[5] In the same meta-analysis, the first-generation hinged prosthesis had a rate about 6% higher than the rotational hinged prosthesis. Stress distribution was achieved by using a thicker stem, more curved femoral component designs, and special hardening methods.[10] Structural deformities were the least frequently observed complications.

Compared to other studies, our study found different revision rates and occurrence rates of complications. This difference may be because we had 26 rotational hinged and 4 hinged prostheses after the primary surgery, resulting in higher revision rates for rotational hinged prostheses.

In our study, the MSTS scores of the patients varied between fair and excellent (54-97). The mean MSTS score was 84.65 ± 9.94. In the literature, MSTS scores ranged from 78% to 86%.[29] Bickels reported that 33% of hinged prosthesis patients had good or excellent (75%-100%) results while rotational prosthesis patients had 85%. Another study reported good or excellent results in 91% of hinged prosthesis patients.[19] In our study, 83.3% of the rotational hinged group and 83.3% of the hinged group had good or excellent scores. There were no significant differences between the hinged and rotational hinged prosthesis groups for MSTS scores ($P > .05$). When comparing the parameters of the MSTS score between the 2 groups, the rotational prosthesis group had slightly less pain, but there were no significant differences ($P = .088$, $P = .05$).

In our study, the mean ISOLS score was 86.60 ± 10.47 (excellent) (45%-100%) (poor-excellent). In a study, ISOLS scores ranged from poor to excellent, with more than 25% extracortical bone bridging reported in 66.6% of patients.[22] In our study, extracortical bone bridging was observed in 67.74% –(21). When comparing the rotational hinged and hinged prosthesis groups, there were no significant differences in scores ($P > .05$).

When comparing the parameters of the MSTS scores with each other, it was found that as extremity strength increased, emotional acceptance also increased ($P = .005$, $P = .003$, $P < .05$). Additionally, patients with lower range of motion had lower activity levels ($P = .042$, $P < .05$).

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of İstanbul University-Cerrahpaşa, Cerrahpaşa Faculty of Medicine (Approval No: 83045809-604.01.02, Date: October 19, 2017).

Informed Consent: Written informed consent was obtained from all the patients who participated in this study.

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