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A study to analyze the outcomes of limb salvage surgery using modular endoprothesis for bone tumors around the knee joint - A retrospective study from a Tertiary Cancer Centre

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Abstract
Introduction: Knee (distal femur and proximal tibia) is the most frequent site of primary bone tumors. Earlier the treatment of majority of these tumors were amputation but in the last few years, the concept of limb salvage surgery has gradually developed & advancements in musculoskeletal tumor management has given both surgeons and patients better treatment options and better quality of life.
Methods: It's a retrospective cohort study conducted at Department of Surgical Oncology, Vydehi Institute of Medical Sciences. Between 2012 and 2021, 122 patients underwent surgery for lower limb malignant tumours around the knee. The Musculoskeletal Tumour Society (MSTS) scoring system was used to assess their functional outcome.
Results: The study comprised 122 participants with a mean (SD) age of 31.71 (10.42) and an age range of 14 to 54 years. The most common location was distal femur and most of it are giant cell tumors. On MSTS score analysis, the majority of cases fall into Grade II (51.64%) and Grade I (46.72%), with only a small fraction in Grade III (1.64%) and no Grade IV cases reported. The mean MSTS score is 22.15. Age, gender, and MSTS grade did not significantly correlate with one another. Our findings demonstrated a strong correlation between MSTS grade and tumor site and histological type.
Conclusion: Patients undergoing distal femur endoprosthetic reconstruction have better MSTS score, and better quality of life compared to patients with proximal tibia reconstruction. However, as quite regular and significant treatment during follow-up is unavoidably needed, the patients and their families must be carefully chosen with a focus on motivation and acceptance.

Keywords: Limb salvage surgery, modular endoprothesis, bone tumors, knee joint

Introduction
For the local treatment of aggressive bone and soft tissue tumors that arise around the knee, limb-salvage surgery has become the standard because of advancements in biomaterials, advanced mechanics, enhanced surgical technique, and effective adjuvant therapy. In addition to having clear functional, psychological, and cosmetic benefits over amputation, limb-salvage surgery does not violate oncological principles.
Since Buchanan's initial description of total femur repair in 1950, the definitive surgical therapy of malignancies in the extremities has undergone significant development [1].Biological and endoprosthetic reconstruction are options for reconstruction following oncological removal of knee tumors. Soft tissue reattachment and osteosynthesis are made possible by structural bone allografts. The possibility of non-union and implant breakage is one of the main disadvantages. The probability increases considerably with adjuvant radiation. Other crucial factors to take into account are allograft availability, size mismatch, infection, and extended antibiotic use [2]. Allograft-prosthetic composites have been employed more recently in limb salvage surgery, which involves implanting an allograft and then using endoprosthetics to replace its articular surfaces.
When compared to allograft reconstruction, endoprosthetic reconstructions yield consistently predictable results. For knee tumors, segmental resections followed by mobile prosthetic joint reconstructions have become very popular since they allow the patient to move, stabilize, and bear weight early. They might help preserve a healthy body image, alleviate discomfort, and maximize quality of life even in patients with a dismal prognosis. Therefore, endoprosthetic reconstruction is a feasible and alluring surgical option [3].
Over the past three decades, improvements in surgical methods, adjuvant and neoadjuvant chemotherapy, and diagnostic imaging have raised the overall 5-year survival rate following endoprosthetic replacement from 20% to 85% [4-6]. Mega-endoprosthetic replacement is now the main treatment option for bone cancers in patients of all ages due to its excellent outcomes and low risk of complications [7-8]. The debate over different limb salvage techniques has given way over the last thirty years to strategies for improving the functional and oncological results following endoprosthetic replacement [7]. From the standpoint of a developing country, however, the problems are different, and the argument still centers on the most economical course of treatment. Endoprostheses are costly and out of most patients' price range in a healthcare system where patients are the main Medicare payers. In a third-world nation, treating these bone cancers is extremely difficult. This study's goal is to use the Musculoskeletal Tumor Society Score (MSTS) to evaluate the functional outcome following limb salvage surgery utilizing modular endoprosthesis for bone tumors.

Materials and Methods
It's a retrospective cohort study conducted at the Department of Surgical Oncology, Vydehi Institute of Medical Sciences. Between 2012 and 2021, 122 patients underwent surgery for lower limb malignant tumours around the knee. The study was approved by the institutional

review board. Patients diagnosed with tumors around knee joint (proximal tibia, distal femur) both malignant and benign, planned for resection and Modular prosthetic reconstruction-Limb Salvage Surgery, new or recurrent tumors involving knee, both metastatic and non-metastatic were included for the study. Patients with tumors around knee which cannot be salvaged, patients with tumors around the knee requiring other treatment modalities – Intralesional excision and curettage, patient with bone Tumors of fibula and patella are excluded from the study.

The Musculoskeletal Tumour Society (MSTS) scoring system was used to assess their functional outcome. Each of the six categories—pain, function, and emotional acceptance in the upper and lower extremities; supports, walking, and gait in the lower extremities; hand positioning, dexterity, and lifting capacity in the upper extremities—is given a numerical value (0–5) by this approach [9]. The functional score was displayed as a percentage of the highest attainable score once these values were applied. The total score, ranging from 0 (maximum disability) to 30 (no impairment), can be transformed to a point scale of 0 to 100. The grading of MSTS, grade 1 -MSTS>23, grade 2-MSTS 15 to 22, grade 3 MSTS- 8 to 14, grade 4- MSTS < 8.

Statistical analysis: Version 25.0 of the IBM SPSS® software package for Windows was used to conduct the analysis. Numbers (n) and percentages (%) were used to characterize the qualitative data, and the Chi-Square, Fischer Exact, and Monte Carlo tests were used for analysis. The mean±standard deviation (SD) for parametric data and the median (range) [minimum and maximum] for nonparametric data were used to characterize the quantitative data

Results

The study comprised 122 participants with a mean (SD) age of 31.71 (10.42) and an age range of 14 to 54 years. Among these participants, 55 (45.08%) were aged 30 years or younger, 54 (44.26%) were aged between 31 and 45 years, and 13 (10.66%) were aged 46 years or older. Among these 63(51.64%) were males and 59 (48.36%) were females. Among the participants, 70 (57.38%) had tumour location in the distal femur and 52 (42.62%) had had tumour location in the proximal tibia. This distribution reflects a higher proportion of occurrence of tumour in the distal femur as compared to proximal tibia in the study population. The distribution of tumor type are shown in Table 1.

The most common tumours were giant cell tumours (GCT) in 52 participants (42.62%), followed by osteosarcoma in 27 participants (22.13%). Recurrent giant cell tumours (R-GCT) were observed in 23 participants (18.85%), while chondrosarcoma affected 20 participants (16.39 %). The distribution of MSTS grading was shown in Table 2.

The majority of cases fall into Grade II (51.64%) and Grade I (46.72%), with only a small fraction in Grade III (1.64%) and no Grade IV cases reported. The mean MSTS score is 22.15 with a standard deviation of 2.78, while the median is 22 with an interquartile range of 21-24. The distribution is bimodal, with modes at 21 and 23, each occurring 13 times. The association of age with MSTS grade was shown in Table 3.

The study found no statistically significant association between age and MSTS grade (p = 0.16). However, there was a trend observed across age groups: in patients ≤30 years, Grade II was most common (60%, n=33); in the 31-45 age group, Grade I and II were nearly equal (48.15%, n=26 and 50%, n=27 respectively); while in the 46-60 age group, Grade I predominated (76.92%, n=10)

We derived the association between gender and MSTS grade. The study found no significant association between gender and MSTS grade (p = 0.85). Males showed an equal distribution between Grade I and Grade II (49.21% each, n=31 for both), while females had a slightly higher proportion of Grade II (54.24%, n=32) compared to Grade I (44.07%, n=26). Grade III cases were similarly rare in both genders (1.59% in males, 1.69% in females). We derived the association between histology pattern and MSTS grade as shown in Table 4 and Fig 1.

The study found a highly significant association between histological diagnosis and MSTS grade (p < 0.001). Osteosarcoma cases were predominantly Grade II (88.89%, n=24), while Giant Cell Tumour (GCT) and Chondrosarcoma cases were mostly Grade I (67.31%, n=35 and 17 %, n=14 respectively). Recurrent GCT (R-GCT) showed a tendency towards Grade II (69.57%, n=16). The association of location of tumor and MSTS was shown in Table 5 and Fig 2.

The study revealed a significant association between tumour location and MSTS grade (p = 0.004). DF tumours were predominantly Grade I (58.57%, n=41), while PT tumours were mostly Grade II (65.38%, n=34). Notably, the only Grade III cases (1.64%, n=2) were observed in PT tumours, and no Grade III cases were found in DF tumours.

Table 1: Distribution of tumour type among the study participants (N=122)

Location of tumour	Frequency (%)
Osteosarcoma	27 (22.13)
GCT	52 (42.62)
R- GCT	23 (18.85)
Chondrosarcoma	20 (16.39)

Table 2: Distribution of MSTS grades among the study participants (N=122)

MSTS Grade	Frequency (%)	Mean (SD)	Median (IQR)	Mode
Grade I	57 (46.72)	22.15 (2.78)	22 (21-24)	21,23*
Grade II	63 (51.64)			
Grade III	2 (1.64)			
Grade IV	0			

*Bimodal – occurring 13 times

Table 3: Association of age with MSTS grade among the study participants (N=122)

Age (years)	MSTS grade			p value
	Grade I (%)	Grade II (%)	Grade III (%)	
0-15	0	5 (83.33)	1 (16.67)	0.16
16-30	21 (42.86)	28 (57.14)	0	
31-45	26 (48.15)	27 (50)	1 (1.85)	
46-50	6 (100)	0	0	
51-60	4 (57.14)	3 (42.86)	0	

Table 4: Association of histology type with MSTS grade among the study participants (N=122)

Histological diagnosis	MSTS grade			p value
	Grade I (%)	Grade II (%)	Grade III (%)	
Osteosarcoma	2 (7.41)	24 (88.89)	1 (3.70)	<0.001
GCT	35 (67.31)	17 (32.69)	0	
R- GCT	6 (26.09)	16 (69.57)	1 (4.35)	
Chondrosarcoma	14 (70)	6 (30)	0	

MSTS score by histological diagnosis

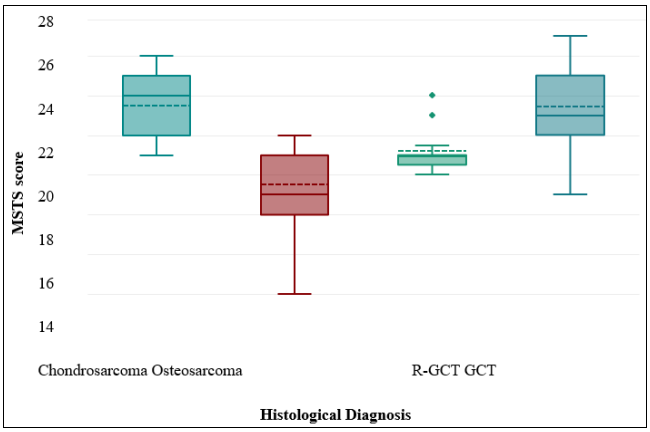

Fig 1: Box Plot showing association of histology type with MSTS grade among the study participants

Table 5: Association of location of tumour with MSTS grade among the study participants (N=122)

Location	MSTS grade			p value
	Grade I	Grade II	Grade III	
DF	41 (58.57)	29 (41.43)	0	0.004
PT	16 (30.77)	34 (65.38)	2 (1.64)	

MSTS score by location

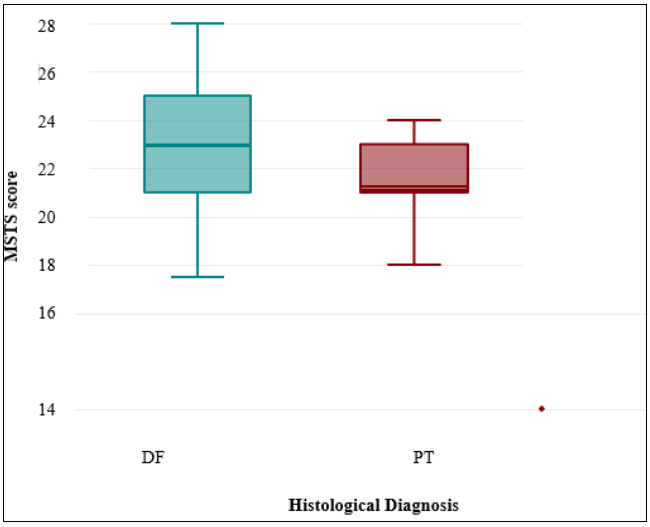

Fig 2: Box Plot showing association of location of tumour with MSTS grade among the study participants

Discussion

Given the requirement to maximize function without sacrificing oncological prognosis, resection and endoprosthetic reconstruction for knee tumors are technically difficult procedures. A multidisciplinary approach has been included into management, which now calls for significant technological and human resources. According to the current study, endoprosthetic repair of the lower limbs may result in high implant survival rates and favorable functional outcomes. After a bone tumor is removed, endoprosthetic repair of the lower extremities typically results in rapid weight bearing and a long-lasting, functional reconstruction. High MSTS scores, between 60% and 80%, have typically been attained with long-term monitoring of hip and knee endoprosthetic replacements [10-12]. Ham *et al*. found that patients with distal femoral endoprosthesis had the greatest functional scores and patients with total femoral replacements had the lowest functional scores in a long-term investigation of 32 patients with primary bone sarcomas of the femur and proximal tibia [13].

Patients who had limb salvage with endoprosthetic repair for lower extremity bone neoplasia in the current dataset had a mean MSTS score of 22.15 at mid-term follow-up. Only 1.64% of instances are in Grade III, and there are no Grade IV cases reported; the bulk of cases are in Grade II (51.64%) and Grade I (46.72%). Futani *et al*. [14] and Wilkins *et al*. [15] studies showed a mean MSTS functional scores of 74 and 73 %, respectively in their series. Age, gender, and MSTS grade did not significantly correlate with one another. Our findings demonstrated a strong correlation between MSTS grade and tumor site and histological type. We can draw the conclusion that early mobilization and clinical recovery are made possible by a standard surgical technique in all locations and customized postoperative rehabilitation, both of which lead to comparatively high MSTS scores at midterm follow-up.

The benefits of megaprosthetic repair are numerous. Prosthetic reconstructive surgery's load-bearing features provide instant postoperative stability and speed up recovery. Because the majority of endoprostheses are modular, the length of the removed bone can be taken into account while replacing the prosthetic. Furthermore, the endurance of contemporary endoprostheses has significantly enhanced due to advancements in implant materials. Their main goal of giving certain patients long-term function with comparatively low physical demands is accomplished. A low risk of complications is a key consideration in the selection process for patients with limited life expectancy. Because of their deteriorating general health and progressing disease, many patients might not be able to have revision surgery. For metastatic bone disease, prosthetic reconstruction surgery might be better since it has fewer risks and failures [16].

Because of the comprehensive nature of the procedure, the significant tissue loss, and the potentially harmful consequences of the concomitant chemotherapy and radiation, oncological reconstruction may seem to have higher risks of complications than routine total joint replacement. Postoperative infection, prosthetic loosening, periprosthetic fractures, and dislocation are the most frequent side effects of prosthetic reconstruction surgery [17].

There are several limitations of this study. It is a retrospective study of a diverse patient population, to start. Although this could be a drawback, the aggregate number of treatments carried out at any one institution is limited due to the rarity of bone cancers requiring endoprosthetic restoration. The absence of a control group is the second drawback. Third, the follow-up period is short duration. Fourth, the MSTS score is not a Turkish-translated and validated measure, despite being widely utilized in clinical trials. Lastly, the absence of a quality-of-life metric and a preoperative functional outcome score represents the fifth constraint.

Conclusion

Patients undergoing distal femur endoprosthetic reconstrucion has better MSTS score, and better quality of life compared to patients with proximal tibia reconstruction. However, as quite regular and significant treatment during follow-up is unavoidably needed, the patients and their

families must be carefully chosen with a focus on motivation and acceptance.

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