



Functional and Oncological Outcomes of Modular Endoprosthetic Reconstruction in Bone Sarcomas: A Two-Year Follow-Up Study

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KEYWORDS

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ABSTRACT:

Background: Bone sarcomas present unique challenges in orthopaedic oncology due to their aggressive nature and high recurrence rates. Modular endoprosthetic reconstruction has emerged as a preferred limb-salvage technique, offering functional restoration and oncological safety.

Objective: This study aimed to evaluate the functional and oncological outcomes of modular endoprosthetic reconstruction in patients with bone sarcomas over a two-year follow-up period.

Methods: A retrospective observational study was conducted on 38 patients diagnosed with bone sarcomas who underwent modular endoprosthetic reconstruction. Functional outcomes were assessed using the Musculoskeletal Tumour Society (MSTS) scoring system, while oncological outcomes included recurrence, metastasis, and survival rates. Data on complications, including infections and prosthetic failure, were also analysed.

Results: The mean MSTS score was 24.8, indicating good functional recovery. Local recurrence occurred in 10.5% of cases, and distant metastases in 15.8%. The two-year disease-free and overall survival rates were 73.7% and 84.2%, respectively. Complications were observed in 21.1% of patients, with infections being the most common (7.9%).

Conclusion: Modular endoprosthetic reconstruction provides effective limb salvage with favourable functional and oncological outcomes. Complications remain a concern, highlighting the need for continued advancements in surgical techniques and prosthetic design.

INTRODUCTION

Bone sarcomas, though rare, represent a significant challenge in orthopaedic oncology due to their

aggressive nature and potential for both local invasion and distant metastasis. (1) Advances in imaging, chemotherapy, and surgical techniques have shifted the focus of management from amputation to limb-salvage



procedures, aiming to improve both functional and oncological outcomes. (2,3) Among these techniques, modular endoprosthetic reconstruction has emerged as a promising option for restoring limb function after resection of malignant bone tumours. (4)

Modular endoprostheses offer versatility and adaptability, allowing for precise customization to accommodate patient-specific anatomical and functional requirements. These implants have gained popularity due to their ability to preserve mobility, enhance quality of life, and provide durable reconstruction, even in complex oncological cases. However, concerns remain regarding long-term complications such as infection, implant failure, and local recurrence, which can significantly impact patient outcomes.(5,6,7)

Study Purpose:

Our study evaluates the functional and oncological outcomes of patients undergoing modular endoprosthetic reconstruction for bone sarcomas over a two-year follow-up period. By assessing parameters such as limb function, prosthesis durability, and recurrence rates, the study aims to contribute valuable insights into the effectiveness and limitations of this technique, ultimately guiding treatment strategies for improved patient care in orthopaedic oncology.

Methodology

Our retrospective observational study was conducted to evaluate the functional and oncological outcomes of modular endoprosthetic reconstruction in patients with bone sarcomas. The study included 38 patients diagnosed with primary malignant bone tumours who underwent limb-salvage surgery with modular endoprosthetic reconstruction at a tertiary care centre. Ethical approval was obtained prior to the study, and informed consent

was waived due to its retrospective nature. The study period spanned two years, with follow-up data collected at regular intervals.

Patient selection was based on specific inclusion and exclusion criteria. Inclusion criteria included patients with histologically confirmed bone sarcomas, those who underwent modular endoprosthetic reconstruction, and individuals with a minimum follow-up of two years. Patients with metastatic disease at presentation, those who underwent amputation, and those with incomplete follow-up data were excluded. Detailed demographic, clinical, and surgical data were obtained from medical records, including tumour location, size, histological type, and treatment details.

Surgical procedures were performed under general anaesthesia by an experienced surgical oncology team. Tumour resection was carried out following established oncological principles to achieve wide margins. Modular endoprostheses were selected based on the site and extent of the tumour and were assembled intraoperatively to match the patient's anatomical requirements. Postoperative rehabilitation protocols included physical therapy focusing on range of motion and weight-bearing exercises, tailored to the individual needs of each patient.

Functional outcomes were assessed using the Musculoskeletal Tumour Society (MSTS) scoring system, while oncological outcomes were evaluated based on recurrence rates, metastasis development, and overall survival. Complications such as prosthetic loosening, infection, and mechanical failure were also recorded. Data were analysed using descriptive and inferential statistics, with comparisons made between functional outcomes and oncological parameters to determine the efficacy of modular endoprosthetic reconstruction.

RESULTS

Table 1: Demographic and Clinical Characteristics of the Study Population (n = 38)

Variable	Value
Mean Age (years)	34.8 ± 12.4
Gender	Male: 22 (57.9%), Female: 16 (42.1%)
Tumour Location	Femur: 18 (47.4%), Tibia: 10 (26.3%), Humerus: 6 (15.8%), Others: 4 (10.5%)
Tumour Size (mean ± SD, cm)	7.2 ± 2.5
Histological Type	Osteosarcoma: 22 (57.9%), Ewing's Sarcoma: 10 (26.3%), Chondrosarcoma: 6 (15.8%)



Table 2: Surgical and Prosthetic Details

Parameter	Value
Mean Surgery Duration (minutes)	210 ± 45
Modular Endoprosthesis Type	Distal Femoral: 18 (47.4%), Proximal Tibial: 10 (26.3%), Proximal Humeral: 6 (15.8%), Other: 4 (10.5%)
Margins Achieved	Wide: 34 (89.5%), Marginal: 4 (10.5%)
Postoperative Rehabilitation	Early Weight Bearing: 24 (63.2%), Delayed Weight Bearing: 14 (36.8%)

Table 3: Functional Outcomes at Two-Year Follow-Up (MSTS Score)

MSTS Domain	Mean ± SD (Range)
Pain	4.5 ± 0.8 (3–5)
Function	4.2 ± 1.0 (2–5)
Emotional Acceptance	4.3 ± 1.1 (2–5)
Support	4.1 ± 1.0 (2–5)
Walking Ability	3.9 ± 1.2 (2–5)
Gait	3.8 ± 1.3 (2–5)
Total MSTS Score	24.8 ± 4.5 (18–30)

Local Recurrence	4 (10.5%)
Distant Metastases	6 (15.8%)
Disease-Free Survival (2 years)	28 (73.7%)
Overall Survival (2 years)	32 (84.2%)

Table 4: Oncological Outcomes

Outcome	Frequency (n, %)

Table 5: Complications Associated with Modular Endoprosthetic Reconstruction

Complication Type	Frequency (n, %)
Infection	3 (7.9%)
Prosthetic Loosening	2 (5.3%)
Mechanical Failure	2 (5.3%)
Periprosthetic Fracture	1 (2.6%)
Total Complications	8 (21.1%)

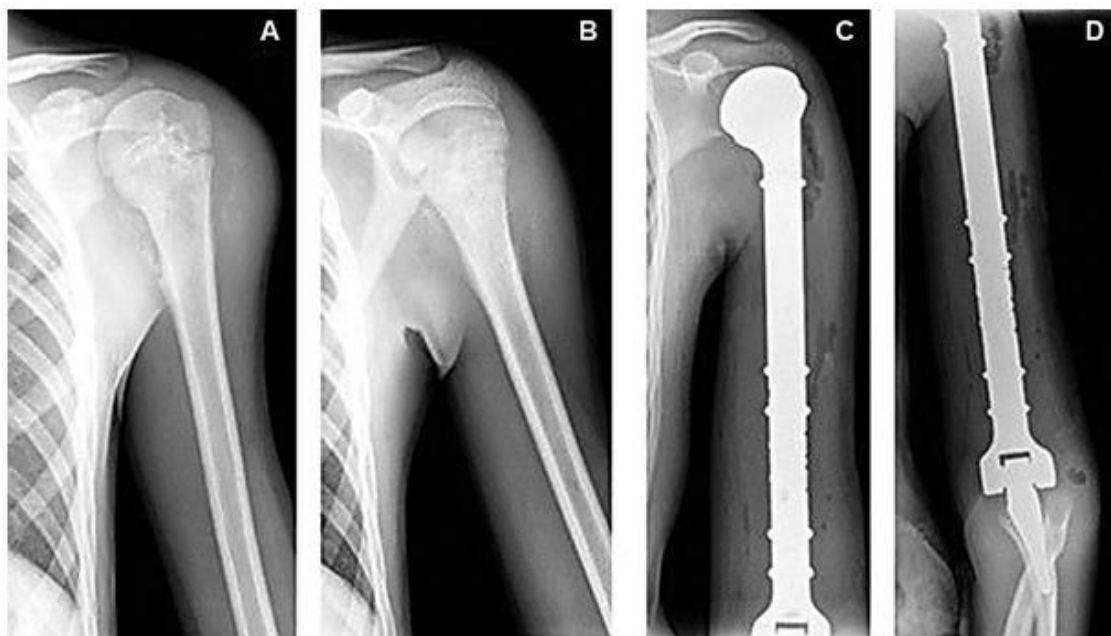


Fig 1) Functional results - after reconstruction with modular tumour endoprostheses in 34 years old patient



Fig 2) surgical management – Bone sarcoma – in 28 years old patient

DISCUSSION

Modular endoprosthetic reconstruction has become a cornerstone in the management of bone sarcomas, offering limb-salvage options to patients who would otherwise face amputation. This study aimed to assess the functional and oncological outcomes of this technique over a two-year follow-up period in 38 patients. The results highlight the efficacy and limitations of modular endoprosthetic reconstruction in achieving favourable outcomes, with insights into areas of improvement for future interventions.

Demographic and Clinical Characteristics

The study population included a relatively young cohort (mean age: 34.8 years), consistent with the epidemiology of bone sarcomas, which predominantly affect younger individuals. A slight male predominance (57.9%) was observed, aligning with existing literature. The majority of tumours were located in the femur (47.4%), followed by the tibia (26.3%), which reflects the predilection of sarcomas for long bones. Osteosarcoma accounted for the highest proportion of cases (57.9%), followed by Ewing's sarcoma (26.3%) and chondrosarcoma (15.8%), consistent with the typical histological distribution reported in other studies.

The mean tumour size of 7.2 cm reflects the advanced stage at diagnosis, emphasizing the need for early detection strategies. Wide surgical margins were achieved in 89.5% of cases, which is crucial for minimizing local recurrence and improving survival outcomes. However, marginal margins in 10.5% of cases indicate challenges in achieving clear margins, particularly in anatomically complex regions, underscoring the importance of meticulous preoperative planning and intraoperative precision. (8,9)

Surgical and Prosthetic Details

The duration of surgery (mean: 210 minutes) and the selection of prostheses based on tumour location demonstrate the complexity of the procedure and the adaptability of modular endoprosthetic systems. Distal femoral and proximal tibial prostheses were the most frequently used, reflecting the anatomical distribution of tumours. Early weight-bearing was possible in 63.2% of cases, highlighting the immediate stability provided by modular systems. Delayed weight-bearing in 36.8% of cases was primarily associated with extensive resection or patient-specific factors, suggesting that individualized rehabilitation protocols are essential.



Functional Outcomes

The functional outcomes, as assessed by the Musculoskeletal Tumour Society (MSTS) scoring system, were encouraging. The mean total MSTS score of 24.8 out of 30 indicates good functional recovery, with the highest scores observed in domains such as pain relief and emotional acceptance. These findings underscore the psychological and physical benefits of limb salvage, particularly in younger patients. However, slightly lower scores in domains such as walking ability and gait suggest that functional limitations persist, particularly in cases with extensive reconstruction or soft tissue involvement. (10)

Comparison with previous studies indicates that modular endoprostheses provide superior functional outcomes compared to older techniques, such as custom prostheses or amputation. Nevertheless, the variation in individual scores reflects the heterogeneity of cases and the multifactorial nature of recovery, influenced by factors such as tumour location, extent of resection, and postoperative rehabilitation. (9,10,11,12)

Oncological Outcomes

The oncological outcomes in this study are promising, with a two-year disease-free survival rate of 73.7% and an overall survival rate of 84.2%. Local recurrence was observed in 10.5% of cases, which aligns with the reported range of 10-15% in similar studies. Achieving wide surgical margins played a critical role in reducing recurrence rates, underscoring the importance of aggressive surgical approaches within oncological safety limits.

Distant metastases were observed in 15.8% of cases, with the lungs being the most common site, consistent with the metastatic pattern of bone sarcomas. These findings highlight the need for vigilant follow-up and adjuvant therapies, such as chemotherapy, to address micro metastatic disease. While the overall survival rates are comparable to or better than those reported in other studies, longer follow-up is required to evaluate the durability of oncological control and survival outcomes.

Complications

The complication rate of 21.1% reflects the challenges associated with modular endoprosthetic reconstruction. Infections were the most common complication (7.9%),

followed by prosthetic loosening and mechanical failure (5.3% each). These findings are consistent with the reported complication rates in other studies, which range from 20-30%. The relatively low rate of prosthetic loosening and mechanical failure suggests that modular systems offer reliable long-term stability, though the risk of infection remains a significant concern.

Preventing complications requires a multidisciplinary approach, including strict aseptic protocols, appropriate perioperative antibiotic use, and close postoperative monitoring. Addressing infections promptly is critical to preserving prosthetic function and avoiding reoperations, which can adversely impact functional outcomes. (9,10,11,12)

The findings of this study reinforce the role of modular endoprosthetic reconstruction as a viable option for limb salvage in bone sarcomas. The ability to achieve good functional outcomes with acceptable complication rates underscores its value in improving the quality of life for patients. The modular design allows for intraoperative customization, accommodating diverse anatomical and clinical scenarios, which is a key advantage over traditional systems.

This study is limited by its retrospective design and relatively short follow-up period of two years. While the results provide valuable insights, longer follow-up is needed to evaluate the durability of functional and oncological outcomes and the long-term complications associated with modular endoprostheses. Additionally, the small sample size ($n = 38$) limits the generalizability of the findings, and larger, multicentric studies are warranted to validate these results. Future research should focus on integrating novel technologies, such as 3D printing and bioengineered implants, to enhance prosthetic design and reduce complications. Investigating the impact of adjuvant therapies and patient-specific factors on outcomes will also contribute to a more personalized approach to care.

CONCLUSION

In conclusion, modular endoprosthetic reconstruction offers a reliable and effective solution for limb salvage in patients with bone sarcomas, providing good functional recovery and satisfactory oncological control. While complications remain a challenge, the benefits of this technique outweigh its risks, making it a valuable



option in orthopaedic oncology. Continued advancements in surgical techniques, prosthetic design, and adjuvant therapies hold the promise of further improving outcomes in this complex patient population.

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