

Limb-Salvage Surgery with Modular Endoprosthetic Reconstruction for Distal Humeral Ewing Sarcoma: A Case Report and Literature Review

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Abstract—Background: Ewing sarcoma is an aggressive malignant bone tumor predominantly affecting children and young adults. Multimodal treatment combining systemic chemotherapy with definitive local control has improved survival, while limb-salvage surgery has become an important treatment option for resectable tumors. However, wide resection of tumors involving the distal humerus may result in substantial skeletal defects and compromise elbow function. Modular tumor endoprostheses provide an option for immediate reconstruction and restoration of limb function following oncological resection.

Case presentation: We present the case of a 19-year-old male diagnosed with Ewing sarcoma of the distal humerus after approximately one year of pain during active and passive movements of the affected upper limb. Following multidisciplinary evaluation, the patient underwent neoadjuvant chemotherapy followed by wide surgical resection of the tumor and reconstruction using a MUTARS modular tumor endoprosthesis. Postoperatively, the patient received additional chemotherapy. During follow-up, no major postoperative complications, local recurrence, or prosthetic failure were observed. Functional recovery was favorable, with only a slight limitation of forearm pronation reported at the latest follow-up.

Conclusion: Limb-salvage surgery with modular endoprosthetic reconstruction can provide satisfactory functional restoration following wide resection of distal humeral Ewing sarcoma. In appropriately selected young patients, the use of a MUTARS prosthesis may allow preservation of the affected limb and facilitate early functional rehabilitation. Further long-term follow-up is required to assess prosthetic durability and oncological outcomes.

Keywords— Ewing sarcoma; distal humerus; limb salvage; modular endoprosthesis; MUTARS; tumor resection; reconstruction; case report.

1. INTRODUCTION

Ewing sarcoma (ES) is an aggressive malignant small round cell tumor that predominantly affects children, adolescents, and young adults and represents one of the most common primary malignant bone tumors in this age group. It most frequently arises in the pelvis and long bones of the extremities, with clinical presentation commonly including localized pain, swelling, and functional impairment. Although advances in mul-

timodal treatment have considerably improved survival, Ewing sarcoma remains a potentially life-threatening disease because of its early metastatic potential and the risk of local and distant recurrence.^{1,2}

The treatment of Ewing sarcoma requires a multidisciplinary approach combining systemic chemotherapy with definitive local tumor control. For patients with localized disease and a resectable tumor, wide surgical excision remains an important method of achieving local control, while radiotherapy represents an alternative or complementary treatment in selected cases.^{3,4} The surgical management of lesions involving the major long bones, however, presents an additional challenge. Wide resection may result in substantial segmental bone and soft-tissue defects, compromising limb stability and function. This problem is particularly relevant in children and adolescents, in whom preservation of limb length and future growth must also be considered.

The development of limb-salvage techniques and modern tumor endoprostheses has substantially changed the surgical treatment of malignant bone tumors. Modular endoprosthetic systems allow reconstruction of large skeletal defects following tumor resection while facilitating restoration of limb alignment, joint function, and early mobilization. Expandable systems may additionally address the problem of limb-length discrepancy in skeletally immature patients.^{5,6} Nevertheless, endoprosthetic reconstruction is associated with a considerable risk of complications, including soft-tissue failure, infection, instability, aseptic loosening, mechanical failure, and local tumor recurrence.⁵

Despite the established role of endoprosthetic reconstruction in limb-salvage surgery, the specific literature concerning Ewing sarcoma remains limited. A systematic review by Abu El Afieh et al. identified only 57 patients with Ewing sarcoma treated with endoprosthetic reconstruction across 17 studies, highlighting the rarity of this treatment scenario and the difficulty of obtaining robust outcome data.⁵ More recently, the use of the Modular Universal Tumor and Revision System (MUTARS) has been reported in pediatric patients with Ewing sarcoma, with encouraging limb preservation and functional outcomes, although mechanical complications remain a concern.⁶

The purpose of this report is to present a case of Ewing sarcoma treated with wide surgical resection and reconstruction using a modular tumor endoprosthesis and to review the current literature concerning limb-salvage surgery and endoprosthetic reconstruction in patients with Ewing sarcoma.

2. MATERIALS AND METHODS

A focused literature review was conducted to identify published studies concerning the surgical management of Ewing sarcoma with limb-salvage procedures and modular endoprosthetic reconstruction. Electronic searches were performed in PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar using combinations of the following keywords: "*Ewing sarcoma*," "*distal humerus*," "*elbow*," "*limb salvage*," "*modular endoprosthesis*," "*megaprosthesis*," "*MUTARS*," "*tumor reconstruction*," and "*endoprosthetic reconstruction*."

Articles published in English reporting clinical outcomes, surgical techniques, complications, functional results, or reconstruction following resection of Ewing sarcoma were considered eligible. Additional relevant studies were identified by manually screening the reference lists of selected publications. Priority was given to systematic

reviews, clinical studies, and reports describing modular endoprosthetic reconstruction of the upper extremity.

3. CLINICAL CASE

Clinical presentation

A 19-year-old male patient was referred to our institution with a one-year history of pain localized to the distal aspect of the right upper extremity. The pain was present during both active and passive movements and progressively interfered with the function of the affected limb.

Xray findings on the plain radiographs (anteroposterior and lateral views) of the proximal humerus and the elbow joint visualizing the lesion with its common findings -periosteal reaction and bone lysis and destruction) (Figure 1.)

Magnetic resonance imaging of the right upper extremity demonstrated an extensive destructive lesion involving the distal humerus, with involvement of the surrounding soft tissue (Figure 2). The imaging findings, together with the clinical presentation, raised suspicion of a primary malignant bone tumor. Following multidisciplinary assessment and histological confirmation of Ewing sarcoma, the patient was treated according to a multimodal oncological protocol, including neoadjuvant chemotherapy followed by definitive surgical treatment.

After completion of neoadjuvant chemotherapy, the patient underwent wide resection of the distal humeral tumor. A 16-cm segment of the distal humerus was resected, with 2-cm margins of macroscopically healthy tissue achieved around the tumor. Following tumor removal, reconstruction of the resulting segmental bone defect was performed using a MUTARS modular tumor endoprosthesis (Figure 3.). The prosthesis was positioned to restore the anatomical continuity of the humerus and allow preservation of the elbow joint and upper-limb function (Figure 4.).

Imaging findings



Figure 1. Plain radiographs (anteroposterior and lateral views) of the proximal humerus and the elbow joint visualizing the lesion with its common findings (periosteal reaction and bone lysis and destruction)



Figure 2. Preoperative MRI demonstrating the distal humeral lesion.

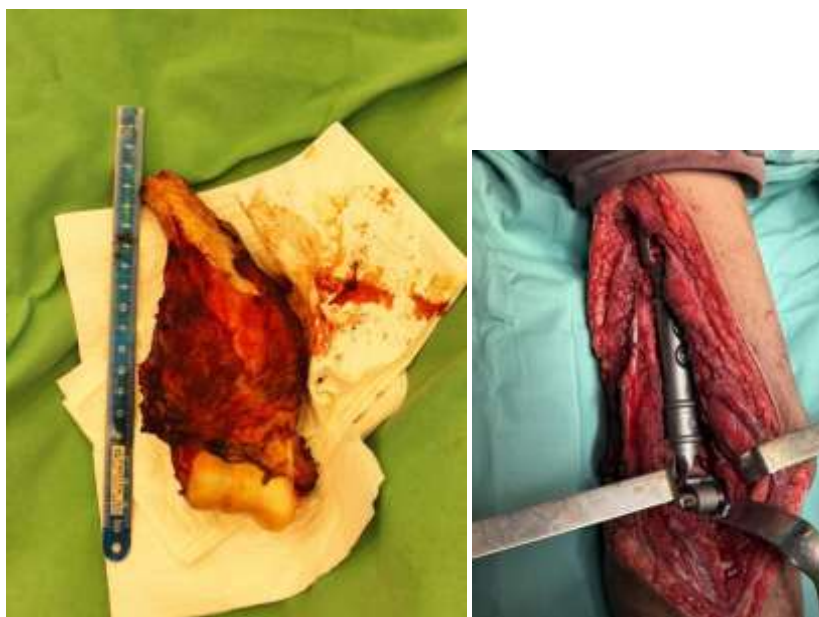


Figure 3. Intraoperative photograph demonstrating the resection and MUTARS reconstruction.



Figure 4. Immediate postoperative radiographs (anteroposterior and lateral views) of the elbow joint..

Management and outcome

The postoperative course was uneventful and the 6th month postoperative Xray findings show no complications (Figure 5.). Early rehabilitation was initiated, and approximately 90° of elbow flexion was achieved during the first postoperative week, indicating satisfactory early functional recovery. The patient subsequently continued postoperative systemic chemotherapy according to the established treatment protocol. At 6th month follow-up, there were no reported postoperative complications, including infection, wound complications, prosthetic failure, or local recurrence. The patient demonstrated satisfactory functional use of the affected upper limb, with only a slight limitation in forearm pronation. Overall elbow function was well preserved (Figure 6.).¹²



Figure 5. 6-month postoperative X-ray showing no radiographic evidence of progressive periprosthetic translucency, osteolysis, periprosthetic fracture or implant migration.



Figure 6. At follow-up, there were no reported postoperative complications, including infection, wound complications, prosthetic failure, or local recurrence. The patient demonstrated satisfactory functional use of the affected upper limb, with only a slight limitation in forearm pronation. Overall elbow function was well preserved.¹²

4. DISCUSSION

Ewing sarcoma is an aggressive primary malignant bone tumor that predominantly affects children and young adults. Its management requires multimodal therapy, with

systemic chemotherapy combined with definitive local control. In patients with a resectable lesion, wide surgical excision remains an important component of treatment. The development of modern reconstructive techniques has allowed limb-salvage surgery to be performed in situations where amputation was historically considered necessary. However, reconstruction following extensive /tumor resection remains challenging, particularly when the lesion involves the distal humerus and the elbow joint.

The present case demonstrates the feasibility of limb preservation following extensive distal humeral resection in a young patient with Ewing sarcoma. A 16-cm segment of the distal humerus was removed with planned 2-cm surgical margins and reconstructed using a MUTARS modular endoprosthesis. Despite the extent of the resection, the postoperative course was uncomplicated, and early rehabilitation resulted in approximately 90° of elbow flexion during the first postoperative week. At subsequent follow-up, the patient retained satisfactory function of the affected limb, with only a slight limitation of pronation.

In selected cases, reconstruction of bone defects can be achieved using bioproducts or bone graft substitutes.¹³ The literature specifically addressing endoprosthetic reconstruction in Ewing sarcoma is relatively limited. Abu El Afieh et al. performed a systematic review in which the mean patient age was 14.5 years, and the most frequently reported locations were the proximal humerus, proximal femur, distal femur, and distal tibia. MUTARS was among the prosthetic systems used, although the small number of patients treated with each individual implant prevented meaningful comparisons between prosthetic designs.¹

The same review emphasizes that the favorable functional potential of endoprosthetic reconstruction must be balanced against a substantial complication burden. Soft-tissue-related failure was the most frequently observed failure mode, while deep infection occurred in 15.7% of patients. Other reported complications included contracture, instability or dislocation, aseptic loosening, structural failure, and local tumor progression.¹²⁻¹⁶ Nevertheless, 53 of the 57 patients in the reviewed cohort retained their limbs, and the mean five-year implant survivorship reported in the subset of studies providing such data was 85.9%. The mean MSTS functional score among 29 patients was 77.5%.¹⁸ Literature findings support endoprosthetic reconstruction as a viable limb-preserving strategy, while also demonstrating why prolonged clinical and radiographic surveillance is necessary.¹⁹⁻²¹

The distal humerus represents a particularly demanding anatomical site for reconstruction. Unlike intercalary reconstruction of a long-bone diaphyseal defect, reconstruction around the elbow must restore not only skeletal continuity but also a stable and functional joint while preserving the surrounding neurovascular and soft-tissue structures. A 2023 series of 30 patients undergoing limb-salvage procedures for tumors around the elbow included eight patients with Ewing sarcoma. Distal humeral lesions represented the majority of tumors in that cohort. Different reconstructive methods were employed, including elbow arthrodesis, endoprosthetic reconstruction, excision arthroplasty, and biological reconstruction. The median postoperative MSTS score was 27/30, demonstrating that satisfactory function can be obtained despite the complexity of these procedures.¹⁸

An important advantage of modular endoprosthetic reconstruction is the ability to restore limb function without requiring biological union across a massive segmental defect. Following a 16-cm resection in the present case, a biological reconstruction

would potentially require prolonged healing and carries the additional risks of nonunion, graft resorption, fracture, and delayed rehabilitation. A modular endoprosthesis instead provides immediate structural reconstruction and allows early postoperative mobilization. This may be particularly valuable in patients undergoing prolonged systemic treatment, where minimizing the period of functional impairment is clinically relevant. While reconstruction of the lateral ulnar collateral ligament has been advocated to restore stability following conventional elbow reconstruction, no additional ligament reconstruction was required in our patient. The stability achieved with the modular MUTARS prosthesis permitted early rehabilitation, and no clinical signs of recurrent instability were observed during follow-up.¹¹

Mechanical failure of the expansion mechanism was the principal complication in their series. Although the patients in that study were younger than the patient described here, their results support the feasibility of MUTARS reconstruction in the setting of Ewing sarcoma and highlight the importance of long-term monitoring for implant-related complications.

The absence of major postoperative complications in the present patient is encouraging, particularly considering the extent of the resection and the patient's ongoing oncological treatment. Preservation of useful elbow motion is also clinically meaningful in a 19-year-old patient, for whom maintaining upper-limb function has substantial implications for activities of daily living, education, employment, and long-term quality of life. Early achievement of 90° of flexion suggests that the reconstruction permitted prompt initiation of functional rehabilitation. The mild residual limitation of pronation appears to have had little effect on overall limb function.

At the same time, the favorable early clinical outcome should be interpreted cautiously. Ewing sarcoma is characterized by the potential for both local recurrence and distant metastatic disease, while endoprosthetic reconstruction carries risks that may become apparent only after prolonged follow-up. Aseptic loosening, mechanical failure, periprosthetic fracture, infection, and soft-tissue dysfunction can occur years after the initial operation. Therefore, an uncomplicated early postoperative course does not eliminate the need for long-term oncological and prosthetic surveillance.

The main limitation of this report is its single-patient design. Consequently, the favorable functional result cannot be generalized to all patients with distal humeral Ewing sarcoma, and no conclusions regarding the superiority of MUTARS over other reconstructive systems can be drawn. The existing literature is itself limited by small cohorts, heterogeneous prosthetic designs, different tumor locations, variable follow-up periods, and inconsistent functional outcome measures. The systematic review by Abu El Afieh et al. specifically emphasized the rarity of the available population and the difficulty of deriving robust comparative conclusions.

In this context, the present case contributes to the limited clinical literature on endoprosthetic reconstruction following resection of Ewing sarcoma and illustrates the potential of modular reconstruction to achieve limb preservation and useful elbow function following extensive distal humeral resection. The combination of adequate oncological resection, systemic chemotherapy, modular reconstruction, and early rehabilitation may provide a satisfactory treatment strategy in carefully selected patients.

5. CONCLUSION

Limb-salvage surgery with modular endoprosthetic reconstruction represents a valuable treatment option for selected patients with Ewing sarcoma of the distal humerus. Wide resection of a tumor segment followed by reconstruction with a MUTARS modular endoprosthesis allowed preservation of the affected limb and satisfactory early functional recovery. Despite the extensive resection, the literature supports that a patient may achieve useful elbow motion with only minor limitation of pronation and experienced no significant postoperative complications. The findings support the role of modular endoprosthetic reconstruction in restoring function after extensive tumor resection around the elbow. However, given the limited evidence concerning this rare tumor location and the potential for late oncological and prosthetic complications, long-term clinical, radiographic, and oncological follow-up remains essential.

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