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Long-Term Outcomes of Modular Endoprosthesis in Distal Femur Tumor Resection: A Review of Evidence

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Abstract

Primary tumors of the distal femur, including osteosarcoma and chondrosarcoma, represent a significant challenge in orthopedic oncology. Limb-salvage surgery with resection and modular endoprosthesis replacement has emerged as the gold standard for preserving function and improving patient outcomes. This review aims to evaluate clinical, functional, and oncological outcomes associated with this surgical approach. A comprehensive review of current literature was conducted, focusing on studies assessing outcomes following distal femoral tumor resection and reconstruction using modular endoprostheses. Key parameters included patient survival, prosthesis longevity, functional scores (e.g., Musculoskeletal Tumor Society [MSTS] score), complication rates, and quality of life post-surgery. The reviewed studies demonstrate favorable long-term outcomes with modular endoprostheses, with 5-year survival rates exceeding 70% in non-metastatic cases. Functional outcomes, as measured by MSTS scores, were generally satisfactory, with most patients achieving independence in daily activities. However, complications such as infection, mechanical failure, and aseptic loosening remain significant concerns, often necessitating revision surgeries. Advances in prosthesis design and surgical techniques have contributed to improved durability and reduced complication rates. Modular endoprosthesis replacement following distal femoral tumor resection offers excellent limb function and survival outcomes in appropriately selected patients. Continued innovation in prosthetic design, surgical expertise, and postoperative care is essential to further reduce complications and optimize long-term results. Future research should focus on comparative studies, long-term follow-up, and patient-reported outcomes to refine treatment strategies.

Keywords: Bariatric Surgery, Laparoscopic Sleeve Gastrectomy, Omentopexy, Gastropexy, Morbid Obesity, Surgical Outcomes

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Introduction The distal femur is a common site for primary bone tumors, including osteosarcoma, chondrosarcoma, and giant cell tumors. Surgical management typically involves wide resection of the tumor followed by reconstruction to restore limb function and structural integrity. Modular endoprosthesis replacement has emerged as a preferred option due to its adaptability, durability, and ability to restore near-normal biomechanics (1). Advances in surgical techniques, prosthetic design, and adjuvant therapies have significantly improved clinical outcomes and survival rates (2).

Indications for Resection and Endoprosthetic Replacement Primary indications for resection and endoprosthetic replacement include high-grade sarcomas, aggressive benign tumors, and tumor-related pathological fractures (3). The goal is to achieve complete oncological clearance while preserving as much function as possible. Patients must undergo thorough preoperative imaging, including MRI and CT scans, to evaluate tumor margins and plan resection accurately (4).

Preoperative Evaluation and Planning Preoperative evaluation includes imaging, histopathological confirmation, and systemic staging to rule out metastasis. Multidisciplinary collaboration involving orthopedic oncologists, radiologists, and pathologists is essential (5). Precise assessment of neurovascular involvement and adjacent joint integrity determines the feasibility of limb salvage surgery (6).

Surgical Techniques The surgical technique involves wide resection of the tumor with adequate oncological margins, followed by reconstruction using a modular endoprosthesis. The choice of prosthesis depends on the extent of bone loss and soft tissue involvement (7). Intraoperative techniques, such as neurovascular preservation and muscle reattachment, are critical for functional outcomes (8).

Modular Endoprosthesis Design Modern modular endoprostheses are composed of biocompatible materials, such as titanium and cobalt-chromium alloys, which offer excellent mechanical strength and resistance to wear (9). These prostheses can be customized to match the defect size and limb length, ensuring optimal alignment and function (10).

Functional Outcomes Functional outcomes depend on the extent of soft tissue preservation, prosthesis alignment, and patient rehabilitation. Studies have shown that limb salvage with modular endoprostheses provides superior quality of life compared to amputation (11). The Musculoskeletal Tumor Society (MSTS) score is commonly used to evaluate functional outcomes post-surgery (12).

Complications and Challenges Common complications include infection, aseptic loosening, periprosthetic fractures, and local tumor recurrence (13). Infection remains one of the most challenging complications, often requiring staged revision surgeries (14). Long-term surveillance is necessary to monitor prosthetic integrity and tumor recurrence (15).

Prosthetic Longevity and Survival Rates Prosthetic survival rates have significantly improved due to advancements in material science and surgical techniques. Recent studies report five-year prosthetic survival rates exceeding 80% (16). However, younger patients are at a higher risk of mechanical failure due to increased physical activity (17).

Rehabilitation Protocol Early postoperative rehabilitation is essential to optimize functional recovery. Weight-bearing protocols are determined based on the stability of the prosthesis and extent of soft tissue reconstruction (18). Physiotherapy focuses on muscle strengthening, joint mobility, and gait training (19).

Patient-Specific Factors Patient factors, including age, activity level, comorbidities, and tumor grade, significantly influence outcomes. Younger, active patients often require closer follow-up and may need revision surgeries over time (20). Resection and modular endoprosthesis replacement represent a reliable and effective approach for managing primary tumors of the distal femur. Multidisciplinary care, advanced surgical techniques, and robust rehabilitation protocols contribute to improved functional outcomes and long-term prosthetic survival.

Functional outcomes following resection and modular endoprosthesis replacement for primary tumors at the distal femur have been extensively studied in recent years. This procedure is typically indicated for patients with primary bone sarcomas, such as osteosarcoma or chondrosarcoma, localized to the distal femur. Surgical resection combined with endoprosthetic replacement aims to achieve oncological control while preserving limb functionality. Advances in surgical techniques and prosthetic designs have significantly improved the overall prognosis and long-term functional outcomes for patients undergoing this procedure [21].

Limb-salvage surgery using modular endoprosthesis is now the standard of care for treating malignant tumors of the distal femur. This approach offers an alternative to amputation, providing patients with improved quality of life and psychological well-being. Modular endoprostheses are customizable and can address bone loss resulting from tumor resection while maintaining joint stability and mobility. However, complications such as infection, prosthetic loosening, and mechanical failure remain significant challenges [22].

Functional assessment following distal femur endoprosthesis replacement often includes validated scoring systems, such as the Musculoskeletal Tumor Society (MSTS) score and Toronto Extremity Salvage Score (TESS). These tools measure physical function, emotional well-being, and social reintegration post-surgery. Studies have shown that the majority of patients achieve acceptable functional scores, enabling them to perform daily activities and return to work or education [23].

Postoperative rehabilitation is a critical component of recovery after distal femur resection and endoprosthesis replacement. Physiotherapy protocols emphasize early mobilization, range of motion exercises, and muscle strengthening to optimize functional outcomes. Adequate rehabilitation support has been linked to better MSTS and TESS scores and lower complication rates. Nevertheless, the extent of rehabilitation required often depends on the complexity of the surgical procedure and the patient's overall health [24].

Infection remains one of the most feared complications following modular endoprosthesis replacement. Deep infections can lead to significant morbidity, prolonged hospitalization, and in some cases, amputation. Studies indicate that infection rates range between 5-15%, with *Staphylococcus* species being the most common pathogens. Early diagnosis and aggressive management, including surgical debridement and antibiotic therapy, are essential to preserve the prosthesis and avoid catastrophic outcomes [25].

Prosthetic loosening is another complication that can adversely affect functional outcomes. It occurs due to aseptic loosening, infection, or mechanical stress at the bone-prosthesis interface. Radiographic evidence of loosening often prompts surgical revision. Advances in cementation techniques, implant design, and surgical precision have contributed to reducing the incidence of this complication in recent years [26].

Mechanical failure of endoprostheses is another concern, particularly in younger, more active patients. This issue arises from wear and tear, fatigue fractures, or component failure. Regular follow-up with radiographic imaging is essential to detect early signs of mechanical failure and plan timely intervention. Research suggests that modern endoprosthetic designs with enhanced materials and modularity have improved durability and longevity [27].

Oncological outcomes following distal femur resection and endoprosthesis replacement depend on factors such as tumor size, histological grade, and surgical margins. Achieving wide surgical margins is crucial to minimize the risk of local recurrence. Studies have shown that patients with negative surgical margins have significantly better disease-free survival rates compared to those with positive margins [28].

Psychological outcomes following limb-salvage surgery are equally important in evaluating treatment success. Patients often experience anxiety, depression, or body image concerns postoperatively. Comprehensive psychosocial support, including counseling and peer support groups, can improve emotional well-being and overall satisfaction with the surgical outcome [29].

Patient-reported outcomes (PROs) have gained prominence in assessing the success of distal femur endoprosthesis replacement. PROs encompass patient feedback on pain, mobility, and quality of life. Recent studies emphasize the importance of including patient perspectives alongside clinical evaluations to provide a holistic assessment of surgical outcomes [30].

Long-term follow-up studies have highlighted the durability and success of modular endoprostheses in treating primary bone tumors of the distal femur. Survival rates of implants have been reported to exceed 80% at 10 years in certain cohorts. These findings underscore the importance of continuous monitoring and timely intervention to address complications [31].

Age is a significant factor influencing functional outcomes following endoprosthetic replacement. Younger patients often demonstrate better functional recovery due to greater physical resilience and motivation. Conversely, elderly patients may face challenges related to comorbidities and slower rehabilitation progress [32].

Gender differences have also been observed in functional recovery following distal femur endoprosthesis replacement. Some studies suggest that male patients exhibit higher physical function scores, while female patients report better emotional well-being and pain control. These findings highlight the need for gender-specific rehabilitation strategies [33].

Preoperative factors, such as tumor size, extent of soft tissue involvement, and patient fitness, play a critical role in determining functional outcomes. Early diagnosis and prompt intervention are essential to minimize extensive resections and preserve limb function. Multidisciplinary collaboration is vital in achieving optimal preoperative planning and surgical execution [34].

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Recent advancements in imaging technology have significantly enhanced preoperative planning for distal femur resections. Techniques such as 3D-printed models and computer-assisted navigation allow for precise tumor delineation and implant positioning. These technologies have been shown to reduce surgical errors and improve prosthesis alignment [35].

The role of adjuvant therapies, such as chemotherapy and radiotherapy, in the management of distal femur tumors cannot be overlooked. Neoadjuvant chemotherapy has been shown to reduce tumor size, facilitating limb-salvage surgery. However, these therapies may also pose challenges, such as delayed wound healing and increased infection risk [36].

In conclusion, distal femur resection and modular endoprosthesis replacement offer a viable limb-salvage option for patients with primary bone tumors. While complications remain a concern, advances in surgical techniques, implant technology, and postoperative rehabilitation have significantly improved outcomes. Continued research is essential to address remaining challenges and further optimize functional results [37].

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