https://doi.org/10.48047/AFJBS.6.2.2024.4403-4408

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Balancing Oncological Control and Function: Resection and Modular Endoprosthesis in Distal Femoral Tumors

Ahmed Mohammed Fathy Atia, Ahmed Hashem Amin, Mohammed Al-Sadek Attia, Ahmed Mashhour Gaber

Orthopedic Surgery Department, Faculty of Medicine - Zagazig University, Egypt

Corresponding author: Ahmed Mohammed Fathy Atia

Email: drahmed9250@gmail.com

Article History

Volume 6, Issue 2, Apr-Aug 2024

Received: 5 August 2024

Accepted: 15 August 2024

Published: 15 August 2024

doi:10.48047/AFJBS.6.2.2024.4403-4408

Abstract: Background: Resection and modular endoprosthesis replacement have revolutionized the surgical management of primary tumors at the distal femur, offering patients improved functional outcomes and enhanced quality of life. This review article provides a comprehensive analysis of current surgical techniques, oncological principles, and functional outcomes associated with this approach. We discuss indications for limb-salvage surgery, preoperative planning, and the intricacies of distal femoral resection. Additionally, we evaluate the design evolution, biomechanical properties, and survivorship of modular endoprostheses. Key factors influencing long-term success, including implant failure, infection, and local recurrence, are thoroughly examined. The review also highlights rehabilitation protocols and their role in optimizing postoperative recovery. By synthesizing recent advancements and clinical evidence, this article aims to guide orthopedic oncologists in making informed decisions for managing primary distal femoral tumors while balancing oncological control and functional preservation.

Keywords: *Resection and Modular Endoprosthesis, Distal Femoral Tumors*

Introduction

Primary tumors of the distal femur are relatively rare but represent an important subset of musculoskeletal oncology. These tumors can be benign or malignant, with osteosarcoma being the most common primary malignant bone tumor affecting this region [1]. The distal femur, due to its rich vascular supply and high cellular activity in the metaphyseal region, is particularly susceptible to tumor formation [2]. The incidence of primary bone tumors is higher in adolescents and young adults, coinciding with periods of rapid bone growth [3].

The most common primary malignant bone tumors of the distal femur include osteosarcoma, chondrosarcoma, and Ewing sarcoma, while benign tumors such as osteochondroma and giant cell tumors are also frequently encountered [4]. Osteosarcoma is often diagnosed in the second decade of life, with a slight male predominance [5]. Chondrosarcoma, on the other hand, tends to occur in older adults and is characterized by cartilage matrix production [6].

Clinical presentation often includes persistent localized pain, swelling, and sometimes a palpable mass. Pain is usually progressive and may worsen at night or with activity [7]. Pathological fractures are not uncommon,

especially in aggressive lesions [8]. Radiographic imaging remains the cornerstone of diagnosis, with plain X-rays revealing typical findings such as cortical destruction, periosteal reaction, and soft tissue mass [9].

Magnetic resonance imaging (MRI) is essential for local staging, providing detailed information about intraosseous and extraosseous tumor extent, neurovascular involvement, and joint infiltration [10]. Computed tomography (CT) may be used to assess cortical integrity and detect subtle mineralization patterns within the tumor [11]. Whole-body bone scans and PET-CT are useful for detecting distant metastases [12].

Histological confirmation is mandatory for definitive diagnosis, with core needle biopsy being the preferred method to minimize contamination of surrounding tissues [13]. Osteosarcoma typically demonstrates malignant osteoid production, while chondrosarcoma shows atypical chondrocytes within a hyaline cartilage matrix [14]. Ewing sarcoma is characterized by small round blue cells with CD99 positivity on immunohistochemistry [15].

Treatment approaches depend on the histological type, grade, and stage of the tumor. Osteosarcoma is primarily managed with neoadjuvant chemotherapy followed by surgical resection and adjuvant chemotherapy [16]. Advances in limb-salvage surgeries have significantly improved functional outcomes while maintaining oncological safety [17]. Endoprosthetic reconstruction is commonly employed after wide resection of distal femoral tumors [18].

For chondrosarcoma, surgical resection remains the mainstay of treatment, as these tumors are largely resistant to chemotherapy and radiotherapy [19]. Ewing sarcoma, however, requires a multimodal approach with chemotherapy, surgery, and often radiotherapy [20]. Early diagnosis and multidisciplinary management are crucial for optimizing patient outcomes [21].

Rehabilitation plays a key role in restoring function and mobility following surgical intervention. Physical therapy focuses on improving range of motion, strength, and overall functional independence [22]. Long-term follow-up is essential for early detection of local recurrence or distant metastasis [23].

Despite significant advancements in treatment modalities, prognosis varies widely depending on tumor type, size, grade, and metastatic status at the time of diagnosis. Osteosarcoma has a 5-year survival rate of approximately 60-70% for localized disease, while metastatic disease significantly reduces survival rates [24]. Research is ongoing to identify molecular and genetic markers for early diagnosis, targeted therapies, and improved prognostication. Agents targeting specific pathways such as VEGF and mTOR are being actively investigated in clinical trials [25]. Immunotherapy is also emerging as a potential therapeutic option for select cases [26], primary tumors of the distal femur represent a challenging group of pathologies requiring a multidisciplinary approach for optimal outcomes. Early recognition, accurate diagnosis, and appropriate treatment are critical in managing these patients effectively [27].

Balancing Oncological Control and Function: Resection and Modular Endoprosthesis in Distal Femoral Tumors

The management of distal femoral tumors presents a significant clinical challenge, requiring a delicate balance between achieving oncological control and preserving limb functionality. Advances in surgical techniques and endoprosthetic design have revolutionized the treatment landscape, enabling better outcomes for patients. Modular endoprostheses, in particular, offer customizable solutions tailored to individual patient anatomy and surgical requirements [28]. These prostheses are essential in maintaining structural integrity and functional mobility post-resection while minimizing complications.

Oncological control remains the primary objective in the management of distal femoral tumors. Wide local excision with negative surgical margins is critical to minimize the risk of local recurrence. Achieving this often necessitates extensive resection, which can compromise limb function. However, modern imaging techniques, including MRI and CT scans, aid surgeons in precise preoperative planning, ensuring adequate resection margins while preserving critical structures [29].

Limb-salvage surgery has largely replaced amputation as the standard of care for distal femoral tumors. This shift is attributed to advancements in chemotherapy, imaging modalities, and reconstructive techniques. Modular endoprostheses have become the preferred reconstruction method due to their durability and adaptability. They allow for immediate weight-bearing postoperatively, significantly improving the patient's quality of life [30].

The design of modular endoprostheses allows for intraoperative flexibility, enabling surgeons to address unexpected findings during resection. Components can be adjusted to match the patient's residual bone stock, ligamentous structures, and soft tissue integrity. This modularity ensures optimal fit and function, reducing the risk of prosthetic failure [31].

Functional outcomes following endoprosthetic reconstruction are influenced by multiple factors, including the extent of resection, soft tissue preservation, and rehabilitation protocols. Studies have shown that patients with well-preserved soft tissue envelopes and stable prosthetic components achieve superior functional scores. Early mobilization and physiotherapy are integral to optimizing recovery [32].

Infection remains one of the most challenging complications associated with endoprosthetic reconstructions. Despite advancements in aseptic techniques and perioperative antibiotic prophylaxis, infection rates remain significant. Multidisciplinary approaches, including input from infectious disease specialists, are often required for effective management [33].

Mechanical complications, including aseptic loosening and periprosthetic fractures, are common long-term concerns with modular endoprostheses. These complications can compromise implant stability and necessitate revision surgeries. Regular follow-up with radiographic assessments is essential for early detection and intervention [34].

Patient-reported outcomes play a crucial role in evaluating the success of distal femoral tumor resections and reconstructions. Tools such as the Musculoskeletal Tumor Society (MSTS) score and Toronto Extremity Salvage Score (TESS) are widely used for assessing functional outcomes. These assessments provide valuable insights into the physical and psychological impacts of treatment [35].

Advances in biomaterials have significantly enhanced the longevity and biocompatibility of modular endoprostheses. Titanium alloys, cobalt-chromium alloys, and hydroxyapatite-coated implants are commonly used materials that promote osseointegration and reduce implant-related complications. Research into biodegradable materials holds promise for future developments [36].

Preoperative planning is a cornerstone of successful distal femoral tumor management. Advanced imaging, computer-assisted design (CAD), and 3D printing technologies enable the creation of patient-specific prostheses. These innovations enhance precision in tumor resection and prosthetic implantation [37].

Soft tissue management is critical in ensuring the stability and functionality of endoprosthetic reconstructions. Preservation of key anatomical structures, including neurovascular bundles and surrounding musculature, is paramount. Meticulous surgical techniques and innovative soft tissue attachment methods contribute to favorable outcomes [38].

In pediatric patients with distal femoral tumors, growth considerations add another layer of complexity to surgical planning. Extendable modular endoprostheses have been developed to accommodate skeletal growth, reducing the need for repeated surgeries. These implants can be non-invasively expanded, offering significant advantages in pediatric oncology [39].

The psychological impact of distal femoral tumor surgery cannot be overstated. Patients often face significant emotional distress related to cancer diagnosis, limb preservation, and functional limitations. Comprehensive psychological support, alongside physical rehabilitation, is essential for holistic care [40].

Long-term surveillance following limb-salvage surgery is vital for monitoring both oncological and prosthetic outcomes. Routine imaging and clinical evaluations help detect early signs of recurrence or mechanical failure. Early intervention in these cases can prevent catastrophic complications [41].

Revision surgery following endoprosthetic failure is a complex procedure often associated with higher morbidity. Factors such as bone loss, soft tissue damage, and infection must be carefully addressed. Innovations

in revision prostheses and reconstructive techniques have improved outcomes in these challenging scenarios [42].

Multidisciplinary teams play an indispensable role in managing distal femoral tumors. Collaboration among orthopedic oncologists, radiologists, pathologists, and rehabilitation specialists ensures comprehensive care. Such an approach maximizes both oncological and functional outcomes [43].

Personalized medicine is increasingly influencing the treatment of distal femoral tumors. Genetic and molecular profiling of tumors enables targeted therapies, which may complement surgical interventions. These approaches hold promise for improving survival rates and minimizing side effects [44].

Patient education is crucial for optimizing postoperative outcomes. Educating patients about rehabilitation protocols, prosthetic care, and potential complications empowers them to actively participate in their recovery journey. Educational materials and support groups play a key role in this aspect [45].

Financial considerations are a significant aspect of distal femoral tumor management. The cost of endoprostheses, surgical procedures, and long-term care can pose substantial economic burdens on patients and healthcare systems. Efforts to improve cost-effectiveness without compromising care are ongoing [46].

Research continues to drive innovations in the field of modular endoprostheses. Areas such as bioactive coatings, robotic-assisted surgery, and enhanced imaging technologies are being actively explored. These advancements aim to further improve patient outcomes and reduce complication rates [47].

References

1. Mirabello L, Troisi RJ, Savage SA. Osteosarcoma incidence and survival rates from 1973 to 2004: Data from the Surveillance, Epidemiology, and End Results Program. J Orthop Res. 2020;28(6):856-863.
2. Kager L, Zoubek A, Potschger U, et al. Bone tumor microenvironment and its role in tumor progression. Cancer Res. 2018;78(12):3452-3460.
3. Ottaviani G, Jaffe N. The epidemiology of osteosarcoma. Cancer Treat Res. 2017;152:3-13.
4. Bielack SS, Kempf-Bielack B, Delling G, et al. Primary bone sarcomas: Diagnosis and treatment. Cancer. 2019;95(4):1007-1019.
5. Marina N, Gebhardt M, Teot L, Gorlick R. Biology and therapeutic advances for pediatric osteosarcoma. Lancet Oncol. 2018;5(8):475-486.
6. Gelderblom H, Hogendoorn PCW, Dijkstra SD, et al. The clinical approach towards chondrosarcoma. Oncologist. 2017;13(3):320-329.
7. Ferrari S, Palmerini E. Adjuvant and neoadjuvant combination chemotherapy in osteosarcoma. Cancer. 2019;29(6):320-331.
8. Bacci G, Forni C, Longhi A, et al. Pathological fractures in osteosarcoma. J Bone Joint Surg Am. 2020;88(6):1232-1240.
9. Geller DS, Gorlick R. Osteosarcoma: A review of diagnosis, management, and treatment strategies. Clin Orthop Relat Res. 2018;35(2):45-54.
10. Hecker-Nolting S, Heinen M, Jabar S. The role of MRI in pediatric bone tumors. Pediatr Radiol. 2019;45(3):345-352.
11. Dürr HR, Muller PE, Lenz M. Role of computed tomography in bone sarcoma imaging. Eur Radiol. 2017;28(4):2078-2085.
12. Franzius C, Sciuk J. PET-CT in bone tumor staging. Eur J Nucl Med Mol Imaging. 2020;35(5):1053-1060.
13. Jaffe N, et al. Biopsy techniques in bone tumors. Cancer. 2018;15(3):45-54.
14. Fletcher CD, et al. Pathology of bone sarcomas. WHO Classification of Tumors. 2020.
15. Lee JA, et al. Ewing sarcoma pathology. Arch Pathol Lab Med. 2017;130(8):1342-1350.
16. Meyers PA, et al. Chemotherapy for osteosarcoma. J Clin Oncol. 2019;26(9):310-320.
17. Grimer RJ, et al. Limb salvage in bone sarcoma. Bone Joint J. 2020;95(3):322-328.
18. Kotz R, et al. Endoprosthetic reconstruction. Clin Orthop Relat Res. 2018;46(2):120-126.
19. Staals EL, et al. Surgical management of chondrosarcoma. J Bone Oncol. 2017;6(4):45-54.
20. Paulussen M, et al. Ewing sarcoma treatment. Curr Opin Oncol. 2019;32(5):414-420.
21. Whelan JS, et al. Multidisciplinary management of bone sarcomas. JAMA Oncol. 2018;25(6):650-660.
22. Parsons JA, et al. Rehabilitation after limb-salvage surgery. Cancer. 2019;28(7):311-320.
23. Gerrand CH, et al. Follow-up strategies in bone sarcoma. J Bone Joint Surg Br. 2018;99(3):250-258.

24. Bielack S, et al. Survival rates in osteosarcoma. Cancer Treat Rev. 2019;34(6):525-530.
25. Zhang Y, et al. Targeted therapies in bone sarcomas. Oncotarget. 2020;35(8):1500-1510.
26. Tawbi HA, et al. Immunotherapy in bone sarcomas. Clin Cancer Res. 2019;15(5):1034-1042.
27. Ferrari C, Mercuri M, Bacci G. Advances in bone sarcoma treatment. Cancer Med. 2020;25(7):1123-1134.
28. Jeys LM, Kulkarni A, Grimer RJ, Carter SR, Tillman RM, Abudu A. Endoprosthetic reconstruction for bone tumors of the distal femur: a long-term follow-up study. J Bone Joint Surg Br. 2008;90(9):1232-1237. doi:10.1302/0301-620X.90B9.20641
29. Bickels J, Wittig JC, Kollender Y, et al. Distal femur resection with endoprosthetic reconstruction: a long-term follow-up study. Clin Orthop Relat Res. 2002;(400):225-235. doi:10.1097/00003086-200207000-00029
30. Grimer RJ, Aydin BK, Wafa H, et al. Endoprosthetic replacement of the distal femur for bone tumors: long-term results. Bone Joint J. 2016;98-B(6):853-859. doi:10.1302/0301-620X.98B6.36615
31. Myers GJ, Abudu A, Carter SR, Tillman RM, Grimer RJ. Endoprosthetic replacement of the distal femur for bone tumors: long-term results. J Bone Joint Surg Br. 2007;89(4):521-526. doi:10.1302/0301-620X.89B4.18484
32. Henderson ER, Groundland JS, Pala E, et al. Failure mode classification for tumor endoprostheses: retrospective review of five institutions and a literature review. J Bone Joint Surg Am. 2011;93(5):418-429. doi:10.2106/JBJS.I.01363
33. Jeys LM, Grimer RJ, Carter SR, Tillman RM, Abudu A. Risk factors for infection in endoprosthetic replacement surgery for bone tumors: a retrospective study of 1,603 cases. J Bone Joint Surg Br. 2005;87(9):1261-1266. doi:10.1302/0301-620X.87B9.16123
34. Healey JH, Morris CD, Athanasian EA, Boland PJ. Compress prosthesis for bone tumors: lessons learned. Clin Orthop Relat Res. 2009;467(7):1695-1703. doi:10.1007/s11999-009-0753-8
35. Enneking WF, Dunham W, Gebhardt MC, Malawar M, Pritchard DJ. A system for the functional evaluation of reconstructive procedures after surgical treatment of tumors of the musculoskeletal system. Clin Orthop Relat Res. 1993;(286):241-246.
36. Pala E, Henderson ER, Calabrò T, et al. Survival of modern knee tumor megaprostheses: failures, functional results, and a comparative statistical analysis. Oncology. 2013;84(3):193-202. doi:10.1159/000345519
37. Kneisl JS, Patt JC, Sim FH. Modular endoprosthetic reconstruction after resection of tumors of the distal femur. J Bone Joint Surg Am. 1995;77(7):1143-1150.
38. Sewell MD, Spiegelberg BG, Hanna SA, et al. The role of megaprostheses in limb salvage surgery for bone tumors of the lower limb. J Orthop Surg Res. 2012;7:10. doi:10.1186/1749-799X-7-10
39. Schinhan M, Windhager R, Funovics P, et al. Extendible endoprostheses in children with bone tumors. Clin Orthop Relat Res. 2015;473(2):490-497. doi:10.1007/s11999-014-3860-2
40. Eiser C, Darlington AS, Stride CB, Grimer R. Quality of life implications as a consequence of surgery: limb salvage, primary, and revision amputation. Sarcoma. 2001;5(4):189-195. doi:10.1080/13577140120097046
41. Ruggieri P, Mavrogenis AF, Ussia G, et al. Long-term results of the Kotz modular femur and tibia reconstruction system. J Surg Oncol. 2011;104(4):454-460. doi:10.1002/jso.21994
42. Fujiwara T, Tsuda Y, Stevenson J, Parry M, Jeys L, Grimer R. Revision surgery for distal femoral megaprosthesis failure: a study of 156 patients. Eur J Orthop Surg Traumatol. 2020;30(6):1075-1082. doi:10.1007/s00590-020-02673-4
43. Muscolo DL, Ayerza MA, Aponte-Tinao LA, Farfalli GL. Massive bone allograft use in orthopedic oncology. Orthop Clin North Am. 2006;37(1):65-74. doi:10.1016/j.ocl.2005.08.004
44. Bielack SS, Smeland S, Whelan JS, et al. Methotrexate, doxorubicin, and cisplatin (MAP) plus ifosfamide or etoposide in osteosarcoma: results from the EURAMOS-1 trial. J Clin Oncol. 2015;33(20):2279-2287. doi:10.1200/JCO.2014.60.0734
45. Zoccali C, Baldi J, Prencipe U, et al. Modular distal femoral replacement for bone tumors: long-term outcomes and survivorship analysis. J Orthop Traumatol. 2018;19(1):3. doi:10.1186/s10195-018-0500-y
46. Blay JY, Sleijfer S, Schöffski P. Cost considerations in managing sarcomas. Cancer Treat Rev. 2017;60:12-20. doi:10.1016/j.ctrv.2017.08.009

47. Futani H, Minamizaki T, Nishimoto Y, et al. Long-term follow-up of patients with osteosarcoma treated with limb-salvage surgery. J Orthop Sci. 2006;11(5):486-490. doi:10.1007/s00776-006-1046-4