RESEARCH ARTICLE

Knee Hemiarthroplasty as a Reconstructive Option for Distal Femoral Sarcoma in Skeletally Immature Patients: Mid-Term Outcomes

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Abstract

Objectives: Limb-salvage procedures in pediatric patients with malignant bone tumors around the knee are surgically challenging due to the need for skeletal growth preservation and long-term functional demands. Hemiarthroplasty has emerged as a potential solution when other reconstruction options are limited or unfeasible.

Methods: We present a retrospective case series of three skeletally immature patients (ages 5-7) with high-grade malignant tumors of the distal femur. All underwent wide tumor resection followed by reconstruction using a hemiarthroplasty. Functional outcomes were assessed using the Enneking scoring system. Follow-up ranged from 3 to 5 years.

Results: All patients achieved limb preservation with good early functional recovery. The mean Enneking functional score was 23/30 (range, 21-25). Two patients remain disease-free with stable implants at the latest follow-up. One patient experienced pulmonary relapse and died 4 years after surgery. No local recurrences or mechanical implant failures were observed.

Conclusion: Hemiarthroplasty is a viable and cost-effective reconstructive option in pediatric patients with distal femoral sarcoma, particularly in settings where expandable endoprostheses are unavailable or contraindicated. Mid-term outcomes demonstrate acceptable oncologic safety and functional results. Larger studies are needed to validate its role as a standard reconstructive technique.

Level of evidence: IV

Keywords: Distal femur; Enneking score; Hemiarthroplasty; Limb salvage; Pediatric bone tumors; Reconstruction

Introduction

Malignant bone tumors such as osteosarcoma and Ewing sarcoma most commonly affect the distal femur in children and adolescents. Advances in chemotherapy and surgical techniques have made limb-sparing surgery the standard approach, significantly improving functional outcomes and quality of life compared with amputation.[1,2]

In childhood, approximately 6% of malignancies are primary malignant bone tumors. Within this group, the distal femur is the most common site, with osteosarcoma being the most frequent, followed by Ewing sarcoma. Management should be centralized in multidisciplinary sarcoma centers, and treatment decisions must be evaluated by a Multidisciplinary Tumor Board (MDTB).[3]

In skeletally immature patients, reconstruction remains complex due to open physes, small bone dimensions, and

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the need to accommodate future growth. These factors limit the availability and suitability of standard implants and can lead to growth-related deformities when the physis must be sacrificed—for example, small diaphyseal segments in very young children may be too short or narrow to accommodate standard modular or expandable prostheses.[4,5]

Given that the distal femoral and proximal tibial physes are the most active around the knee, their loss implies a substantial and often disabling leg-length discrepancy (LLD), which must be considered when planning oncologic resection and reconstruction. Children with lower-limb malignant neoplasms are therefore at particular risk of LLD after limb-sparing surgery.[6-10]

Surgical options include rotationplasty, amputation, expandable endoprostheses, custom-made hemiarthroplasty, and osteoarticular allografts. Among these, hemiarthroplasty offers immediate structural stability and allows early mobilization. By preserving one of the knee physes, LLD may be reduced compared with other limb-sparing strategies. The concept of custom-made hemiarthroplasty arises as an alternative after wide resections adjacent to the joint, respecting the unaffected physis and thereby allowing continued growth.[11-24]

Therefore, the purpose of this study is to evaluate the outcomes of distal femoral hemiarthroplasty in skeletally immature patients with malignant tumors, focusing on oncologic safety and functional results. Oncologic safety refers to achieving wide histologically negative margins.

Materials and Methods

Patients and Inclusion Criteria

Eligible patients included were considered those with primary malignant bone tumors of the distal femur, with more than 5 cm of residual growth remaining in the distal femur and proximal tibia. Cases in which a total knee prosthesis would have damaged the proximal tibial physis—thereby compromising or limiting future reconstructive options—were considered suitable candidates for distal femur hemiarthroplasty.

This retrospective study includes three skeletally immature patients (ages 5–7) treated between 2017 and 2021 at a tertiary referral bone oncology center. All had high-grade sarcomas of the distal femur (two osteosarcomas and one Ewing sarcoma) and underwent wide resection followed by hemiarthroplasty. Informed consent was obtained for surgical treatment and clinical documentation.

The therapeutic strategy for bone reconstruction after extensive tumor resection of the distal femur was guided by two main goals: (1) to preserve the contralateral growth plate, including the proximal tibial physis, and (2) to maintain knee joint mobility. Preserving the proximal tibial growth plate to minimize leg-length discrepancy (LLD) and maintaining joint motion restricted the reconstruction options to two joint-preserving procedures—osteoarticular allograft or hemiarthroplasty.

However, in very young patients, matching the host bone with an osteoarticular allograft of appropriate size is technically challenging, and suitable grafts that provide perfect articular congruence are rarely available. For this reason, a custom-made hemiarthroplasty was selected in each case, ensuring optimal articular matching, stable fixation, and early mobilization.

Consequently, hemiarthroplasty was indicated when other reconstructive methods—such as expandable prostheses or osteoarticular allografts—were technically unfeasible due to the patients' age, small bone size, and limited availability of size-compatible grafts. Given the satisfactory clinical and functional results observed in these cases, we consider hemiarthroplasty a viable reconstructive option, particularly when other methods are limited or technically unfeasible.

This approach may offer several potential advantages over alternative reconstructions. By preserving the proximal tibial physis, it helps reduce the risk of iatrogenic growth disturbance and limits future limb-length discrepancy. Furthermore, hemiarthroplasty involves a shorter operative time compared with biological reconstructions or expandable prostheses, which could potentially lower the risk of infection and allow for earlier mobilization. These are, however, theoretical benefits that have not been specifically assessed in the present study.

Surgical Technique

All procedures were performed under general anesthesia. A wide resection with adequate oncologic margins was achieved based on magnetic resonance imaging (MRI) and intraoperative findings. Preoperative planning of oncologic margins was performed using contrast-enhanced MRI of the entire femur after completion of neoadjuvant chemotherapy, in accordance with institutional and international sarcoma protocols.

During surgery, margins were carefully assessed through intraoperative frozen sections obtained from the host medullary canal, combined with direct macroscopic inspection of the resected specimen. The excised bone was personally transported by the surgeon to the musculoskeletal pathology unit, where the specimen was oriented, sectioned, and together examined by both the pathologist and surgeon to verify macroscopic margins and proper orientation before definitive histological processing.

After tumor removal, reconstruction of the femoral defect was achieved using a custom, uncemented hemiarthroplasty stem in Cases 1 and 3 and cemented hemiarthroplasty stems in case 2, with the distal femoral surface articulating directly against the native proximal tibial cartilage. The soft-tissue reconstruction strategy prioritized anatomic reattachment of the quadriceps mechanism and stabilization of the knee capsule to restore joint balance and mobility. In each case, ligamentous structures were reconstructed when necessary to improve anteroposterior and varus–valgus stability, following previously described techniques.

During the first case performed without ligament reconstruction, anterior–posterior instability was identified as the main limiting factor for functional recovery, with marked anterior drawer laxity affecting patient comfort and gait. Based on this observation, anterior cruciate ligament (ACL) reconstruction was incorporated in subsequent cases as the primary stabilizing procedure. At the time, this represented the first experience using ligament reconstruction in conjunction with distal femur hemiarthroplasty in our institution. The quadriceps mechanism, as well as the hamstring and biceps tendons, were preserved during surgery. Combined with the anterior cruciate ligament reconstruction, this preservation provided a stable knee with only mild varus and valgus laxity. Given the satisfactory stability achieved with ACL reconstruction and the preserved soft-tissue envelope, additional varus–valgus reconstruction was not initially performed. However, in future cases, the reconstruction of collateral ligaments is being considered to further enhance mediolateral stability and optimize overall knee kinematics.

Postoperative Care and Follow-Up

Patients underwent early mobilization with partial weight-bearing. Drains were removed within 48 hours. Follow-up included serial radiographs, oncologic surveillance, and functional assessment using the MSTS/Enneking system. Imaging was reviewed for local recurrence, implant loosening or joint degeneration.

The general principles of rehabilitation were based on individual factors such as soft-tissue healing and oncologic status, under close coordination between orthopedic oncologists, physiotherapists, and rehabilitation specialists.

Phase I (Weeks 0–4): Immediate postoperative period focused on pain and edema control, maintaining mobility in unaffected joints. Patients were instructed to use crutches with touch or non-weight-bearing; a hinged knee brace was locked at 0–30°.

Phase II (Weeks 4–8): Early recovery with progressive weight-bearing and active-assisted range of motion between 30° and 60°, targeting 0–90° by 12 weeks. Knee brace was retired at 6 weeks.

Phase III (Months 2–6): Neuromuscular strengthening phase to normalize gait, improve strength and proprioception, and achieve full weight-bearing.

Results

Case 1

A 5-year-old girl was referred with progressive right thigh pain over one month. Initial symptoms included resting and nocturnal pain with limping. On examination there was quadriceps atrophy, swelling, and increased local temperature in the right thigh. Anteroposterior and lateral radiographs revealed an expansive osteoblastic lesion in the distal femoral metaphysis with cortical thinning and periosteal reaction. MRI demonstrated a T1-hypointense, heterogeneously T2-hyperintense metaphyseal lesion with cortical rupture and a substantial extraosseous soft-tissue component. [Figs. 1(a) and 1 (b)]. Computed tomography (CT)-guided core needle biopsy confirmed high-grade conventional osteosarcoma. The MDTB recommended neoadjuvant chemotherapy. Post-chemotherapy restaging showed no metastatic disease. Limb-salvage surgery with wide intraarticular distal femoral resection and custom, uncemented hemiarthroplasty MUTARS® (Modular Universal Tumor and Revision System, Implantcast, Buxtehude, Germany) distal femur hemiarthroplasty was **planned [Fig. 1 (c)].**

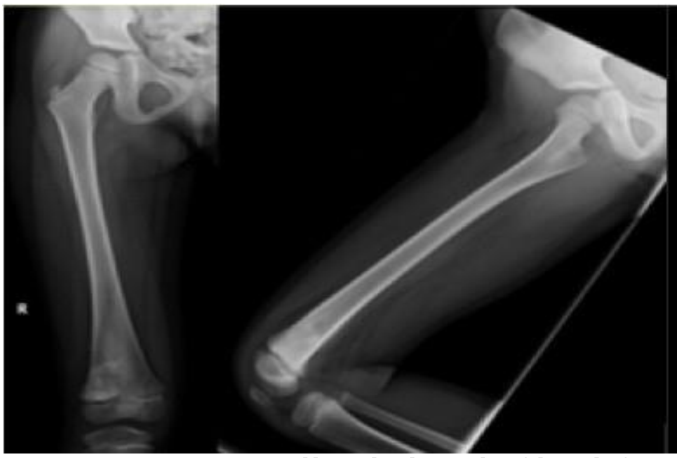

Figure 1A. Anteroposterior and lateral radiographs of the right femur showing an expansive osteoblastic lesion in the distal metaphysis with cortical thinning and periosteal elevation

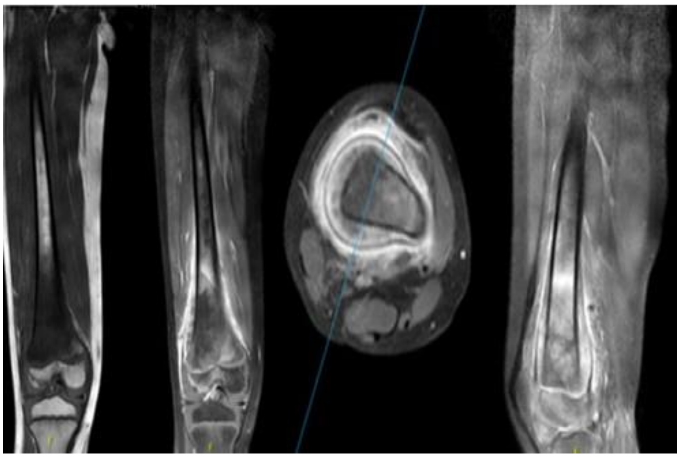

Figure 1B. Magnetic resonance imaging (MRI) showing a metaphyseal lesion with low T1 signal and high T2 signal associated with a soft-tissue mass

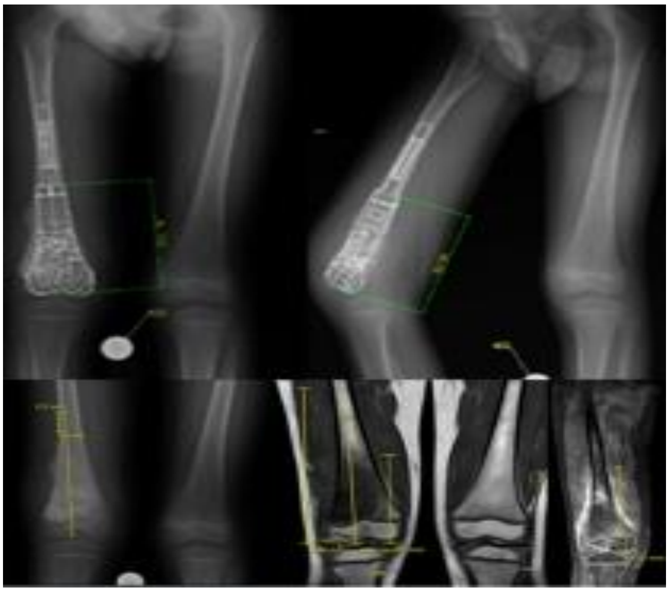

Figure 1C. Preoperative surgical planning

Surgery consisted of wide intra-articular resection and reconstruction with a custom, uncemented MUTARS® distal femur hemiarthroplasty, as mentioned above. Ligamentous reconstruction was performed using tendon allograft, including anterior cruciate ligament (ACL) reconstruction via an over-the-top technique. This approach followed prior experience in which the absence of ligament reconstruction led to instability and chronic pain that later improved with orthotic management. Histopathology confirmed high-grade osteosarcoma with epiphyseal extension and 70% tumor necrosis after chemotherapy. Postoperative orthopedic management included 8 weeks of non-weight-bearing and a removable knee orthosis. Continuing adjuvant chemotherapy. Surveillance included quarterly radiographs, periprosthetic ultrasound, and chest CT [Fig.1 (d)].

Figure 1D. Follow-up radiograph at 3 months showing stable implant positioning

At 4 months, pulmonary metastases were detected and surgically excised. By 1 year, the patient had resumed dancing and skating, with knee range of motion (ROM) of 0°-120° and only mild anteroposterior and varus-valgus instability. A 1.8-cm LLD was corrected with a 1.5-cm shoe lift. At 2 years, recurrent pulmonary metastases were observed, and a new proximal tibial osteosarcoma developed in the contralateral limb. The patient died 3 years postoperatively. Her MSTS score prior to relapse was 23/30.

Case 2

A 6-year-old previously healthy girl presented with a 15-day history of intermittent left knee pain radiating to the foot. She was afebrile and ambulatory. Examination revealed mild valgus alignment and a 2-cm leg-length discrepancy (left shorter). A firm, non-mobile mass was palpable at the distal femur. Knee motion was preserved without instability.

Radiographs revealed an ill-defined osteolytic lesion in the distal femoral metaphysis with a wide transition zone and periosteal reaction forming a Codman triangle; a soft-tissue component was suspected. Chest CT identified three pulmonary nodules (≤3 mm), suggestive of metastatic disease. Bone scintigraphy demonstrated increased tracer uptake in the distal femoral condyles without additional skeletal involvement.

MRI showed a large metaphyseal intramedullary lesion with cortical destruction and soft-tissue extension. The lesion was T1-hypointense and heterogeneously T2-hyperintense with extra-compartmental spread and popliteal vessel displacement. No skip lesions were identified [Fig. 2(a)].

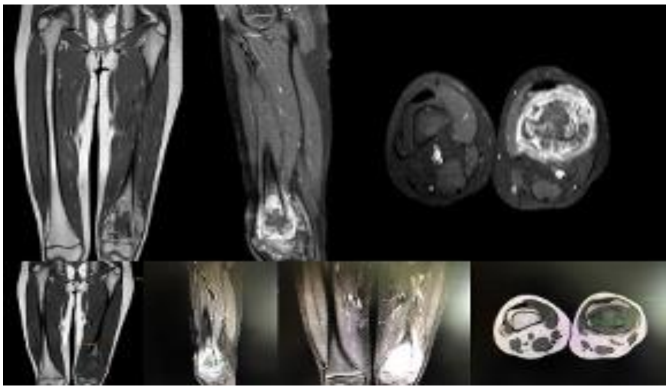

Figure 2A. Magnetic resonance imaging [MRI (T1 and T2)] showing a large metaphyseal lesion with cortical destruction and a 67-mm soft-tissue mass displacing neurovascular structures

CT-guided core needle biopsy confirmed conventional osteosarcoma of the distal femur. The MDTB indicated neoadjuvant chemotherapy. Post-treatment imaging showed partial response: one pulmonary nodule calcified, one decreased in size, and one resolved; tumor volume also decreased on MRI to reduced tumor size (7 × 5 × 5 cm) and decreased soft-tissue involvement.

Wide intraarticular tumoral resection of the distal femur with a 12-cm osteotomy and reconstruction using a custom cemented Impol® distal femur hemiarthroplasty was planned.

Surgery involved resection of the distal 12 cm of the femur followed by reconstruction with a custom distal femur hemiarthroplasty and tendon allograft for ligamentous stabilization [Fig. 2 (b)].

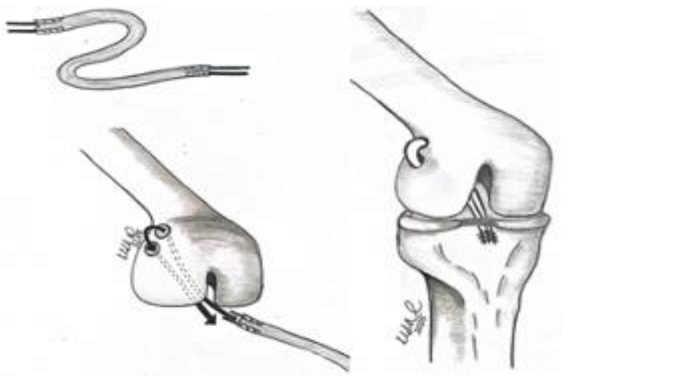

Figure 2B. Ligamentoplasty for anteroposterior stabilization. To address future leg-length discrepancy (LLD), contralateral distal femoral epiphysiodesis was performed with 8-plates

Histopathology confirmed conventional fibroblastic and osteoblastic osteosarcoma (Broders´ grade 3) with epiphyseal extension and 98.5% tumor necrosis; no lymphovascular invasion was identified. The patient completed 28 weeks of adjuvant chemotherapy. On follow-up, a single calcified pulmonary nodule remained stable over 4 years. Functionally, she maintained excellent knee performance, including sports and dance; examination showed 0°-130° active motion with mild anteroposterior laxity without functional impairment. At 3 years, radiographs showed no loosening; long-leg standing films and chest CT remained stable [Figs. 2 (c) and (d)]. At the 4-year follow-up, the patient presented an approximate limb-length discrepancy of 3 cm between the operated and contralateral limbs, consistent with expected growth loss after distal femoral physeal resection, and no local recurrence.

Figure 2C. Three-year follow-up radiograph showing a stable prosthesis without evidence of loosening

Figure 2D. Clinical image showing active knee range of motion of 0°-130°

Case 3

A 7-year-old girl presented with progressive left knee pain for 2 months, associated with nocturnal pain and functional limitation. Clinical examination revealed mild effusion, anterior knee tenderness, and quadriceps hypotrophy. ROM was preserved, and gait was independent. Plain radiographs showed a metaphyseal lesion in the distal femur with cortical destruction, a wide transition zone, and periosteal reaction. MRI demonstrated a T1-hypointense, heterogeneously T2-hyperintense lesion extending into the soft tissues without clear physeal involvement.

CT-guided core needle biopsy confirmed conventional osteosarcoma. The MDTB initiated neoadjuvant chemotherapy. Post-chemotherapy evaluation demonstrated a good radiologic response with no metastatic disease.

Surgical planning included wide intra-articular distal femur tumor resection, sparing the proximal tibia, and reconstruction with a custom, uncemented distal femur hemiarthroplasty (Prospon®) incorporating a manual lengthening mechanism designed to compensate for potential leg-length discrepancy through minor procedures during growth. This was the only case in which an expandable prosthesis was used, unlike Cases 1 and 2, which employed non-expandable hemiarthroplasties. Based on MRI, expected limb growth was 27 cm for the affected extremity, with an anticipated distal femoral physeal contribution of approximately 8.5 cm **[Fig. 3(a)].** Histopathology confirmed high-grade conventional osteosarcoma with 100% tumor necrosis and wide surgical margins.

Figure 3A. Immediate postoperative image showing symmetrical alignment after reconstruction with a custom, uncemented distal femur growing hemiarthroplasty

Rehabilitation included 8 weeks of protected weight-bearing with a knee orthosis, followed by progressive mobilization and strengthening. Adjuvant chemotherapy was completed without complications. At 12 months, the patient was pain-free with symmetrical alignment and no functional limitations; she resumed sports and school activities. Clinical evaluation showed full extension and 130° of active flexion without instability or effusion.

During follow-up, 3 years after prosthesis implantation, an attempt was made to manually lengthen the prosthesis by 3 cm. However, the expansion procedure resulted in excessive soft-tissue tension, compromising knee stability, and the lengthening was discontinued. Less than 1 cm of elongation was ultimately achieved. To compensate for the resulting limb-length discrepancy, a contralateral distal femoral epiphysiodesis was performed, which partially restored symmetry at follow-up.

At the 4-year latest follow-up, the patient presented with a residual limb-length discrepancy of approximately 4 cm between the operated and contralateral limbs. There was no local recurrence or metastasis, and radiographs confirmed stable implant positioning without loosening or mechanical complications [Fig. 3 (b, c)]. This case highlighted the technical limitations of current manual expansion systems, emphasizing the need for further design improvements to enhance both reliability and knee stability during future applications.

Figure 3B. Lower limb weight-bearing radiograph prior to lengthening

Figure 3C. Lower limb weight-bearing radiograph after attempted failed lengthening only achieving less than 1 cm of length

Discussion

In 2024 Malek et al analyzed 95 pediatric patients with limping referred to their rheumatology department. They found that benign and malignant bone tumors, including osteoid osteoma, osteosarcoma, and Ewing sarcoma, contributed to limping in 4.2% of pediatric patients.[25]

Limb-salvage surgery in growing children presents unique challenges, requiring meticulous planning to achieve oncologic control while maintaining long-term structural integrity and limb-length equality. Unlike adults, pediatric patients have open physes and ongoing skeletal development; surgeons must therefore consider long-term implications for limb growth, joint function, and implant durability.

Prediction of LLD at maturity is critical during planning; in our practice, we reference the method described by Paley et al.[15] Reconstruction options—expandable prostheses, biological reconstructions, and epiphyseal-sparing techniques—must be weighed according to age, tumor location, expected growth, and prognosis. The goal is to enable an active lifestyle while minimizing the need for multiple future interventions.

Techniques have evolved from amputation and rotationplasty to limb-salvage with biological reconstruction (allograft, vascularized fibula) or endoprosthesis (fixed or expandable). Each approach carries specific risks and must be individualized. Because two-thirds of lower-limb growth derives from the distal femur and proximal tibia, any disruption of the growth plate can lead to major LLD in skeletally immature children.[9] Oncologic requirements frequently mandate wide resections that include the joint, via intraarticular or extraarticular techniques.

When planning resection for distal femoral sarcoma in children, factors to consider include remaining growth potential, age, the possibility of epiphyseal preservation, longevity of the reconstruction, the child's overall prognosis, and the size and extent of bone involvement. In skeletally immature patients, preserving the tibial growth plate is recommended to minimize LLD. A staged or bridging strategy may be used to ensure oncologic safety, with conversion to total knee replacement once skeletal maturity is reached and the disease is controlled.

Hemiarthroplasty is sparsely described in the literature. Conceptually similar to osteoarticular allograft reconstruction in replacing the resected joint segment, it relies on a prosthetic implant rather than biological incorporation and can act as an internal spacer until growth is complete and oncologic control is established. Reports describe the use of synthetic devices designed as temporary hemiarthroplasties in children with osteosarcoma around the knee.[15]

Imanishi et al. described a temporary spacer using an intramedullary nail and molded polymethylmethacrylate, though dislocation was a concern.[11] Our prosthetic design permits anterior ligamentoplasty to mitigate dislocation and restore anteroposterior stability. Valgus alignment of the distal femur was also incorporated with the design engineer to reflect the normal alignment of the growing skeleton.

Reconstruction using a polyethylene-on-bone hemiarthroplasty system, which allows a satisfactory and reliable functional outcome while preserving the knee joint described by Manfrini, et al., appears to be a viable option for the treatment of sarcoma around the knee joint in children, however the technique was described for proximal tibia.

In our cases, rotationplasty could have been a viable reconstructive option, but this surgical indication is not always optimal, since it is not emotionally accepted by some patients and parents, a situation that happened in our cases. Therefore, it was ruled out as a reconstructive option.

Alternatively, reconstruction with an osteoarticular allograft after resection of the distal femur is probably the most accepted indication. Although in our cases it was not possible to obtain an allograft that fit perfectly to the femoral shaft (cortical-cortical junction) or that was not perfectly congruent with the proximal tibia.

In 2017 Jamshidi et al. stated that there was no consensus concerning the best technique of reconstruction in pediatric population after the wide resection of malignant bone tumors.[24] In their study, long-run results and adverse events of osteoarticular allograft reconstruction of primary distal femoral bone sarcomas in 22 children with mean age of 10.7 years old were analyzed. With a mean follow-up time of 6.7 years, the results of 16 children with allografts at the final follow-up were assessed. As expected, LLD was found in all patients (mean LLD = 2.73cm), which was significantly correlated to allograft survival time ($p < 0.001$). Degenerative joint disease (DJD) was also observed in all children and its grade was also significantly correlated to allograft survival time ($p < 0.001$). The mean MSTS-score was 74% at the latest follow-up, ranging from 60% to 90%. The survival rate of allografts was 93.3% at 5 years and 62.2% at 10 years. It was concluded that osteoarticular allograft reconstruction was a long-enduring but still a transient solution prior to carrying out megaprosthesis. This permitted children to maintain their remaining physis for limb growth and become old enough for an adult megaprosthesis.[24]

Reconstruction with a conventional tumor prosthesis was neither feasible nor realistic due to the narrow intramedullary diameter of the recipient femur in these very young patients and similarly to the osteoarticular allograft, congruence with the small tibial plateau is not possible with the conventional tumor prosthesis.

It's worth stating that, compared to the custom-made prosthesis, the intramedullary diameter of the femur could be adjusted, although it remains very thin, which was practically not an ideal option. The volume of the femoral metaphyseal module could also be adjusted, but the narrow diameter of the femur remained a significant problem. Additionally, the proximal tibia would have to be resected in its articular portion, and the proximal tibial growth plate would also be invaded with the tibial, with an uncertain outcome, despite a very narrow tibial stem.

In the final decision, reconstruction with an osteoarticular allograft or hemiarthroplasty was considered. A composite allograft and prosthesis, as demonstrated by Manfrini et al.[20] However, we did not consider this option, as we sought to avoid increasing the risk of complications both from the allograft and prosthesis at the same time.

From a functional standpoint, maintaining the integrity of the tibial physis and cruciate ligaments contributes to a more physiological knee kinematic pattern and improved proprioception. The preservation of the quadriceps mechanism and hamstring-biceps complex, combined with anterior cruciate ligament reconstruction, resulted in satisfactory stability with only mild varus–valgus laxity. This configuration may promote long-term joint balance and facilitate later conversion to total knee arthroplasty if required.

Mid-term outcomes in our series demonstrate that distal femur hemiarthroplasty can provide durable fixation and excellent function in skeletally immature patients. Residual LLD, as expected from the loss of distal femoral growth, ranged between 3 and 4 cm at four years but was clinically well tolerated and compensated with contralateral epiphysiodesis or orthotic correction. Importantly, no mechanical failure or local recurrence was observed, and all patients maintained high functional scores and return to daily and recreational activities.

Despite its advantages, hemiarthroplasty remains a technically demanding procedure reserved for selected cases where other reconstructive methods are unfeasible due to size limitations or growth potential. Long-term follow-up into skeletal maturity will be necessary to assess prosthetic wear, tibial cartilage degeneration, and the feasibility of conversion to total knee arthroplasty.

Study limitations include the small sample size, inherent to the rarity of such tumors in early childhood, and the relatively short follow-up, which limits long-term conclusions about prosthetic longevity and growth-related alignment changes. Nevertheless, this case series demonstrates the feasibility, safety, and functionality of hemiarthroplasty in very young patients. Strengths of this study include the detailed radiographic and functional follow-up, the multidisciplinary approach, and the inclusion of three consecutive cases treated with consistent surgical principles.

Conclusion

Hemiarthroplasty is a functional and reliable reconstructive option following resection of malignant bone tumors around the knee in skeletally immature patients. By preserving an uninvolved physis, it may reduce subsequent leg-length discrepancy and support favorable functional outcomes.

As demonstrated by our three cases, hemiarthroplasty can serve either as a definitive or temporary solution until skeletal maturity, when conversion to definitive arthroplasty may be indicated. Although long-term growth-related behavior of hemiarthroplasty remains uncertain, early and mid-term results are encouraging, allowing patients to resume physically demanding activities.

In very young patients—such as those presented in this study—the narrow intramedullary canal of the femur limits the use of standard modular or expandable prostheses. In these cases, custom hemiarthroplasty represents a practical and safe alternative that minimizes limb-length discrepancy, preserves joint motion, and provides a bridge to future reconstruction once skeletal maturity and oncologic control are achieved.

Ultimately, hemiarthroplasty should be considered a temporary, growth-compatible spacer that not only maintains limb function during ongoing development but also facilitates future reconstructive surgery, adding valuable functional years to the patient's overall limb preservation timeline.

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Authors Contribution:

Author who conceived and designed the analysis: MJ M-Q, DJ M-G, IE B-S, JC-B, EJ O -C, EC R-M; Author who collected the data: MJ M-Q, DJ M-G, IE B-S, JC-B, EJ O -C, EC R-M; Author who contributed data or analysis tools: MJ M-Q, DJ M-G, IE B-S, JC-B, EJ O -C, EC R-M; Author who performed the analysis: MJ M-Q, DJ M-G, IE B-S, JC-B, EJ O -C, EC R-M; Author who wrote the paper: MJ M-Q, DJ M-G, IE B-S, JC-B, EJ O -C, EC R-M

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Declaration of Informed Consent: The authors declare that there is no information (names, initials, hospital identification numbers, or photographs) in the submitted manuscript that can be used to identify patients.

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