ORIGINAL ARTICLE

A NEW APPROACH TO PARTIALKNEE ENDOPROSTHESIS IN PRIMARY BONE SARCOMAS

Valter Penna[1],
Eduardo Areas Toller[2],
Carla Pinheiro[3],
Ricardo Gehrke Becker[4]

ABSTRACT

Objective: Partial knee endoprosthesis to bone sarcomas resections seems to be a good solution to treat this immature skeletal patients. The purpose of this study is to evaluate the functional score in fourteen patients, advantages and the technique indications. Methods: Retrospective analysis was done to assess in this group of patients the functional evolution and the possible complications of the procedure. 14 patients between 10 and 22 years functionally evaluated in Ennekin/ISOLS (International Society of Limb Salvage) criteria, being all of them operated in the same institution by the same surgeon. Were used distal femur and proximal tibia partial endoprosthesis. Results: General analysis demonstrated that the functional results were over than 67 percent (ISOLS criteria) in 78,6 percent of the patients, being considered excellent. 21,4 percent were considered good results, being between 50 and 66 percent. Bone storage was preserved when avoiding the adjacent segment resection. Surgery time was not prolonged in ligament reconstruction. Conclusion: Knee partial endoprosthesis are less damage to bone storage in young patients. The critics about the bad functional results are being supplied by new surgical techniques, excellent rehabilitation protocols, implants technology and the consequent learning curve. This option of treatment permits the preservation of healthy bone and provides the possibility of a revision replacement less aggressive.

Keywords – Knee; Sarcoma Ewing's; Osteosarcoma; Knee prosthesis; Retrospective studies

INTRODUCTION

The most common primary malignant bone tumors in childhood and adolescence are osteosarcoma and Ewing's sarcoma. The distal femur and the proximal tibia are two of the main sites of localization. These localizations often compromise the knee joint, requiring limb salvage surgery to replace segments with endoprostheses. Several models of endoprostheses are available for various indications in surgical resection of bone tumors of the knee(1). However, in cases where the tumor does not respect the limits of the growth cartilage, invading the epiphysis of the long bones of the knee joint without joint invasion, it is possible to indicate resection with partial replacement by endoprosthesis. This technique allows en bloc resection of the distal femur or proximal tibia, preserves the adjacent joint epiphysis, and the implant replaces only the affected segment of the femur or tibia.

The use of partial endoprostheses is limited to patients with tumors with the characteristics described above and in the skeletally immature age group between 10 to 16 years. Individuals aged between 17

1 – Specialist in Orthopedic Oncology, Chief of the Orthopedic Oncology Clinic, Hospital de Câncer de Barretos, SP.
2 – Orthopedist, Orthopedic Oncology Clinic, Hospital de Câncer de Barretos, SP.
3 – Resident Orthopedic Oncologist, Hospital de Câncer de Barretos, SP.
4 – Resident Orthopedic Oncologist, Hospital de Câncer de Barretos, SP.

Study completed at the Hospital de Câncer de Barretos, SP – Department of Orthopedic Oncology.
Correspondence: Rua Antenor Duarte Vilela, 1331 – Bairro Dr. Paulo Prata – CEP 14784-400 – Barretos, SP – Departamento de Ortopedia.
Email: ricardogbecker@hotmail.com / walter_penna@terra.com.br

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and 22 years also benefit from partial endoprostheses due to bone stock preservation and residual growth until near the age limit of 22 years[2]. Very young patients who have not yet started the second growth spurt and undergo replacement with an implant in the lower limbs will present discrepancies incompatible with the functionality of the lower extremity over the years. In our opinion, radical surgery (amputation) is more prudent in these cases. Yet in individuals who have completed growth, the benefits of preserving the epiphyseal region are much smaller, and total knee endoprosthesis is more suitable[3,4].

In the not too distant past, primary malignant bone tumor resection with an oncologic margin during childhood and adolescence was synonymous with limb amputation. The development of new surgical techniques, better hospital conditions, the introduction of neoadjuvant chemotherapy with well-defined protocols, the improvement of the types of implants and the surgical learning curve for orthopedic surgeons have provided more security and better quality of life for patients with these diseases[3,5-9].

The increase in disease-free survival and tumor cure for tumors such as Ewing's sarcoma and osteosarcoma brought concern for the life of the implant used[10]. In young patients, implants such as total knee endoprosthesis have the disadvantage of requiring resection or femoral/tibial osteotomy for fixation of the implant to the adjacent segment, and therefore the removal of the meta-epiphyseal area of growth. This implies a discrepancy in the growth of the lower extremities, decreased bone stock, and future complications for revision of the implant due to cementation and resection of bone not affected by the tumor.

In order to reduce complications such as those described and evaluate the functionality and characteristics of patients to this exceptional indication, we analyzed the cases where non-articulating partial knee implants were used (partial endoprostheses) in young patients, associated with ligament reconstruction in resections with oncological margins in the distal femur and proximal tibia.

METHODS

All patients were operated by the orthopedic oncology group of the Hospital de Câncer de Barretos, São Paulo. Fourteen patients aged between 10 and 22 years included in the Brazilian Osteosarcoma and Ewing protocols who underwent resection of the distal femur or proximal tibia due to primary bone tumors with replacement by non-articulating partial knee endoprosthesis and ligament reconstruction were evaluated retrospectively.

Surgical indication was based on morphological characteristics of the tumor in the knee, that is, tumors located in the distal femur or proximal tibia with invasion of the growth cartilage and epiphysis, but no joint involvement visible on MRI. The presence of lung metastases was not an exclusion criterion.

All cases were operated with oncological criteria in the period between February 2003 and February 2008 in the same institution and by the same surgeon. The 14 patients had free surgical margins on pathological examination.

The implants of choice were: non-articulating partial distal femoral endoprosthesis (IMPOL®) for tumors of the distal femur and non-articulating partial distal tibial endoprosthesis (IMPOL®) for cancers of the proximal tibia. The articular surface of the implant is made of a chromium-cobalt-molybdenum alloy, minimizing friction with the normal cartilage of the adjacent segment. The body of the endoprosthesis was made of ultra high molecular weight polyethylene and the femoral or tibial stem was made of titanium alloy. The fixation of the implant to the bone was made with radiopaque bone cement.

Functional evaluation was based on a score as proposed by Enneking et al.[11] The score is based on six variables (pain, function, emotional acceptance, use of support such as canes or crutches, walking, and running), with each assigned a maximum of 5 points. The total sum can be up to 30 points. The patient's number of points is then divided by the maximum value (30 points). The percentage is then expressed as follows: excellent (67%-100%), good (50%-66%) and poor (< 50%) according to at least six months postoperative follow-up. All patients were instructed to remain with a private instructor postoperatively for a period of 60 to 90 days without load-bearing and, afterwards, to follow a rehabilitation protocol for gaining range of motion, proprioception, and muscle strengthening included by the authors[12, 13].

Quantitative variables were described by mean ± standard deviation and qualitative variables by absolute and relative frequencies.

To evaluate possible associations between categorical variables the Fisher's exact test was used. The Student's t-test was used to compare means.

A 5% ($p \leq 0.05$) level of significance was adopted and analyses were performed using SPSS (Statistical Package for the Social Sciences) version 13.0.

In the 14 patients evaluated, the mean age was 13.5 ± 3.5 years. Regarding gender, 10 patients (71.4%) were female and four (28.6%) were male. In this group, osteosarcoma appeared in twelve of the patients (85.7%), while one (7.1%) belonged to the Ewing's sarcoma group, and one (7.1%) was diagnosed with malignant fibrous histiocytoma (treatment protocol equal to the osteosarcoma). Nine tumors (64.3%) were located in the distal femur and five (35.7%) were in the proximal tibia. Most patients (57.1%) were from the state of São Paulo. The study was approved by the Research Ethics Committee of the Hospital de Câncer de Barretos, Fundação Pio XII.

RESULTS

Data analysis showed that eleven patients (78.6%) had an excellent Enneking score, and three (21.4%) had good results. The presence of complications was low, and all resolved in the early postoperative period. Of the 14 patients, nine showed no arthroplasty complications; one had a superficial infection; one had joint instability with subluxation, probably due to very early removal of immobilization in the city of origin; three others developed complications such as pressure ulcers and patellar tendon rupture in the tibial prosthesis. Of the patients with a good score, 100% had postoperative complications ($p = 0.027$), so the complications during the course of treatment decreased the functionality of the knee (Chart 1).

The average time of immobilization was 9.76 ± 3.3 weeks (maximum of 16.4 and minimum of 3.8 weeks) and average patient follow-up period was 23.1 ± 15.8 months (maximum of 68.2 and minimum of 2.2 months). We found that the group with the longest time of immobilization had the best functional score ($p = 0.048$) (Chart 2).

We did not find a statistical correlation between the patients' age and functional score. Younger individuals did not have better knee function.

The location of the tumor in the proximal tibia or distal femur was not responsible for variations in the Enneking score with any statistical significance.

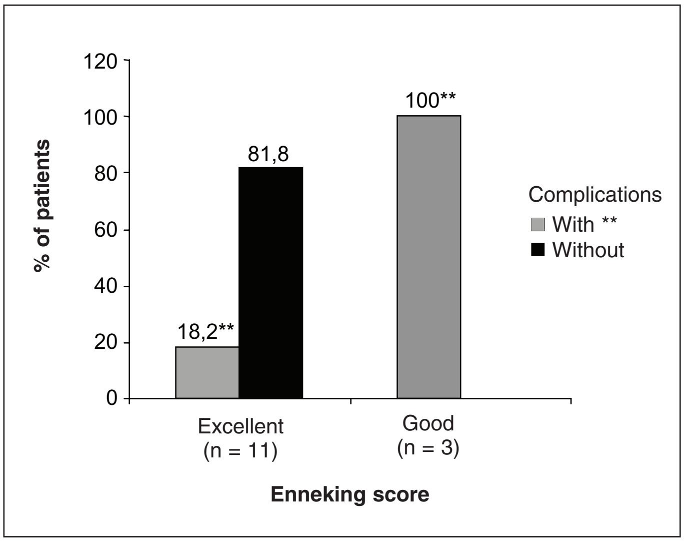

Chart 1 – Association between the Enneking score and the incidence of complications (p = 0.027).

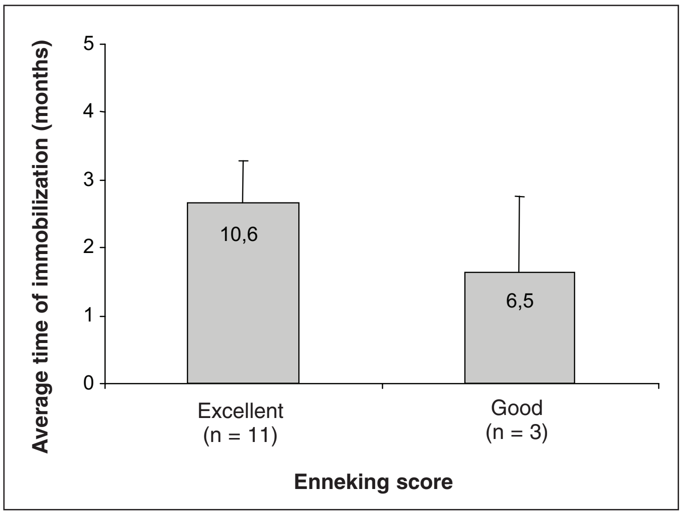

Chart 2 – Evaluation of the average time of immobilization according to the Enneking score (p = 0.048).

During patient follow-up, we identified eleven (78.6%) who are living and three (21.4%) who died due to disease progression (Table 1).

DISCUSSION

The introduction of neoadjuvant chemotherapy in the 1980s greatly increased the possibility of tumor resection with limb preservation. Over 80% of patients with osteosarcoma of the extremities become candidates for limb salvage surgery[3]. Limb salvage surgery for bulky primary bone tumors require large resection of the knee and create significant segmental defects that require some kind of replacement that preserves the functionality of the joint (Figures 1 and 2).

Table 1 – Sample characteristics.

Variables	n=14
Age (years) – Mean ± SD	13.5 ± 3.6
Gender – n (%)	
Male	4 (28.6)
Female	10 (71.4)
Type of tumor – n (%)	
Osteossarcoma	12 (85.7)
Ewing's sarcoma	1 (7.1)
MFH	1 (7.1)
Location of tumor – n (%)	
Femur	9 (64.3)
Proximal tibia	5 (35.7)
Enneking/ISOLS score – n (%)	
Excellent	11 (78.6)
Good	3 (21.4)
Complications – n (%)	
No complications	9 (64.3)
Infection	1 (7.1)
Instability	1 (7.1)
Other	3 (21.4)
Time of immobilization (weeks) – Mean ± SD	9.76 ± 3.3
Follow-up period (months) – Mean ± SD	23.1 ± 15.8
Current status – n (%)	
Living	11 (78.6)
Deceased	3 (21.4)

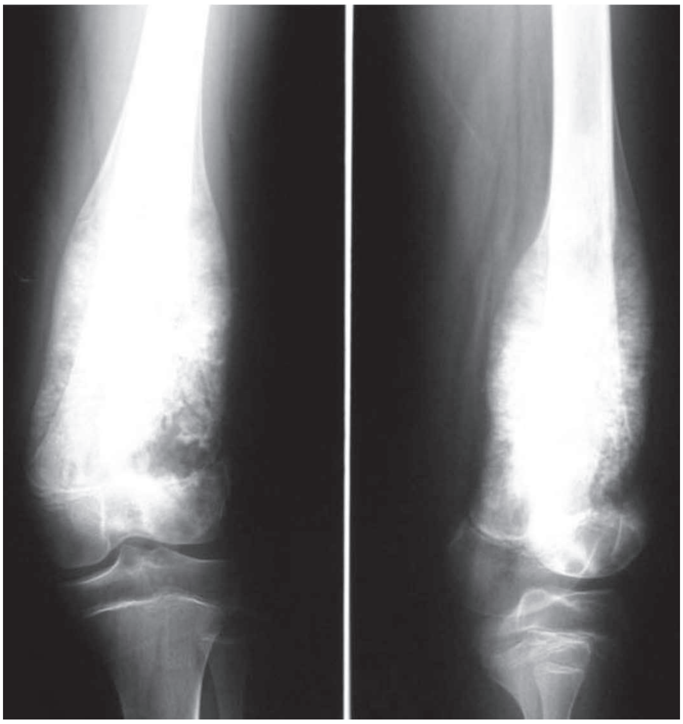

Figure 1 – X-ray of the knee.

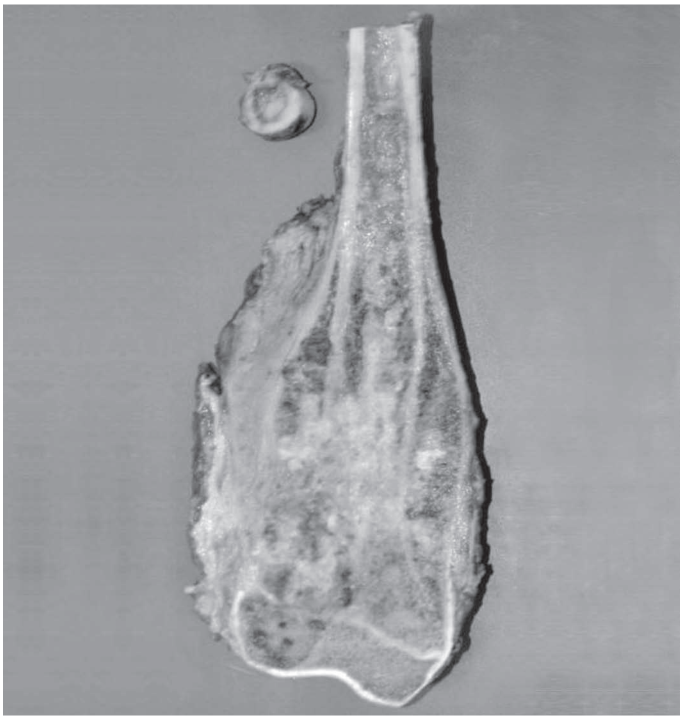

Figure 2 – Cut piece.

The replacement methods may vary greatly, and among them are biological options such as using free or vascularized grafts from the patient or other individuals (allograft). Other options include distal femoral and proximal tibial endoprostheses. Among the different endoprostheses available on the market are the hinged, rotatory, and those used for arthrodesis. Some use cement for femoral fixation and others are fixed by press-fit[4].

The indication for surgery for tumors located in the distal femur and proximal tibia depends on the anatomical relationship of the tumor with the structures that are part of the normal knee. Tumors invading the knee joint make the patient a candidate for extra-articular resection with or without arthrodesis, and consequently, partial or total functional restriction. Neoplasias that do not invade the joint but compromise the growth cartilage and epiphysis reduce the number of surgical alternatives and require the orthopedic surgeon to resort to more specific procedures. Among them, osteoarticular allograft was described as a good alternative in a study performed by Muscolo et al.[14] with 80 patients with tumors in the distal femur subjected to this method and followed up for five to 10 years. This alternative, however, is described by many authors as having complications such as graft fracture, pseudoarthrosis, infection, and osteoarthritis secondary to condylar osteonecrosis[15-17].

An option that has long been used for tumors located in the knees of young patients is the hinged total endoprosthesis for the distal femur and proximal tibia. This implant provides stability, a faster return to activities, and better quality of life to patients with bone tumors. However, in skeletally immature patients, its use compromises the epiphysis of adjacent bone, resulting in decreased bone stock and a greater discrepancy between the lower limbs. The indication for this type of implant is better suited for individuals who do not have any more open growth cartilage or who are at least already at the end of the second growth spurt[2-4,18].

In this study, we opted for an implant that replaced only the distal femur or proximal tibia (Figures 3, 4 and 5). All patients had tumor invasion of the growth cartilage without penetration into the joint cavity or extension to the cruciate ligaments. The implant allowed for the preservation of the epiphysis of the adjacent bone (tibia or femur), reducing the risk of discrepancy or future problems with little bone stock for prosthetic revision. Cruciate and collateral ligament reconstruction was necessary, in addition to patellar tendon reconstruction in proximal tibial replacement. Despite the need for the reconstruction of ligaments, surgical time remained very similar to that for total knee endoprosthesis because no time was used for osteotomy of the adjacent segment.

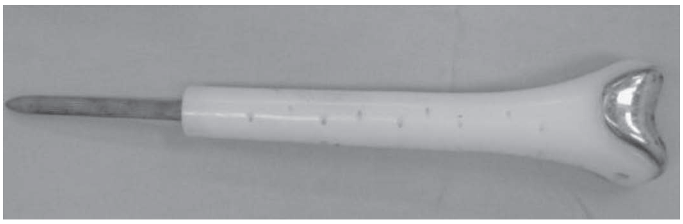

Figure 3 – Fabroni-type unconventional endoprosthesis.

Figure 4 – Joint reconstruction.

Figura 5 – Raio X controle

There are no articles in the literature that evaluate the partial implant apart from total knee endoprostheses. The method has a number of advantages over hinged implants in skeletally immature patients. Clinically, the dynamic gait evaluation is very similar to non-conventional total knee arthroplasties[19,20]. Although there is some degree of static hyperlaxity, there is no instability in the standing position or walking. Muscular action in the stance and swing phases keeps the knee stable. This study of 14 patients shows excellent functional assessment results, with those individuals who developed complications had lower scores. In vivo biomechanical gait analysis of partial endoprostheses still requires more refined research, and this study in the Hospital de Câncer de Barretos is one of the first steps in the validation of this surgical technique.

CONCLUSION

Partial knee endoprostheses provide the orthopedic surgeon and the patient a method of limb salvage with excellent functionality, maintenance of bone stock for revision, and reduction of discrepancies in skeletally immature individuals.

REFERENCES

1. Kawai A, Muschler GF, Lane JM, Otis JC, Healey JH. Prosthetic knee replacement after resection of a malignant tumor of the distal part of the femur: medium to long-term results. J Bone Joint Surg Am. 1998;80(5):636-47.
2. Behrman K, Jenson. N. Tratado de pediatria. 17°ed. Rio de Janeiro: Elsevier; 2005.
3. Futani H, Minamizaki T, Nishimoto Y, Abe S, Yabe H, Ueda T. Long term follow-up after limb salvage in skeletally immature children with a primary malignant tumor of the distal end of the femur. J Bone Joint Surg. 2006;88(3):595-603.
4. Krepler P, Dominkus M, Toma CD, Kotz R. Endoprosthesis management of the extremities of children after resection of primary malignant bone tumors. Orthopade. 2003;32(11):1013-9.
5. Almeida MTA. Tratamento combinado do Sarcoma de Ewing: análise do Protocolo Ewing –II –94 [tese]. São Paulo: Faculdade de Medicina da Universidade de São Paulo; 2000.
6. Croci AT, Camargo OP, Oliveira NRB. Tratamento cirúrgico do sarcoma de Ewing: avaliação oncológica funcional. Rev Bras Ortop. 1996;31(11):909-18.
7. Penna V, Lopes A, Tanaka MH, Wu TC, Melaragno R, Epelman S. Osteossarcoma: tratamento multidisciplinar. Rev Bras Ortop. 1993;28(11/12):791-4.
8. Petrilli AS, Macedo CRD. Tumores ósseos malignos na criança e no adolescente. Pediatria Moderna.1999; 35:600-8.
9. Próspero JD. Tumores ósseos. São Paulo: Roca; 2001.
10. Rougraff BT, Simon MA, Kneisl JS, Greenberg DB, Mankin HJ. Limb salvage compared with amputation for osteosarcoma of the distal end of the femur. A long-term oncological, functional, and quality-of-life study. J Bone Joint Surg Am.1994; 76(5):649-56.
11. Enneking WF, Dunham W, Gebhardt MC, Malawar M, Pritchard DJ. A system for the functional evaluation of reconstructive procedures after urgical treatment of tumors of the musculoskeletal system. Clin Orthop Relat Res. 1993;(286):241-6.
12. Schultz K, Souza RV. Fisioterapia. Kowalski LP. Manual de condutas diagnósticas e terapêuticas em oncologia. 2ª. ed. São Paulo: Âmbito; 2002.
13. Tsai LY, Jesus-Garcia Filho R, Petrilli AS, Korukian M, Viola DCM, Petrilli M, et al. Protocolo fisioterapêutico em pacientes submetidos à endoprótese não convencional de joelho por osteossarcoma: estudo prospectivo. Rev Bras Ortop. 2007;42(3):64-70.
14. Muscolo DL, Ayerza MA, Aponte-Tinao LA, Ranalletta M. Use of distal femoral osteoarticular allografts in limb salvage surgery. Surgical technique. J Bone Joint Surg Am. 2006;88(Suppl 1 Pt 2):305-21
15. Harrington KD, Johnston JO, Kaufer HN, Luck JV Jr, Moore TM. Limb salvage and prosthetic joint reconstruction for low-grade and selected high-grade sarcomas of bone after wide resection and replacement by autoclaved autogenic grafts. Clin Orthop Relat Res. 1986;(211):180-214.
16. Nishida J, Shimamura T. Methods of reconstruction for bone defect after a tumor excision: a review of alternatives. Med Sci Monit. 2008;14(8):RA107-13.
17. Komiya K, Nasuno S, Uchiyama K, Takahira N, Kobayashi N, Minehara H, et al. Status of Bone Allografting in Japan – Nation-Wide Survey of Bone Grafting Performed from 1995 through 1999. Cell Tissue Bank. 2003;4(2-4):217-20.
18. Roberts P, Chan D, Grimer RJ, Sneathe RS, Scales JT. Prosthetic replacement of the distal femur for primary bone tumors. J Bone Joint Surg Br. 1991;73(5):762-9.
19. Kabo JM, Yang RS, Dorey FJ, Eckardt JJ. In vivo rotational stability of the kinematics rotating hinge knee prosthesis. Clin Orthop Relat Res 1997;(336):166-76.
20. Dennis DA, Komistek RD, Scuderi GR, Zingde S. Factors affecting flexion after total knee arthroplasty. Clin Orthop Relat Res. 2007;(464):53-60.