

FUNCTIONAL ASSESSMENT OF PATIENTS WITH BONE SARCOMAS SUBMITTED TO SURGICAL TREATMENT USING TOTAL OR PARTIAL PROSTHESIS IN REPLACEMENT OF THE DISTAL FEMORAL END

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SUMMARY

Objectives: Osteosarcoma and Ewing's sarcoma are the most common malignant primary bone tumors in individuals under the age of 15 years. The purpose of the study is to retrospectively compare functional outcomes of patients submitted to resection of the distal femoral end and to reconstruction with total or partial non-conventional prosthesis of the knee. **Methods:** We assessed 26 patients with bone sarcomas in the distal femoral end treated at the Boldrini's Children Center between 1990 and 2003. Twenty-four presented with Osteosarcoma and two had Ewing's sarcoma. The assessment system employed was the one proposed by Enneking (1987) as recognized by the Musculoskeletal Tumor Society. For the statistical analysis between the criteria and final scores, we have used the Wilcoxon's test, with an

alpha error of 5%. **Results:** Ages ranged from 5 to 17 years, (mean: 11 years and 9 months); with prevalence being higher in females (61.5%). The only statistically significant difference found in this study was concerned to stability ($p=0.0037$). No statistical significance was found on any other criteria such as movement ($p=0.7546$), pain ($p=0.4848$), deformity ($p=0.8695$), strength ($p=1.0000$), functional activities ($p=0.9127$) and final functional outcome ($p=0.5866$). **Conclusions:** The overall functional end score did not show statistically significant differences ($p=0.6027$). The type of prosthesis for femoral reconstruction did not affect patients' functional outcomes.

Keywords: Bone neoplasm, Child, Surgery, Treatment outcome.

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INTRODUCTION

Primary, highly-malignant bone tumors account for approximately 7% of all tumors among individuals younger than 20 years old. The osteosarcoma is the most common tumor in that age group, occurring at an 8.7 cases: 1 million ratio, followed by Ewing's sarcoma, in 2.9 cases: 1 million^(1,2). These tumors preferably affect the appendicular skeleton. In 75% of the cases, it predominantly affects long bones' metaphysis adjacent to epiphyseal plate, preferentially at the distal femoral end^(3,4).

Until the 1970's, bone sarcoma treatment was based on amputation. About 80% of the cases evolved to death within up to two years. Surgical techniques basically consisted on resection procedures primarily targeting tumor eradication, in an attempt to locally control the disease⁽⁵⁾.

The use of endoprosthesis in tumor resection surgeries did not usually interfere on patients' survival rates, ultimately becoming an alternative to amputation. Endoprosthesis, then, started to be employed as a reconstruction method, aiming to save those

patients' limbs, especially the younger ones, since death rates resulting from those neoplasias were still high. With a low life expectancy, this would provide good function and limbs discrepancy would not represent an issue⁽⁶⁾.

With the development of multiple chemotherapy associated to the use of new imaging diagnostic methods, more accurate staging, and to recent awareness raised by the assessment of these tumors' biological response, patients progressively had significantly higher survival rates⁽⁴⁾.

With such higher survival rate, the functional activity issue was raised, particularly in those patients below the age of 12 affected by knee neoplasias. In this age group, resections involving knee joint may cause discrepancies on the resultant limb length, because tumor's metaphyseal-epiphyseal involvement does not allow growth cartilage salvage⁽³⁾. With the increased survival rate for patients, prostheses reviews started to be required due to breaks or loosening, or due to limbs discrepancy resulting from non-affected limbs' growth. Frequent reviews caused infections on endoprotheses or knee stiffness, leading

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to late amputations, even in the absence of local neoplastic disease relapse^(7,8,9). This, combined with continuous prostheses reviews, have led some surgeons to prefer amputation to conservative surgery in patients younger than 6 years old, making ablation surgery the most commonly employed technique in this age group⁽¹⁰⁾.

Although in the past amputation had been the most frequently employed procedure for local bone tumor control, advancements in medicine allowed for 80% of the patients with highly-malignant bone tumors to have their limbs saved, thus contributing to better functional outcomes^(6,7).

In patients requiring distal femoral reconstruction with unconventional endoprosthesis, a partial or total knee endoprosthesis may be used. The criteria adopted by the surgeon when selecting an implant vary according to patient's age, tumor site and extension⁽⁴⁾. Partial endoprosthesis is particularly indicated to skeletally immature patients, because it preserves tibial growth cartilage, minimizing future discrepancies between limbs length⁽¹⁰⁾.

In skeletally immature patients with tumors on femoral distal end where the joint is invaded by tumor or where there is no oncologic safety margin, total endoprosthesis is used. For the surgical preparation of tibial proximal end, perforating bone medullary cavity is recommended and, as a result, the cartilage growth core that will receive the tibial nail component. Tibial joint cartilage is removed with the menisci. Some endoprosthesis models enable flexion-extension movements associated to inner and outer rotation, translation, varus and valgus bent of about five degrees. They provide joint stability, since the removal of ligaments next to tumor results in instability, compromising gait and patient's comfort⁽¹⁰⁾.

Lower limbs reconstruction using unconventional knee endoprosthesis allows for early ambulation, fast functional recovery and social reintegration. However, the durability of a femoral distal end unconventional prosthesis ranges from five to ten years, approximately^(11,12). Problems associated to limbs length asymmetry may occur, as well as complications inherent to orthopaedic implants, such as infections, aseptic loosening, wear-offs, breaks, and joint degeneration, which imply on reviews. In children, this kind of prosthesis' duration is even shorter, due to the high levels of physical activity found in this age group, high biomechanical demand, and to medullary channel remodeling, leading to intramedullary nail fixation loss^(9,13).

The objective of this study was to retrospectively assess the functional outcomes in patients with femoral distal end sarcoma, submitted to reconstruction with total knee endoprosthesis, and compare them to those submitted to reconstruction with partial endoprosthesis.

MATERIAL AND METHOD

This was a retrospective study on 26 patients with highly-malignant bone sarcomas located at the femoral distal end and submitted to resection and reconstruction of the limb with unconventional knee endoprosthesis, either total or partial, treated with pre- and postoperative chemotherapy, diagnosed and followed up from January 1990 to December 2003 at the Centro Infantil Dr. Domingos A. Boldrini. Patients with incom-

plete medical files precluding functional assessment, and those who passed away or were referred to other services before one year of postoperative follow-up were excluded from the study. The Committee on Ethics and Research of the Institution where this study was carried out has exempted patients participating in the study of signing a Free and Informed Consent Term.

The criteria adopted for selecting knee endoprotheses were skeletal maturity, tumor site and extension.

Twenty-four patients had osteosarcoma, and other two had Ewing's sarcoma; as for gender, 10 were males and 16 were females, ages ranging from 5 to 17 years old (mean: 11.9; median: 11.5 years). Regarding ethnicity, five patients were African descendants and 21 were Caucasian. Fifteen cases (57.7%) were reconstructed with total endoprosthesis, and eleven (42.3%) with partial knee endoprosthesis. Figure 1 shows a reconstruction with partial endoprosthesis and Figure 2 shows reconstruction with total endoprosthesis.

All patients were submitted to physiotherapeutic rehabilitation programs for the first 48 postoperative hours, when isometric and passive movement exercises were performed. From the first week on, active-assisted, free, resisted and proprioceptive exercises were introduced. At the outpatient facility, stretching, ADM and muscular strength gain, gait training, balance and proprioception were worked on aiming to promote independence at ambulation. Patients submitted to reconstruction with total knee endoprosthesis remained load-free on reconstructed limb during the first two weeks after surgery, and those submitted to partial endoprosthesis, for six weeks after surgery. All patients were assessed for function, with a minimum follow-up time of 12 months.

The functional assessment of the 26 patients was consistent to the classification recommended by Enneking⁽¹⁴⁾, and adopted by the Musculoskeletal Tumor Society (MSTS), measuring knee motion, pain, stability, deformity, muscular strength, functional activity and emotional status. Each functional measurement parameter was comparatively assessed between both endoprotheses groups (total and partial). Follow-up time was measured by taking the period between surgery and last assessment time into account.

The comparison of functional outcomes achieved between both patients groups was performed by using the Wilcoxon's non-parametric test. The same test was used to compare each parameter on the studied classification between both patients groups. The software employed for statistical analysis was the SAS® and the significance level adopted was 5%.

RESULTS

The 26 patients in the study had a mean age of 11.9 ± 3.2 years (median: 11.5 years). The group of patients submitted to total knee endoprosthesis ($n=15$), had a mean age of 13.3 ± 3.0 years. The group receiving partial knee endoprosthesis ($n=11$) had a mean age of 11.0 ± 3.2 years. There was no statistical difference between the groups for mean age ($p=0.53$) (Table 1).

The mean follow-up time for the group of patients submitted to reconstruction with partial endoprosthesis was 48.6 ± 32 months, while among the patients submitted to total endo-

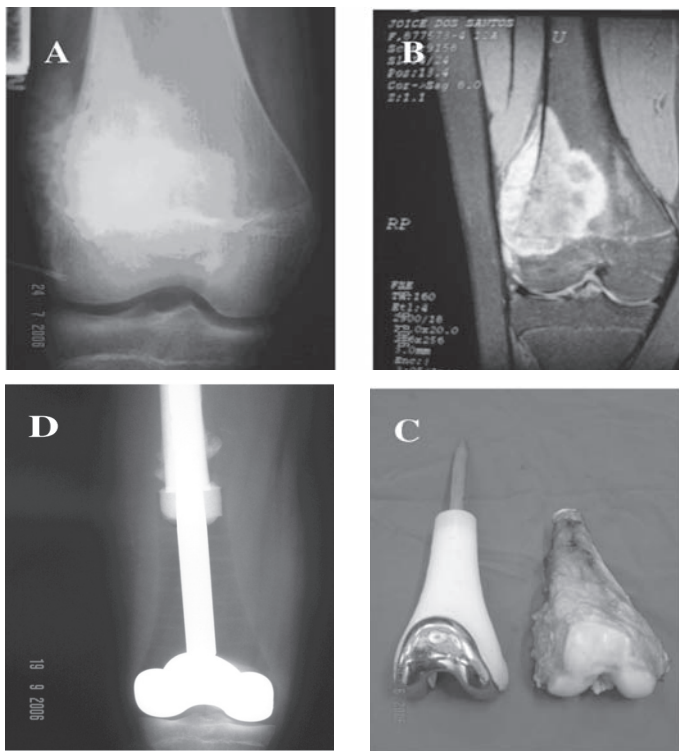


Figure 1 - Case 5: A 10 year-old. X-ray image showing an osteosarcoma at femoral distal end. A) Plain X-ray image of the femur; B) Magnetic resonance image of the involved region; C) Dried piece and partial endoprosthesis at distal femur; D) Postoperative plain X-ray image showing reconstruction.

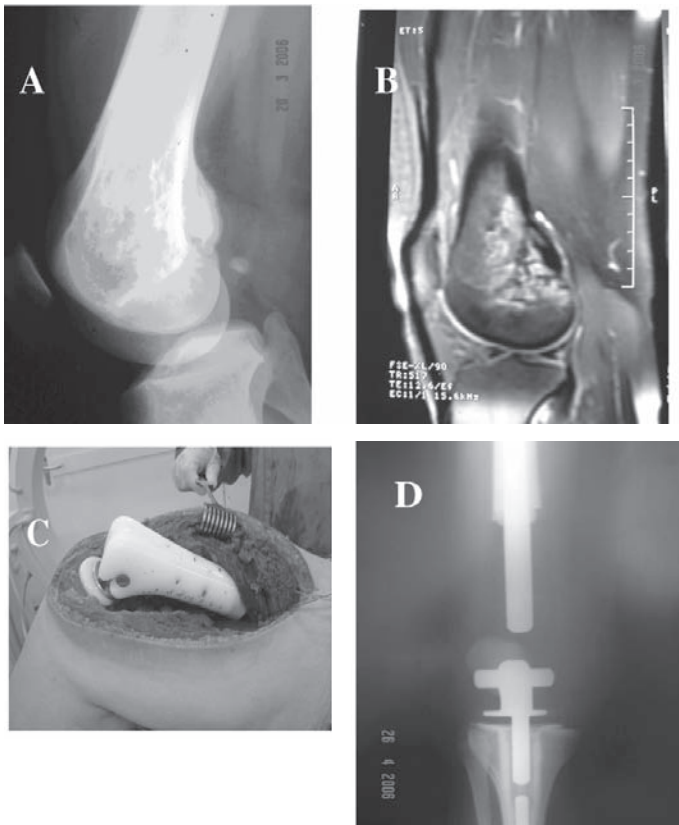


Figure 2 - Case 22, A 15 year-old. Osteosarcoma at the femoral distal end. A) Plain X-ray image of the femur; B) Magnetic resonance image of the involved region; C) Intraoperative appearance of the reconstruction with total femoral distal endoprosthesis; D) Postoperative plain X-ray image showing reconstruction.

prosthesis, this was 38.9 ± 21.4 months. The difference in follow-up times was not statistically significant between groups ($p=0.60$) (Table 2).

Regarding the distribution of patients for histopathological diagnosis, there was a prevalence of osteosarcoma, which occurred in 24 cases (92.3%) and the two remaining cases (7.7%) were classified as Ewing's sarcoma (Table 3).

The overall functional outcome achieved was regarded as excellent in 26.7% of the patients reconstructed with knee total endoprosthesis, good in 46.7%, regular in 13.3% and poor in 13.3%. For patients submitted to partial endoprostheses, 9.1% were rated as excellent, 54.5% as good, 18.2% as regular and 18.2% as poor in terms of overall functional outcome.

Of the 15 patients submitted to reconstruction with total knee endoprosthesis, 73.4% were rated as good/excellent, and, of the 11 patients reconstructed with partial knee endoprosthesis, 63.6% presented good/excellent overall functional outcome (Table 4). When taken together, 19.2% of the patients were rated as excellent, 50.0% as good, 15.4% as regular and poor, respectively, regardless of the kind of reconstruction. Of the twenty six patients assessed, 69.2% presented a good/excellent rate, while 30.8% presented regular/poor rates, according to the overall functional outcome.

Kind of Endoprosthesis	Nr. of Patients	Mean \pm Standard Deviation (Minimum-maximum) (years)	Median (years)	p* value
Partial	11	11.0 \pm 3,2 (5.0 - 17.8)	11.3	
Total	15	13.3 \pm 3,0 (8.3 - 17,3)	12.8	0,53

* Wilcoxon's test - Source: SAME Centro Infantil Boldrini

Table 1 - Distribution of patients with bone sarcomas as per the kind of endoprosthesis employed on surgical reconstruction according to age at diagnosis.

Kind of endoprosthesis	Nr. of patients	Mean \pm Std. Deviation (Minimum-maximum) (months)	Median (months)	p* value
Partial	11	48.6 \pm 32.0 (13.0 - 125.0)	45.0	
Total	15	38.9 \pm 21,4 (12.0 - 78.0)	33.0	0.60

* Wilcoxon's test - Source: SAME Centro Infantil Boldrini

Table 2 - Distribution of patients with bone sarcomas as per the kind of reconstruction with total or partial endoprosthesis according to follow-up time (in months).

Histopathological Diagnosis	Frequency	
	Absolute (n)	Relative (%)
Osteosarcoma	24	92.3
Ewing's sarcoma	02	7.7
Total	26	100

Source: SAME Centro Infantil Boldrini

Table 3 - Distribution of absolute (n) and relative (%) frequency of patients submitted to reconstruction with knee endoprosthesis, either total or partial, according to histopathological diagnosis of bone sarcoma.

When each criterion of the Functional Assessment System proposed by Enneking⁽¹⁴⁾ was compared between both patient groups, according to the kind of endoprosthesis employed for bone reconstruction, only the stability criterion was found to have a statistically significant difference ($p=0.0037$) (Table 5).

DISCUSSION

Sadao⁽⁷⁾ conducted a literature review and found few studies addressing treatments for highly-malignant bone sarcomas, particularly concerning treatment of patients with compromised growth cartilage. Few studies assessed functional outcomes in patients with bone sarcomas at the femoral distal end and reconstructed with knee endoprostheses within the same age group as the patients in this study^(3,9,15,16,17), thus regarded as skeletally immature.

In the case series studied, there was a higher number of female patients (61.5%) compared to male patients (38.5%), a finding that is consistent to data published by other researchers^(18,19,20). However, we also found studies in which male gender was prevalent^(3,9,15). We found a prevalence of Caucasian ethnicity, accounting for 80.8% of the cases, consistently with other literature reports^(18,19).

Patients' age ranged from five to 17 years old, with mean age of 11.9 years and median 11.5 years. These values can be as-

Overall functional outcome	Total Endoprosthesis		Partial Endoprosthesis	
	N	%	N	%
<i>Excellent</i>	4	26.7	1	9.1
<i>Good</i>	7	46.7	6	54.5
<i>Regular</i>	2	13.3	2	18.2
<i>Poor</i>	2	13.3	2	18.2
Total	15	100	11	100

Source: SAME Centro Infantil Boldrini

Table 4 – Overall functional outcome according to Enneking's classification (14), in patients with bone sarcomas at femoral distal end, according to the kind of endoprosthesis employed on surgical reconstruction (n=26).

sociated to the characteristics of the hospital where the study was conducted, where the maximum age to admission is 25 years old. Studies report that osteosarcomas and Ewing's sarcomas predominantly affect children and teenagers^(2,4,21,22). Of the 26 assessed patients, only one was 5 years old, three were 5-10 years old, while the remaining patients were at their second decade of life.

In the present study, patients were assessed for functional outcomes according to the kind of knee endoprosthesis employed, whether partial or total. The group submitted to reconstruction with partial endoprosthesis had an average age of 11 years, while the group with total endoprosthesis had a mean age of 13.3 years. This difference was not statistically significant ($p=0.53$). Although the case series is small, we can infer that both groups were at similar bone growth periods, thus the functional differences found cannot be attributed to age differences.

The postoperative follow-up time constitutes another factor that could influence the functional outcomes of reconstructions with endoprostheses due to reviews caused by biomechanical complications^(9,12). From the functional point of view, the minimum postoperative follow-up time of 12 months allowed for an appropriate assessment of results. The average follow-up time for these patients was similar for both groups, with no statistically significant difference being found ($p=0.60$). These data allow us to infer that, although assessment times are not uniform, the follow-up time had no influence on functional outcomes of the patients in the study.

In the present study, complications were found in 54.3% of the patients submitted to reconstruction with partial knee endoprosthesis, and in 46.6% of the patients group with total endoprosthesis. Although the identification of these complications does not constitute an element of the functional assessment system adopted herein, no statistically significant correlation was found between the emergence of complications and functional outcomes ($p=0.089$), probably because these were addressed and treated at the follow-up period, and were no longer present at the time of the last outcomes evaluation.

Functional parameters	Total Endoprosthesis			Partial Endoprosthesis			p* value
	Average ± SD	Median	Range (Min-Max)	Average ± SD	Median	Range (Min-Max)	
Motion	3.3 ± 1.9	3.0	0 - 5	3.4 ± 2.3	5.0	0 - 5	0.7546
Pain	3.9 ± 1.5	5.0	1 - 5	3.3 ± 2.1	5.0	0 - 5	0.4848
Stability	4.6 ± 1.1	5.0	1 - 5	2.8 ± 1.7	3.0	1 - 5	0.0037
Deformity	1.7 ± 2.1	1.0	0 - 5	1.2 ± 1.3	1.0	0 - 3	0.8695
Strength	3.4 ± 1.6	3.0	1 - 5	3.4 ± 1.8	3.0	1 - 5	1.0000
Functional activity	3.1 ± 1.9	3.0	0 - 5	3.2 ± 2.0	3.0	0 - 5	0.9127
Emotional status	2.8 ± 1.5	3.0	0 - 5	3.1 ± 2.3	5.0	0 - 5	0.5866
Overall functional outcome	22.7 ± 9.1	24.0	5 - 35	20.2 ± 10.9	27.0	2 - 31	0.6027

* Wilcoxon's test - Source: SAME Centro Infantil Boldrini

Table 5 – Comparison of Enneking's classification specific criteria (14) and of overall functional outcomes according to the kind of endoprosthesis employed on the reconstruction of study patients' bones (n=26).

The earlier the physiotherapeutic intervention provided for these patients, the higher the chances of achieving satisfactory functional outcomes⁽¹⁶⁾. Rehabilitation was started at the early postoperative period, which is a challenge for a physical therapist, since patients were not always collaborative with the treatment provided.

Concerning motion criterion, of the 11 patients submitted to reconstruction with partial endoprosthesis, seven were rated as excellent (63.6%), two as regular (18.2%) and two (18.2%) as poor. But, among the 15 patients submitted to reconstruction with total endoprosthesis, seven were rated as excellent (46.7%), four as good (26.7%), two as regular (13.3%) and two as poor (13.3%). Eckardt et al.⁽¹⁶⁾ studied the functional outcomes of seven patients with osteosarcoma at the femoral distal end, with mean age of 9.3 years, submitted to reconstruction with expansive total knee endoprostheses, and achieved excellent results in 57% of the patients. Kenan et al.⁽¹⁷⁾ studied the functional outcomes of eleven skeletally immature patients with osteosarcoma at femoral distal end who were submitted to reconstruction with expansive total knee endoprostheses and achieved results rated as excellent in 63.7%.

For muscular strength criterion, five of the 11 patients submitted to surgical reconstruction of the knee with partial endoprosthesis were rated as excellent (45.4%), three as good (27.3%) and three as regular (27.3%). When we assess the 15 patients whose knee reconstruction was provided with total endoprosthesis, six were rated as excellent (40%), six as good (40%) and three as regular (20%). Assessing the muscular strength criterion, Eckardt et al.⁽¹⁶⁾, found results rated as excellent in 57% of their patients and good in 43%. Kenan et al.⁽¹⁷⁾ in a study with 11 children with osteosarcoma at femoral distal end and submitted to reconstruction with total knee endoprosthesis found about 80% satisfactory results for muscular strength.

When comparing the results of the group reconstructed with total knee endoprosthesis to the one with partial knee endoprosthesis, no statistically significant differences were found for motion ($p=0.7546$) and muscular strength ($p=1.000$) criteria. As for the pain criterion, both in the group with total endoprosthesis and the group with partial endoprosthesis, good and excellent rates were predominantly found. While no statistically significant difference was found between both groups ($p=0.4848$), Kenan et al.⁽¹⁷⁾ reported excellent rates in 63% of the patients submitted to reconstruction with total endoprosthesis, which is consistent to the results found for patients studied by Eckardt et al.⁽¹⁶⁾.

When assessing the deformity criterion, among the patients submitted to reconstruction with partial knee endoprosthesis, four were rated as poor, four as regular, and three as good. For those patients with total knee endoprosthesis, six were rated as poor, five as regular and four as excellent. No statistically significant difference was found between both groups assessed ($p=0.8695$). As the presence of lower limb shortening was one of the items assessed by this criterion, those patients submitted to reconstruction with total endoprosthesis were expected to show a more significant discrepancy on limbs' length than patients submitted to reconstruction with partial endoprosthe-

sis, since the latter preserves the growth cartilage at the tibial proximal end.

When assessing the functional activity criterion, most patients were able to perform all functions, according to their corresponding age groups, such as ambulate, climb up and down stairs, run, dress, take shower, and other ($p=0.9127$).

When assessing the emotional status criterion, results were regarded as satisfactory when rated as excellent and good. Of all patients submitted to reconstruction with partial or total knee endoprosthesis, seven (63.6%) and eleven (73.4%), respectively, showed satisfactory results. In the comparative analysis between both groups, no statistically significant difference was found ($p=0.5866$). Skaliczki et al.⁽²⁰⁾ working with patients with a mean age of 24 years and nine months, found that most of the patients with highly-malignant bone sarcomas involving knee joint and reconstructed with total endoprosthesis showed satisfactory results. Satisfactory results were also published by other authors^(8,16,17). In the three latter studies, the assessed patients were also skeletally immature, their tumors were located at femoral distal end and were reconstructed with total knee endoprosthesis.

Only the stability criterion presented a statistically significant difference between both groups ($p=0.0037$). Thirteen patients submitted to knee reconstruction with total endoprosthesis (86.7%) and 2 with partial endoprosthesis (18.2%) were rated as excellent. The group reconstructed with total endoprosthesis had an average score of 4.6 ± 1.1 , while the group reconstructed with partial endoprosthesis had an average of 2.8 ± 1.7 . This difference was shown to be statistically significant ($p=0.0037$). This result is consistent to the findings of Camargo and Croci⁽⁸⁾ who report on the fact that total knee endoprosthesis provides better stability than partial endoprosthesis with a femoral component. No studies were found in literature comparing stability between both groups. However, as no difference was found on overall functional outcomes, we can infer that the stability of a partial knee endoprosthesis did not influence the overall function of the assessed patients.

At the postoperative assessment, the overall functional outcome was predominantly rated as good and excellent in both groups (69.2%). In the group reconstructed with total endoprosthesis, 11/15 patients presented good and excellent rates (73.4%), and for the partial endoprosthesis group, 7/11 were rated as good and excellent (63.6%). These results are consistent with the ones published by Tunn et al.⁽⁹⁾, who studied children with osteosarcoma at the femoral distal end submitted to reconstruction with total endoprosthesis, and by Cassone⁽¹⁵⁾ who conducted a multicenter comparative study for the oncologic and functional assessment of 62 skeletally immature patients with bone sarcomas submitted to transepiphyseal resection with bone grafting or osteoarticular resection with prosthesis at knee region. In the group submitted to reconstruction with total endoprosthesis, 7/13 were rated as good (53.8%) and in the group with partial endoprosthesis, 11/16 were rated as good or excellent (68.7%). Good and excellent rates were prevalent in both groups, when overall functional outcomes were assessed. Other authors studying children with bone sarcomas at the femoral distal end and submit-

ted to reconstruction with total knee endoprosthesis showed overall functional outcomes rated as good and excellent^(3,9,16). The studies described above used the Functional Assessment System proposed by Enneking⁽¹⁴⁾.

When comparing the overall functional outcomes between both groups, no statistically significant difference was found ($p=0.6027$).

The functional outcomes found in this study corroborate the benefits of reconstructing femoral distal ends, either with total or partial knee endoprosthesis. Although stability is better in those submitted to reconstruction with total endoprosthesis, the overall functional outcomes were similar. A surgeon's choice for a different kind of reconstruction is influenced by patient's age, precise location of the tumor, as well as its extension. The reconstruction technique certainly contributes to provide a bet-

ter quality of life for patients and minimizes the challenges for their psychosocial reintegration.

CONCLUSIONS

Of the 26 patients with bone sarcomas at femoral distal end, the kind of endoprosthesis employed for reconstruction, either partial or total, has not influenced the overall functional outcomes ($p=0.6027$). When the specific criteria for functional assessment are compared, only the stability criterion showed differences between both groups, with the group submitted to reconstruction with total knee endoprosthesis presenting an average score of 4.6 ± 1.1 , while the group submitted to reconstruction with partial endoprosthesis showed an average score of 2.8 ± 1.7 . This difference was shown to be statistically significant ($p = 0.0037$).

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