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# Patellar height influences knee function in patients with aggressive bone tumors of the proximal tibia after endoprosthetic reconstruction

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ABSTRACT

*Background:* The proximal tibia is the second most common site of aggressive bone tumors. In proximal tibia resection, the patellar tendon is sectioned one to two centimeters from its insertion on the tibial tubercle, which makes it technically challenging to achieve an appropriate patellar height and firm fixation of the patellar tendon. The purpose of this study was to determine whether the patellar height influences knee function after proximal tibia endoprosthetic reconstruction (EPR).

*Methods:* Twenty-nine patients with pathologically confirmed aggressive bone tumors in the proximal tibia were retrospectively analyzed. We used the Insall–Salvati ratio (ISR) and the Blackburne–Peel index (BPI) to radiographically analyze the patellar height. Functional outcomes were retrospectively assessed using the Musculoskeletal Tumor Society (MSTS) score, the Oxford Knee Score (OKS) and the range of motion (ROM) which was evaluated through extensor lag and active flexion. Univariate analysis with Pearson's correlation and a multivariate linear regression of patient characteristics and surgery-related changes were performed.

*Results:* The postoperative ISRs were negatively correlated with the functionality domain of the MSTS score (function, gait, walking) and the OKS. Pearson's correlation analysis showed a significant correlation between the postoperative ISR and extensor lag. The change in patellar height had no impact on the active flexion of the knee.

*Conclusions:* Patellar height is an independent factor contributing to knee function after proximal tibia EPR. The quality of patellar tendon reconstruction is a key point in proximal tibia EPR after tumor resection.



## 1. Introduction

Endoprosthetic reconstruction (EPR) after wide resection of an aggressive tumor involving the proximal tibia has become a commonly applied method to provide rapid postoperative recovery, a lower lifetime cost and similar oncologic outcomes compared with other reconstruction techniques [1–3].

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However, for patients with an aggressive tumor of the proximal tibia after wide resection and EPR, the factors contributing to knee function remain unclear. Shoji Shimose [4] reviewed seven cases of patients with proximal tibial malignant tumors who underwent EPR, and they failed to find a correlation between patellar height and the functional Musculoskeletal Tumor Society (MSTS) score. Jentzsch [5] reported the functional outcomes of 16 patients who underwent proximal tibia EPR but without statistical validation. In proximal tibia resection, if the knee joint is free of tumor, the patellar tendon is sectioned one to two centimeters from its insertion on the tibial tubercle to attain an appropriate oncological margin, which makes it technically challenging to achieve an appropriate patellar height and a firm patellar tendon fixation [3, 4, 6, 7]. The potential factors related to knee function include the quality of extensor apparatus reconstruction, the extent of soft tissue resection, and the appearance of prosthesis failure (loosening, breakage, infection, etc.). According to previous studies [4, 5], we tend to use the patellar height as a parameter to reflect the quality of extensor apparatus reconstruction. Patellar height can be measured by several indexes, including the Insall–Salvati ratio (ISR) and the Blackburne–Peel index (BPI) [4, 8]. The extent of soft tissue resection cannot be directly assessed. Because it depends on the extraosseous extension of the tumor, we use tumor volume as an indirect parameter.

The proximal tibia is the second most common site of involvement of aggressive bone tumors [9, 10], but there are few studies that have evaluated the factors related to knee function. Many patients with aggressive bone tumors are young and active. Because of their long-term survival, maximizing joint function is crucial. The purpose of this study was to identify the factors that contribute to knee function following proximal tibial EPR. The general patient characteristics and surgery-related changes were considered as potential factors.

## 2. Patients and methods

We conducted a retrospective follow-up of patients between January 2004 and December 2015 referenced from our database. Patients were included if they: (1) were diagnosed with locally aggressive intermediate or malignant tumors in the proximal tibia according to the World Health Organization (WHO) classification, fourth edition [11]; (2) were treated with a wide-margin resection according to the Enneking tumor surgical treatment principle [12]; (3) were treated with standardized EPR; (4) completed a rehabilitation program; and (5) completed a follow-up period of at least 18 months. The exclusion criteria were: (1) patients with a complication of infection around their endoprosthesis; (2) patients who developed local recurrence or metastasis; (3) patients who died during the follow-up; (4) patients who were not treated at our center; and (5) patients who showed an inequality in length (>2 cm) of the lower limbs during follow-up. A total of 29 patients fulfilled our selection criteria with a mean follow-up of 57.8 ± 38.9 (range, 18.7–143.5) months. There were nine males and 20 females with a mean age of 29.5 (mean) ± 14.9 (standard deviation) (range 14–72) years. The left knee was involved in 17 patients and the right in 12 patients. Twenty tumors (69.0%) were less than or equal to 100 ml in volume, and the other nine tumors (31.0%) were larger than 100 ml. The pathological

**Table 1**
Patient demographics and clinical profiles.

| Variable | Number of patients (%) |
|---|---|
| Gender | |
| Male | 9 (31.0%) |
| Female | 20 (69.0%) |
| Laterality | |
| Left | 17 (58.6%) |
| Right | 12 (41.4%) |
| Pathology | |
| Malignant | 21 (72.4%) |
| Locally aggressive | 8 (27.6%) |
| Tumor volume | |
| ≤100 ml | 20 (69.0%) |
| >100 ml | 9 (31.0%) |
| **Variable** | **Mean ± SD (range)** |
| Age | 29.5 ± 14.9 (14–72) years |
| Duration of follow-up | 57.8 ± 38.9 (18.7–143.5) months |
| Osteotomy length | 13.6 ± 2.9 (8.8–19.5) cm |
| Preoperative ISR | 1.04 ± 0.15 (0.81–1.48) |
| Postoperative ISR | 1.16 ± 0.27 (0.77–1.87) |
| Preoperative BPI | 0.92 ± 0.13 (0.75–1.44) |
| Postoperative BPI | 1.10 ± 0.31 (0.57–1.74) |
| Active knee flexion | 111.7 ± 21.2 (90–142)° |
| Knee extensor lag | 3.24 ± 6.36 (0–29.4)° |
| MSTS score | 26.1 ± 2.4 (17–30) |
| Functionality domain of the MSTS score | 12.3 ± 1.7 (6–15) |
| Oxford Knee Score | 39.8 ± 4.5 (23–45) |

BPI, Blackburne–Peel index; ISR, Insall–Salvati ratio; MSTS, Musculoskeletal Tumor Society.

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