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Long term outcomes of cemented endoprosthetic reconstruction for periarticular tumors of the distal femur

Matthew T. Houdek [a], Eric R. Wagner [a], Benjamin K. Wilke [a], Cody C. Wyles [b], Michael J. Taunton [a], Franklin H. Sim [a,*]

[a] Mayo Clinic, Department of Orthopedic Surgery, 200 First St. SW, Rochester, MN 55905, United States
[b] Mayo Graduate School of Medical Education, 200 First St. SW, Rochester, MN 55905, United States

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ABSTRACT

Background: In order to achieve an oncological margin during limb salvage surgery for tumors of the distal femur, part or the entire knee joint is frequently sacrificed. Endoprosthetics make limb salvage possible through restoration of a functional extremity. Currently there remains a paucity of data concerning their long-term outcomes and associated risk factors for failure.
Methods: We identified 152 patients who underwent an endoprosthetic reconstruction for an oncological process of the distal femur between 1972 and 2013. The mean follow-up was 10 years. Mean age and body mass index (BMI) were 39 years and 25.8 respectively. The most common pathology was osteosarcoma (n = 78, 48%). Outcomes were compared to a control group of 20,643 patients undergoing total knee arthroplasty (TKA) for degenerative joint disease (DJD) during the same time period.
Results: The mean five-, 10-, 15-, 20-, and 25-year revision-free survival for an endoprosthesis was 76%, 63%, 51%, 36%, and 28%. Compared to the five-, 10-, 15-, 20-, and 25-year survival of 95%, 90%, 82%, 74%, and 67% for control TKAs ($p < 0.0001$ at all-time points). Overall limb survival was 93%, with 11 patients undergoing amputation. There was no difference in implant survival comparing modular and custom endoprostheses.
Conclusion: The results of this study show that given the complexity of these operations, the rate of revision surgery following endoprosthetic replacement is high. Nevertheless, the use of these modular reconstructions leads to a high rate of limb salvage (93%) over a 25-year period at our institution.
Level of Evidence: Level III.

1. Introduction

Although technically complex, limb-salvage surgery has become more common for treatment of periarticular tumors of the knee due to many recent innovations, including advances in adjuvant treatments, biomaterials, surgical techniques and radiological imaging modalities [1–5]. Limb salvage options following the resection of a periarticular tumor around the knee include endoprostheses, osteoarticular allograft, allograft prosthetic composite, arthrodesis and rotationplasty [1,6–17].

Arthroplasty, specifically endoprosthetic replacement, is felt to be the treatment of choice to reconstruct bone defects when limb salvage is possible [15]. The advantages of an endoprosthesis include immediate weight bearing on the effected limb, cost-effectiveness, and availability [13,14,18,19]. Even with these advantages, endoprosthesis in this setting has been fraught with complications related to aseptic loosening, mechanical failure, periprosthetic fracture and prosthetic joint infections [1,2,12–17,20–24]. Currently, there remains a paucity of large studies with mid- or long-term outcomes examining the use of endoprosthetic components following resection of a periarticular tumor of the knee [13–17,25,26]. The purpose of this study was to report our institution's long-term outcomes of knee arthroplasty following a periarticular tumor resection with regard to (1) revision, (2) infection, (3) reoperation, and (4) overall limb-salvage. Secondarily, we assessed for any factors that might have been associated with worse outcomes.

2. Materials and methods

After obtaining approval from our Institutional Review Board we reviewed all patients who underwent total joint reconstruction following tumor resection of the knee from 1972 to 2013 using our institution's total joint database. This registry prospectively captures all patients either during their clinical follow-up or they are contacted by letter or telephone twice during the first postoperative year, at two

* Corresponding author.
E-mail addresses: houdek.matthew@mayo.edu (M.T. Houdek), wagner.eric@mayo.edu (E.R. Wagner), wilke.benjamin@mayo.edu (B.K. Wilke), wyles.cody@mayo.edu (C.C. Wyles), taunton.michael@mayo.edu (M.J. Taunton), sim.franklin@mayo.edu (F.H. Sim).

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and five years, and then every five years thereafter. During this contact they are asked to fill out a standardized data collection form regarding patient and implant survival, complications, and patient-reported outcomes [27].

2.1. Patient information

Over a 41-year period we identified 260 patients who underwent a total knee arthroplasty (TKA) for reconstruction of an oncological process of the distal femur and/or proximal tibia. Two children with expandable prostheses were removed from the cohort, leaving 258 patients in the study group. From this group we identified 152 (60%) patients undergoing a cemented arthroplasty using a modular (n = 110) or custom (n = 42) endoprosthesis. This cohort consisted of 85 (56%) females and 67 (44%) males, with a mean age at the time of surgery of 40 years (range 10 to 84). There was no difference in the gender or age between patients with custom or modular endoprosthesis, however there were significantly more ($P < 0.0001$) patients with a rotating hinge and all-polyethylene tibia in the modular group (Table 1). Thirty-three (22%) patients were less than 18 years of age at the time of surgery. Mean body mass index (BMI) for all patients from 1988 or later (n = 115, 71%) was 25.9 w kg/m^2 (range 14.5 to 57.7 kg/m^2). Osteosarcoma (n = 72, 47%) was the most common pathology, with malignant tumors making up 87% of tumors in this study.

Patients were prospectively followed over the course of the study at regular intervals to the time of death, revision, or amputation. The mean follow-up of surviving patients was 10 years (range one to 38 years). Fifteen (10%) patients died and five (three percent) underwent revision prior to the one-year follow-up visit. The control group consisted of 27,024 patients undergoing TKA for primary osteoarthritis (OA) during the same time period to compare the overall and implant survival between groups. Revision was defined as the removal and/or replacement of the knee components. Reoperation was defined as any surgical procedure performed on the knee where the arthroplasty components were not removed or exchanged.

Continuous variables were compared using the unpaired Student t-test and categorical variables were compared with the Fisher exact test. Survival estimates were made using the Kaplan–Meier survival method. Comparisons to the patients with a diagnosis of OA were performed using the log-rank test. Proportional hazard univariate regression analysis was performed to assess the association of clinically applicable covariates with the risk of implant failure and reoperation. Knee Society clinical rating and function scores [28] were calculated for all patients in the endoprosthetic and custom arthroplasty group at their last clinical follow-up. All statistical calculations were made using JMP version 9 (Statistical Analysis Software, Cary, NC) with statistical significance set at a P-value <0.05.

3. Results

3.1. Overall survival

The five-, 10-, 15-, 20-, and 25-year overall survival of patients in the endoprosthetic group was 61%, 56%, 50%, 42%, and 25%. There was no difference (hazard ratio (HR) 0.94, $P = 0.59$) in the overall survival in patients undergoing an endoprosthetic reconstruction for an oncological process of the knee compared to patients undergoing first time TKA for OA, where the five-, 10-, 15-, 20-, and 25-year overall survival was 90%, 70%, 44%, 20%, and 8%. There was a significant ($P < 0.0001$) difference between the overall survival between patients with benign, local malignant and metastatic disease (Fig. 1). The mean time to death for patients with benign, malignant and metastatic disease was two years (range two months to eight years), six years (range four months to 26 years) and 16 years (range nine to 23 years).

Table 1
Comparison of patients with a custom vs. modular endoprosthesis.

	Custom endoprosthesis	Modular endoprosthesis	P value
% males	43%	43%	1.0
Mean age (years)	40.5	38.9	0.70
Rotating hinge	0%	100%	<**0.0001**
Cemented component	100%	100%	1.0
All polyethylene tibia	0%	23%	**0.0002**

Bold represents statistical significance.

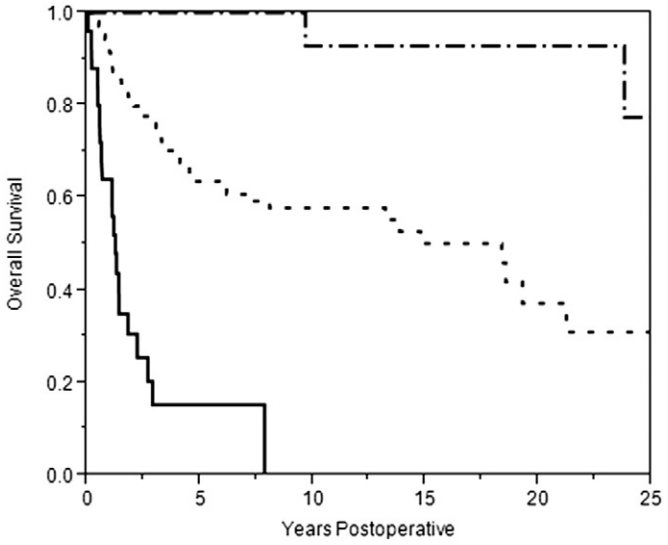

Fig. 1. Comparison of overall survival of patients with benign (dot-dash line), local malignant (dash line) and metastatic (solid line) disease at the time of custom or modular endoprosthetic distal femoral reconstruction. Patients with benign tumors had improved survival compared to the patients with malignant disease.

3.2. Revision

Fifty-three (35%) patients underwent a revision arthroplasty over the course of the study at a mean of six years postoperatively (range three months to 23 years). The overall revision-free survival following primary arthroplasty for an oncological process at the five-, 10-, 15-, 20-, and 25-year time points were 74%, 59%, 50%, 37%, and 32% (Fig. 2). Revision surgery was performed for component loosening (n = 32, 60.3%), septic causes (n = 15, 28.3%), periprosthetic fracture (n = 3, 5.6%), and component fracture (n = 3, 5.6%). Patients undergoing a knee arthroplasty for an oncological process were at a significantly increased risk of revision (HR 4.02, $P < 0.0001$) compared to patients undergoing a TKA for OA over the same point, where revision free survival at the five-, 10-, 15-, 20-, and 25-year time points were 95%, 90%, 82%, 74%, and 67%.

Univariate analysis revealed that, patients with a malignant lesion were more likely to undergo revision surgery (HR 2.03, $P = 0.02$) and had significantly overall worse five-, 10-, 15-, 20- and 25-year revision free survivals (73% vs. 87%, 59% vs. 78%, 46% vs. 68%, 31% vs. 44%, 20% vs. 44%) compared to patients with a benign lesion (Table 2). There was no difference (HR 1.46, $P = 0.18$) in implant survival between custom and modular endoprosthetic constructs (Fig. 3).

3.3. Reoperation

Including the 53 patients with revision TKA above, a total of 75 (49%) patients underwent a reoperation over the course of the study at a mean of four years postoperatively (range one day to 17 years). The overall reoperation-free survival following primary arthroplasty for an oncological process at the five-, 10-, 15-, 20-, and 25-year time points were 55%, 45%, 35%, 26%, and 26% (Fig. 2). Patients undergoing a TKA for an oncological process were at a significantly increased risk of reoperation (HR 4.37, $P < 0.0001$) compared to patients undergoing a TKA for OA (Table 2), with reoperation-free survival at the five-, 10-, 15-, 20-, and 25-year time points of 92%, 86%, 78%, 70%, and 62%. The most common indication for reoperation was wound irrigation and debridement (n = 16, 30%), with 29 (55%) patients undergoing multiple reoperations, and in 21 of these patients (72%) leading to a revision procedure or amputation.

The risk of reoperation was increased in patients with a postoperative complication including delayed wound healing (HR 11.71, $P < 0.0001$) and infection (HR 43.49, $P < 0.0001$) (Table 3). Likewise, patients with a malignant lesion were more likely to undergo reoperation (HR 2.13, $P = 0.008$) compared to patients with a benign lesion ($P = 0.01$). There was no difference (HR 1.07, $P = 0.76$) in the need for reoperation between patients with a custom and modular endoprosthetic reconstruction (Fig. 3).

3.4. Postoperative infection

Following the arthroplasty reconstruction, 20 (13%) patients developed a postoperative infection (superficial above the fascia or deep to the fascia) at a mean of three years