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Primary arthroplasty in healed osteoarticular allograft in patients with history of primary femoral bone tumors

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ABSTRACT

Background: Roughly 25–35% of patients who are treated with osteoarticular allograft for primary bone sarcomas or aggressive benign bone tumors require surgery in the long-term due to degenerative changes of the articular surface of the allograft. There are three established methods of reconstruction for this complication; a total hip arthroplasty (THA) or total knee arthroplasty (TKA) in the retained osteoarticular allograft, a proximal or distal endoprosthesis after removal of the allograft, and an allograft-prosthesis composite (APC). The aims of this study are 1) to determine the rate of complication and failure of THA/TKA in healed femoral allograft; 2) to compare the methods of revision for allograft degeneration; and 3) to compare the use of arthroplasty in healed allograft to that of arthroplasty in native bone.

Methods: We included all patients with primary bone sarcomas and locally aggressive primary benign bone tumors treated between 1984 and 2014 with an osteoarticular allograft followed by any subsequent arthroplasty technique as described above. Complications and reasons for failure are described following the classification of Henderson et al. Failure was defined as any complication leading to removal of the initial treatment construct. Failure rates of these groups were compared to primary arthroplasty in a live host bone (Control Group).

Results: Complications happened in 25 (61.0%) of the patients with a THA/TKA in the retained allograft, of these, 24 (58.5%) experienced failure, the most common being structural failure/type III (14, 58.3%). Thirteen patients (81.3%) with an endoprosthesis after removal of the allograft experienced complications, all of whom failed. The most common failure modes were aseptic loosening/type II (4, 30.8%) and infection/type IV (5, 38.5%). Complications in patients with an APC were experienced by 12 (85.7%) patients, 11 (78.6%) of whom failed. The most common failure mode was infection/type IV (4, 36.4%). Significantly ($p < 0.001$) fewer failures were observed in the control group compared to patients with an arthroplasty in a healed allograft.

Conclusions: We found no significant difference in the outcome of treating patients with allograft and subsequent degenerative bone disease with a THA/TKA in a retained allograft, an endoprosthesis after removal of the allograft, or a primary APC, although infection is a significantly greater cause of failure in the latter two. Primary arthroplasty in healed allografts is a less extensive surgery than removing the allograft and shows comparable complication and failure rates.

Level of evidence: Level III, Therapeutic Study.

1. Introduction

Limb-sparing surgery for primary bone sarcomas has significantly improved patient quality of life. With no difference in overall and disease-free survival between amputation and limb-sparing surgery, the latter is the preferred method of treatment in

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oncologic patients when possible [1]. However, the best reconstruction modality after wide resection of bone is still up for discussion. Advantages of osteoarticular allografts over other reconstruction options include bone stock preservation, maintenance of the articular surface of the unaffected bone in the involved joint and the ability to use host ligaments and muscles in order to create a functional joint [2]. This is especially useful in younger and more active patients, who place high demand on constructs. However, osteoarticular allografts are prone to complications (17–70%), which include delayed-union or non-union, tumor recurrence, resorption, fracture, infection, and hardware loosening [2–6]. These complications lead to removal or revision of the allograft in 14–46% of patients [2,6,7]. Around 25–35% of the patients receiving osteoarticular allografts require surgery in the long-term due to degenerative changes of the articular surface of the bone graft [5,7–9]. This can be treated by placing a total hip (THA) or total knee arthroplasty (TKA) in the existing allograft. More recently, the use of endoprosthesis and allograft-prosthesis composites (APC) have also been explored as revision treatment alternatives.

To our knowledge, a comparison of these techniques has not been reported in the literature. The aim of this study is to determine complications and failure rate of the use of a THA/TKA in a healed femoral allograft with degenerative changes. The secondary aim is to compare this revision technique to revision of the entire femoral osteoarticular allograft with a proximal/distal endoprosthesis or a primary APC for management of degenerative bone disease of the allograft. The tertiary study aim is to determine if the use of arthroplasty in a healed femoral allograft is comparable to the use of a primary arthroplasty in the native bone of a non-oncologic patient.

2. Methods

2.1. Study design and setting

This retrospective study included all patients with primary malignant and locally aggressive primary benign bone tumors of the femur that were treated from 1984 to 2014 with bone resection and reconstruction with a proximal or distal femoral osteoarticular allograft followed by a subsequent arthroplasty for management of femoral allograft articular degeneration.

2.2. Participants/study subjects

From our institution's oncology database of 51,334 patients, we identified 9755 patients with the use of ICD-9 codes (170, 170.9, 213, 213.9, 234, 718 and 718.0) for bone tumors of the lower extremity (Fig. 1). We combined this with a search for the terms “allograft” “femur” and “arthroplasty” in radiology reports. We included patients with a history of a primary femoral bone tumor and a femoral osteoarticular allograft placement who received an arthroplasty or endoprosthesis at our institution (Fig. 1). Patients were excluded if they had an allograft placement for metastasis, received an arthroplasty before placement of the allograft, received a unicondylar knee prosthesis, or if no information about the arthroplasty surgery was available. The first arthroplasty surgery for treatment of osteoarticular degeneration is considered the index surgery in this evaluation.

We divided the identified patients into 3 groups: (1) patients in whom the proximal or distal femoral osteoarticular allograft was retained and received a THA or a TKA respectively for management of articular degeneration. In these patients the original osteoarticular allograft was not removed; (2) patients with a failed proximal or distal femoral allograft that was revised to a proximal or distal femur endoprosthesis respectively. In these patients the allograft was removed; (3) patients who received a primary femoral allograft-prosthesis composite (APC) at the time of oncologic excision of the tumor or at the time of revision; both the primary osteoarticular allograft and the prosthesis are placed simultaneously. The indication for all procedures was failure of the allograft placed for primary femoral bone tumor reconstruction and choice of revision modality was made by the attending surgeon. All procedures were executed by one of 6 Orthopedic Oncologists at our institution. Patients with a THA/TKA in a retained osteoarticular allograft were matched 1:1 with non-oncologic patients with a primary THA or TKA in their own femoral bone. Patients were matched by age, gender and joint (hip or knee). Matching for BMI was attempted, but not feasible with the available patients. Due to lack of non-oncologic patients in the youngest age group, we only included 38 patients in the non-oncologic group. We compared all treatment groups to patients with a primary THA or TKA in a healed osteoarticular allograft.

2.3. Variables and outcome measures

We evaluated demographics, oncological, and clinical characteristics using the following outcome variables: age, gender, race, Body Mass Index (BMI), primary tumor type, tumor location, smoking status at time of the index surgery, and metastasis at presentation. Dates were collected for the allograft surgery, the index surgery, subsequent revisions, amputation, death and date of last follow-up. Complications and reasons for failure were described following the classification of Henderson et al., a classification system for failure of limb salvage after allograft or endoprosthetic oncologic reconstructive surgery [10]. Failure was defined as any event leading to removal of the index treatment: removal of the allograft and/or THA/TKA in patients with a THA/TKA in the retained allograft and patients with an APC, and removal of the endoprosthesis in patients with a failed allograft that was revised to a proximal or distal endoprosthesis.

2.4. Study population

A total of 71 patients with primary bone sarcomas or benign locally aggressive bone tumors treated with an allograft and a subsequent arthroplasty modality were identified: 41 patients received a THA/TKA in the retained allograft, 16 were revised to a proximal or distal femoral replacement after removal of the allograft, and 14 were treated with a primary APC at the index oncologic procedure (Table 1).

Patients were mostly male (n = 42, 59.2%) and had a median age of 35 (IQR 23-45) years. Patients were diagnosed most commonly with osteosarcoma (n = 37, 52.1%), chondrosarcoma (n = 13, 18.3%) and giant cell tumor (n = 13, 18.3%). In addition to a wide excision, 37 patients had chemotherapy (preoperative n = 5, postoperative n = 8 or both n = 24) and 12 patients received radiotherapy (preoperative n = 6, postoperative n = 5 or both n = 1). Reasons for revision of the allograft to a THA/TKA or endoprosthesis were bone graft osteoarticular degeneration (n = 30, 52.6%), allograft fracture (n = 17, 29.8%), non-union (n = 5, 8.8%), tumor recurrence (n = 3, 5.3%), joint instability (n = 1, 1.8%) and infection (n = 1, 1.8%). Twenty-four (33.8%) patients had a proximal prosthesis and 47 (66.2%) patients had a distal prosthesis. The types of knee prosthesis placed were non-constrained in 6 (8.5%) patients, semi-constrained in 14 (19.7%) patients and hinged or constrained in 27 (38.0%) patients. All of these were cemented using the same type of cement without antibiotics.