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Factors associated with infection after reconstructive shoulder surgery for proximal humerus tumors

Sjoerd Th. Meijer, MD[a,*], Nuno R. Paulino Pereira, MD[a], Sjoerd P.F.Th. Nota, MD[a], Marco L. Ferrone, MD[b], Joseph H. Schwab, MD, MS[a], Santiago A. Lozano Calderón, MD, PhD[a]

[a]*Department of Orthopaedic Surgery, Orthopaedic Oncology Service, Massachusetts General Hospital–Harvard Medical School, Boston, MA, USA*
[b]*Department of Orthopaedic Surgery, Orthopaedic Oncology Service, Brigham and Women's Hospital–Harvard Medical School, Boston, MA, USA*

Background: The main reconstruction techniques for proximal humerus tumors include osteoarticular allografts (OAs), endoprostheses (EPs), or allograft prosthetic composites (APCs). A common complication is infection, and constructs involving the use of allografts are believed to be at a higher risk of infection. Literature comparing infection rates between different modalities of reconstruction is scarce and underpowered. The study purposes were (1) to determine and compare the prevalence of infection in patients who underwent reconstruction of the proximal humerus including OAs, EPs, and APCs; (2) to identify preoperative, perioperative, and postoperative predictors of infection that might be modifiable; and (3) to present our protocol of treatment in patients with superficial and deep infections.
Methods: We reviewed 150 patients of all ages with proximal humerus tumors treated by an OA, EP, or APC at 2 tertiary institutions. The prevalence of infection for each modality was calculated and compared between groups. We identified potential predictors of infection with stepwise backward multivariate Cox regression analysis.
Results: An infection developed in 19 patients (12%): 5 of 45 (11%) in the OA group, 12 of 85 (14%) in the EP group, and 2 of 20 (10%) in the APC group ($P = .740$). A lower preoperative hemoglobin blood level and low preoperative albumin blood level were independently associated with infection.
Conclusions: We found similar infection rates compared with previously reported series. However, we did not identify a higher infection prevalence in constructs using allografts. Patients with a lower preoperative hemoglobin or albumin level are at higher risk of infection and should undergo optimization before surgery.
Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

Keywords: Proximal humerus tumors; reconstruction; infection; allograft; endoprosthesis; revision

Our institutional review board approved this retrospective study, and a waiver of informed consent was obtained.

*Reprint requests: Sjoerd Th. Meijer, MD, Vondelkade 1, NL-8023aa, Zwolle, The Netherlands.
E-mail address: s.t.meijer@gmail.com (S.T. Meijer).

The shoulder is the second most common location for all primary bone sarcomas. It is the third most common site for osteosarcoma, chondrosarcoma, and Ewing sarcoma.[4] Osteosarcoma and Ewing sarcoma typically occur in teenage and

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young adult patients, whereas chondrosarcoma mostly occurs in the elderly population.[7] Metastatic lesions are also found in this region.[14]

Limb-sparing resection is preferred to amputation in the operative treatment of primary malignant tumors or invasive benign tumors of the proximal aspect of the humerus.[13] The most common surgical reconstruction options include nonmobile (fusion) and mobile techniques. Independent of the method of reconstruction, infection is a common complication that significantly affects functional outcome. In comparison with other complications, there is a role for prevention through modification of risk factors.

Mobile reconstructions include (1) metal endoprostheses (EPs), (2) osteoarticular allografts (OAs), and (3) allograft prosthetic composites (APCs).[3,20] There is no unanimous consensus regarding the best reconstruction technique as all of them have advantages and disadvantages. The concern for infection risk is applicable to all reconstruction modalities. However, the concern is traditionally higher in reconstructions using allografts.[1,8,11,17,20]

To our knowledge, the data are limited comparing infection prevalence and predictors of infection among all 3 modalities of articular reconstruction. This investigation is a retrospective analysis of the experience of our group in the past 30 years at 2 institutes. We sought to (1) assess the prevalence of infection in patients who underwent reconstruction (ie, OA, EP, or APC constructs) for proximal humerus tumors; (2) identify preoperative, perioperative, and postoperative predictors of infection that might be modifiable; and (3) present our protocol of treatment in patients with superficial and deep infections.

Methods

Study design and participants

We established our study cohort by automated systematic query screening of all pathology reports of the departments of orthopedic oncology of 2 hospitals between 1990 and 2013 for "humerus" content. After this first selection, we manually screened all medical records for full eligibility. Moreover, a surgeon's orthopedic oncology registry from one of the institutions was searched for additional eligible patients covering a time frame from 1976 up to 1990.

We identified 150 male and female patients of all ages who underwent wide resection and reconstruction of the proximal humerus for primary bone sarcomas, benign locally aggressive bone tumors, soft-tissue sarcomas, lymphomas, or metastatic lesions of the proximal humerus at 2 tertiary referring hospitals. The distribution of patients between the 2 hospitals was 39 versus 111.

Treatment and follow-up routine

During this process, we included only patients who had the aforementioned pathologic conditions and were treated with a (wide) resection of the proximal humerus and reconstruction with 1 of the 3 modalities of interest: OA, EP, or APC. Use of OA was more common in the late 1990s, with a progressive transition to EP use in early 2000. In recent years, a transition has been made to a more common use of APCs. In general, OAs are used in patients younger than 21 years with primary sarcomas or locally aggressive benign tumors. Older patients with the same scenario are most likely treated with APCs. Patients with metastatic disease are most likely treated with EPs. However, in cases in which treatment of oligometastatic disease with metastasectomy has prognostic implications such as cases of renal cell carcinoma or thyroid adenocarcinoma, there is an increasing trend for treatment with APCs.

Patients were routinely followed up at the outpatient clinic with imaging studies at 2 weeks, 6 weeks, and 3 months postoperatively. Patients with primary malignant bone or soft-tissue tumors were followed up every 3 months for the first 2 years, every 6 months for the following 3 years, and then annually thereafter until a cumulative 10-year follow-up was reached. Patients with benign locally aggressive tumors or low-grade sarcomas were followed up every 6 months for 3 years and annually thereafter until a cumulative 10-year follow-up was completed. Patients with metastatic disease were seen at 3- to 6-month follow-up intervals according to their life expectancy.

In the past 10 years, patients with primary sarcomas and elective and planned resection and reconstruction underwent preoperative optimization. However, the response to treatment was limited, especially in patients who received preoperative chemotherapy. Optimization in patients with metastatic disease was less predictable as the time frame for surgery was not as consistent as for primary bone sarcomas.

Outcome measures and explanatory variables

Our primary outcome measure was infection after proximal humerus reconstruction surgery within patients' follow-up time. All medical records were reviewed to determine if patients had an infection. We classified infections into 2 types: deep and superficial. A deep infection was defined as an infection with clinical symptoms (fevers, chills, and/or rigors), wound drainage, elevated white blood cell (WBC) count, elevated inflammatory markers including erythrocyte sedimentation rate and C-reactive protein, and imaging or intraoperative findings of involvement of the allograft or EP. Imaging findings of allograft or prosthesis involvement included evidence of periostitis or periosteal reaction in the host bone at the junction on radiographs, computed tomography (CT) scans, or magnetic resonance imaging (MRI); bone destruction on radiographs, CT scans, or MRI; or intraosseous fluid collections, bone marrow edema, intraosseous bone abscesses, or soft-tissue inflammation on CT scans or MRI. Superficial infection was defined in the same manner but with no evidence of allograft or EP infection on imaging studies or intraoperatively. Time to infection (in days) was used instead of the traditional subclassification into acute (<2 weeks), subacute (2-6 weeks), and chronic (>6 weeks) infections to describe the timeline per event.

We included the following explanatory variables: sex, age, body mass index in kilograms per square meter, smoking status, affected side, hand dominance, comorbidities (DM), type of tumor, type of reconstruction, duration of procedure, size of resection, preoperative and postoperative hemoglobin level, preoperative and postoperative WBC count, preoperative albumin level, estimated blood loss, intraoperative blood transfusion, use of drains, use of perioperative antibiotics, and resection margins.