PAPER 4

Title: Reverse total shoulder arthroplasty demonstrates improved functional outcomes over hemiarthroplasty following proximal humerus replacement: long-term results of 170 cemented endoprosthetic reconstructions for tumors of the upper extremity

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Background: Given the rarity of musculoskeletal tumors and the associated mortality, long-term survival data following limb salvage surgery is heterogenous and largely limited to small series. Additionally, indications for the use of reverse total shoulder arthroplasty (rTSA) have been expanding to include use for endoprosthetic reconstruction following tumor resection, though data on functional outcomes following rTSA in oncologic patients is limited.

Purpose: The objective of this study was to examine long-term outcomes of cemented stem endoprosthetic reconstruction for tumors of the upper extremity utilizing a large database with up to 30 years of follow-up. Additionally, we sought to compare outcomes of proximal humerus replacement using rTSA with conventional hemiarthroplasty.

Patients and Methods: 170 consecutive patients who underwent limb salvage surgery with endoprosthetic reconstruction for musculoskeletal tumors of the upper extremity between December 1980 and December 2021 were retrospectively reviewed. The average follow-up time of surviving patients was 8.1 years (range: 0.2 – 31.9 years). All follow-up was performed at a single institution. Demographic, oncologic, procedural, and outcome data was analyzed.

Results: 133 proximal humerus, 21 total humerus, and 16 distal humerus endoprostheses in 162 patients were included for analysis. 11 patients had expandable endoprostheses. The tumors were low grade (IA/IB) or benign in 31 patients, high grade (IIA/IIB) in 62, and metastatic carcinoma or stage III primary sarcoma in 69. Kaplan-Meier survivorship analysis revealed 95.0% disease-specific survival at 25 years for patients with low-grade or benign disease (Table 1, Figure 1A). Only 1 patient with clear cell chondrosarcoma died of disease in the low grade/benign group. Disease-specific survival 53.1% at 30-years for patients with high-grade IIA/IIB disease was and 7.7% at 20 years for patients with metastatic disease or stage III primary sarcoma. 44 of 69 (63.8%) of patients in this group died of disease. 30-year implant survival was 82.1% using revision of the stemmed components as the endpoint. Proximal humeral replacements demonstrated 96.7% survival at 25 years, while distal humeral replacements had the lowest survival at 40.1% at 20 years (Figure 1B). Modular implants demonstrated better survival than custom-designed components, with a 25-year survival of 88.1% and 72.7%, respectively. 14 implants (8.2%) required revision of the stemmed components, including 3 for aseptic loosening (1.8%), 6 for structural failure (3.5%), 4 for local recurrence (2.4%), and 1 for infection (0.6%). Local recurrence occurred in 13 patients (7.6%), 9 of whom were treated with amputation (5.3%). Survival of successful limb salvage was 88.9% at 30 years. 6 patients who underwent proximal humerus replacement were treated with reverse total shoulder arthroplasty (rTSA). Average shoulder range of motion was greater following rTSA compared with hemiarthroplasty for forward elevation (112.0° vs 36.7°, p=0.009), abduction (128.3° vs 35.7°, p=0.001), and external rotation (30.0° vs 15.5°, p=0.053).

Conclusions: The present study confirms the long-term durability of cemented endoprosthetic reconstructions for musculoskeletal tumors of the upper extremity, particularly of the proximal humerus. Tumor progression is the most common cause of failure of upper extremity limb salvage. Reverse total shoulder arthroplasty has improved functional outcomes over conventional hemiarthroplasty.

Table 1: Survival Data following Upper Extremity Endoprosthetic Reconstruction

	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years
Implant Survival						
Custom (N=35)	90.8%	81.7%	72.7%	72.7%	72.7%	72.7%
Modular (N=135)	95.4%	92.8%	88.1%	88.1%	88.1%	-
Total Humerus (N=21)	88.0%	65.2%	65.2%	65.2%	65.2%	65.2%
Distal Humerus (N=16)	80.2%	80.2%	40.1%	40.1%	-	-
Proximal Humerus (N=133)	96.7%	96.7%	96.7%	96.7%	96.7%	-
Overall (N=170)	93.4%	89.0%	82.1%	82.1%	82.1%	82.1%
Patient Survival						
Low Grade or Benign (N=32)	95.0%	95.0%	95.0%	95.0%	95.0%	-
High Grade IIA/IIB (N=61)	67.5%	60.3%	51.6%	51.6%	51.6%	51.6%
Stage III/Metastatic (N=69)	29.5%	15.3%	7.7%	7.7%	-	-
Limb Salvage	92.5%	88.9%	88.9%	88.9%	88.9%	88.9%

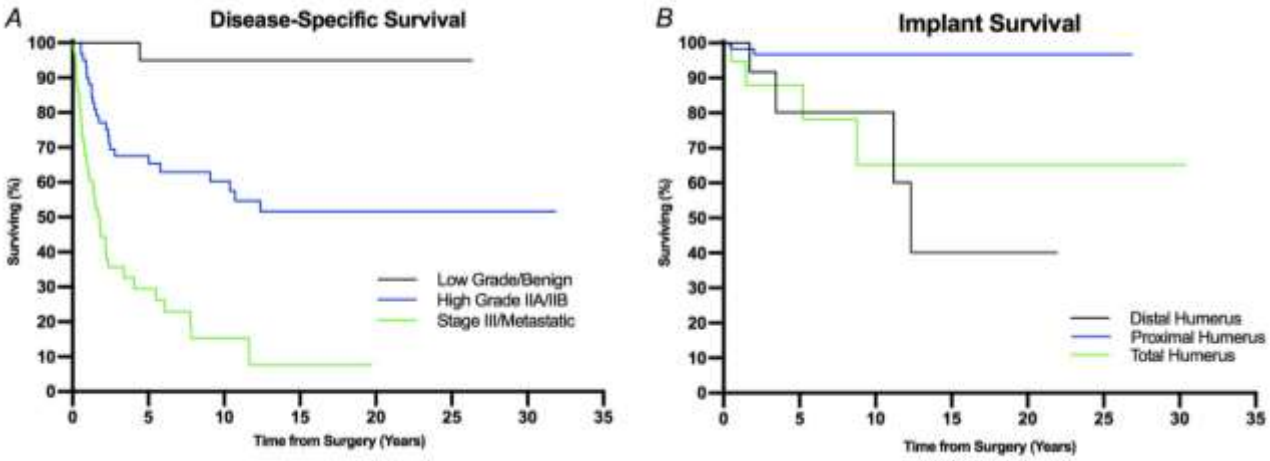

Figure 1A-B: Kaplan-Meier survival curves demonstrating disease-specific patient survival (**Figure 1A**), and implant survival using revision of the stemmed components as the endpoint (**Figure 1B**).