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COMMENTARY

What is the Optimal Reconstruction Option After the Resection of Proximal Humeral Tumors? A Systematic Review

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The authors present a systematic review where 50 of 454 articles were selected on reconstruction for bone loss in both metastatic and primary proximal humerus tumors [1]. Described are a number of reconstruction options, the wide variation of patient demands for which options may be applied, and a number of neuromuscular variables. The review is not intended to be a procedural outline but is designed to show the options for post-tumor reconstruction surgery around the proximal humerus and glenoid. The undertaking of this review required members of a single center where many of these techniques are applied over time. Albeit the patient follow-up in the review is fairly long for some procedures, there is no discussion on specific management for treating more aggressive tumors or those with a high local recurrence rate. The authors do state that there are circumstances where it makes sense to pursue the simplest option with the least risk of complications. On the other hand, more complex procedures might be offered for specific anatomic scenarios along with consideration of the patient's physical demands and tolerance for complications.

In a similar review, the methodology of the literature search is of particular interest [2]. The authors searched PubMed, EMBASE, and the Cochrane Library using a specific search string for title and abstract: (humerus OR shoulder OR "upper limb" OR "upper extremity") AND (neoplasm* OR tumor* OR tumour* OR malign* OR sarcoma* OR cancer*) AND (prosthe* OR autograft OR allograft OR fusion OR flail joint OR Tikhoff linberg OR arthrodesis OR clavicula pro humero OR graft OR forequarter amputation). Hence, those authors would capture all titles that could relate to the proximal humerus (humerus OR shoulder OR "upper limb" OR "upper extremity") but also restrict the search to those that also discuss tumors (neoplasm* OR tumor* OR tumour* OR malign* OR sarcoma* OR cancer*). The second restriction was relative to procedures (prosthe* OR autograft OR allograft OR fusion OR flail joint OR Tikhoff linberg OR arthrodesis OR clavicula pro humero OR graft OR forequarter amputation). The asterisk (*) allows for truncation searching for various endings of the root words. Following their screening of the articles for their exclusion and inclusion criteria as well as removing duplicate records, they had 29 articles that they critically appraised and extracted data from. This is in contrast to the 50 articles considered by Dubina *et al.,* [1]. Teunis *et al*. concluded that a randomized controlled trial has several practical difficulties. Chief is the necessity of a surgeon or group of surgeons being able to confidently perform highly specialized operations. The authors go on to note that a power analysis of 3 reconstructive methods with a difference in Musculoskeletal Tumor Society score of 10% would require 969 patients (alpha 0.05; power 0.8; G*Power 3.1.7) [2].

Tumor stage and aggressiveness are important to procedural selection. In a series of 54 proximal humeral megaprosthetic reconstructions, survival of patients with malignant tumors was 47%, 38%, and 35%, at 5, 10, and 20 years, respectively. Nineteen patients (35.2%) experienced 30 complications (55.5%) [3]. The most common complication was soft tissue failure that required subsequent surgery without implant removal. Unfortunately, articles on reconstructions for more aggressive tumors have a limited number of patients [4 - 6].

Direct comparisons are difficult in a circumstance where a limited number of cases are available. A recent review of 150 reconstructions for a wide variety of tumors, including more aggressive tumors, has been done [7]. Comparing osteoarticular allografts, endoprostheses, or allograft-prosthesis composites, the authors found that the survival rate of the prosthesis was >50%. The key was that there was a trend for a higher risk of failure in the osteoarticular allografts group secondary to the allograft fracture.

The use of irradiation could have an impact on the relative effectiveness of the procedure used in proximal bone loss replacement for tumors. One of the concerns was subsequent infection as a secondary outcome. Authors used a random

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effects meta-analyses of single proportions to estimate pooled rates of events [8]. Add-itionally, meta-regression models were built to assess the effect of moderators (anatomic site and irradiation of the allograft) on the relevant outcomes. Clearly, there would be a relationship to the aggressiveness of these tumors. In this case, the primary outcome was the revision rate. This was for all joints, including the shoulder. The result was that infection rates ranged from 8% (95% CI 4%-16%) for proximal humerus, 23% (95% CI 16%-33%) for proximal tibia, and 23% (95% CI 15%-35%) for acetabulum. There was a difference bet-ween anatomic sites ($p = 0.008$). The net result was that an allograft-prosthesis composite construct after a primary malignant bone tumor varies significantly bet-ween anatomic sites and after irradiation of the allograft. Overall, irradiation of the allograft was significantly associated with revision rates ($p = 0.033$) and infection rates ($p < 0.001$).

There is no question that there is a wide range of options for oncologic and surgical management of defects that occur after tumor resection in the proximal humerus. Investigators have a panoply of limiting factors that make comparative analysis very difficult.

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