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Allograft-prosthetic composite reverse total shoulder arthroplasty for reconstruction of proximal humerus tumor resections

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Background: Proximal humerus reconstructions after resection of tumors are challenging. Early success of the reverse shoulder arthroplasty for reconstructions has recently been reported. The reverse allograft-prosthetic composite offers the advantage of improved glenohumeral stability compared with hemiarthroplasty for proximal humeral reconstructions as it uses the deltoid for stability.
Methods: This article describes the technique for treating proximal humeral tumors, including preoperative planning, biopsy principles, resection pearls, soft tissue tensioning, and specifics about reconstruction using the reverse allograft-prosthetic composite. Two cases are presented along with the functional outcomes with use of this technique. Biomechanical considerations during reconstruction are reviewed, including techniques to improve the deltoid compression force.
Results: Reported instability rates are less with reverse shoulder arthroplasty reconstruction as opposed to hemiarthroplasty or total shoulder arthroplasty reconstructions of tumor resections. Reported functional outcomes are promising for the reverse allograft-prosthetic composite reconstructions, although complications are reported.
Conclusion: Reverse allograft-prosthetic composites are a promising option for proximal humeral reconstructions, although nonunion of the allograft–host bone junction continues to be a challenge for this technique.
Level of evidence: Level IV, Case Report with Narrative Review, Treatment Study.

Keywords: Reverse total shoulder arthroplasty; allograft-prosthetic composite; proximal humerus reconstruction; glenohumeral joint; tumor resections

Limb-sparing resections of malignant tumors of the proximal humerus pose reconstructive challenges. This is largely due to the fact that the glenohumeral joint is inherently unstable and requires an intricate static and dynamic stabilization system through the periarticular soft tissues for function, much of which requires resection to

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obtain a wide margin with bone resections. Many different treatments have been suggested to manage these reconstructive challenges, including allograft arthrodesis,[36] fibular autograft arthrodesis,[6,43] clavicula pro humeri reconstructions,[40] osteoarticular allografts,[14,19,28] endoprostheses,[5,6] and allograft-prosthetic composite (APC) reconstructions.[1,2,7]

APC reconstructions offer the benefit of soft tissue repair for enhanced stability combined with the durability of a prosthetic articular surface. Classically, these have been performed in an ''anatomic'' fashion with either a standard stemmed hemiarthroplasty[1] or a resurfacing hemiarthroplasty. More recently, some investigators have suggested the use of a reverse total shoulder prosthesis combined with allograft[10] as a reconstructive option.

The use of reverse total shoulder arthroplasty has classically been reserved for the elderly, low-demand patient. We have used reverse shoulder arthroplasty in reconstructions of tumor resections in young patients, given reports of excellent functional results. The experience at our institution is that in carefully selected cases, the reverse total shoulder APC reconstruction offers optimal function and stability. The limited data regarding this technique demonstrate encouraging results. The purpose of this paper is to describe the surgical technique for reverse APC reconstructions in detail and to examine the biomechanical considerations of this reconstructive option.

Biopsy

The process of staging a potential malignant tumor of the proximal humerus should begin with physical examination and appropriate imaging studies of the patient and is completed with a biopsy of the lesion. The location of the biopsy track must be carefully considered, as it must be excised with the tumor at the time of resection, especially for tumors with no effective adjuvant treatments. For tumors of the proximal humerus, we perform the biopsy through the anterior third of the deltoid musculature, just lateral to the deltopectoral interval. This allows preservation of the maximal amount of deltoid after resection of the tumor and the biopsy track. The biopsy is done through a small incision, adhering to general biopsy principles. It is preferable that the surgeon performing the definitive resection perform the biopsy.[32,33]

Preoperative planning

As part of the staging process, high-quality magnetic resonance imaging is obtained. This should include the entire humerus to fully evaluate the extent of the tumor with respect to the resection length. Proximally, the T1 axial reconstructions should be scrutinized for margins with respect to the axillary artery and vein, brachial plexus, and axillary nerve. Close inspection should be made of the glenohumeral joint to ensure that tumor has not extended into this space, necessitating extra-articular resection and precluding the use of this technique.

Calculations should be made of the planned resection length as well as of outer cortical and endosteal diameters at the level of the planned resection. This information must be communicated with the allograft provider. In addition, we recommend that all tendon attachments be left on the allograft as they are used to enhance glenohumeral stability.

An appropriate implant must then be selected to span the allograft-host junction by a minimum of 2 cortical diameters. We prefer to span with as much length as possible as afforded by the residual humerus and available prosthetic lengths. In addition to arthroplasty implants, we recommend that the surgeon have available small and large fragment plate and screw sets to apply a unicortical locking plate for added rotational stability of the construct. Short-length locking screws (10 mm or less) should be available to achieve unicortical fixation, avoiding the intramedullary stem and cement mantle.

Resection of the tumor

An ellipse is formed around the biopsy track along with the skin incision (Fig. 1, *A*). The skin incision should extend from the acromioclavicular joint toward the deltoid tubercle and then in line with the anterolateral approach to the humerus. Specific anatomic aspects of the tumor dictate certain portions of the dissection in each case. The deltoid is split in line with the biopsy track so as to leave all contaminated deltoid with the resected tumor. A carefully planned biopsy should allow maximal preservation of the deltoid. The dissection then is carried into the subdeltoid bursa. The biopsy track is dissected down where it enters the humerus (Fig. 1, *B*), and care is taken to avoid avulsion to the biopsy track from the proximal humerus.

The axillary nerve is identified by palpation along the inferior aspect of the subscapularis. The subscapularis and pectoralis are tenotomized from the proximal humerus, leaving a safe margin. The anterior capsulotomy is performed with the subscapularis takedown. The remaining rotator cuff muscles as well as superior and posterior capsule are identified and transected, leaving a safe margin but preserving the maximum length possible. The long head of the biceps is tenotomized at the rotator interval. The latissimus dorsi and teres major should then be identified and transected with a safe margin. The axillary nerve is protected and the inferior capsule released from the humerus. This should completely deliver the proximal humerus from the glenoid.

The dissection is then carried distal as far as the tumor requires on the basis of preoperative planning. If possible, the deltoid insertion should be preserved. If the deltoid insertion cannot be spared because of tumor involvement, it