



CASE REPORT

# Pelvis allograft with constrained total hip arthroplasty for shoulder reconstruction



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Malignant tumors of the upper extremity were treated historically with forequarter amputation.<sup>7</sup> In recent decades, there have been major advancements in limb salvage procedures and reconstruction of a cosmetically pleasing, functional upper extremity. This is accomplished while performing surgical excision according to oncologic principles and providing the best opportunity for a disease-free outcome.

Currently, approximately 95% of patients with sarcomas about the shoulder girdle can be treated safely with limb-sparing resections.<sup>7</sup> Reconstruction of the upper extremity focuses on restoring native shoulder contour, providing a functionally stable shoulder joint, and preserving elbow and hand function. Reconstructions of the proximal humerus are typically achieved with megaprotheses, either alone or as part of allo-prosthetic composites. Scapular reconstructions can be performed with allografts or custom metallic implants.<sup>8,9</sup> When both the proximal humerus and scapula require reconstruction, one option is to connect the humerus to the clavicle without scapular reconstruction. Although this method provides an inexpensive option that requires minimal soft-tissue coverage, it is not cosmetically appealing and lacks a stable post to provide a fulcrum for resisted elbow flexion.

In our case, we describe a unique technique of shoulder girdle reconstruction after total scapulectomy and proximal humerus resection (Tikhoff-Linberg procedure) using an acetabular allograft with a total hip acetabular component and a constrained liner to provide a stable joint with a cosmetically acceptable outcome.

## Case presentation

A 29-year-old man presented with recurrent high-grade osteosarcoma of the right upper extremity localized to the scapula. Six months prior, he was treated at an outside institution with surgery consisting only of proximal humerus resection and reconstruction with a megaprosthesis (Fig. 1). The patient was subsequently treated with an extended course of multiagent chemotherapy. After a lengthy discussion of surgical options, the patient decided to pursue limb salvage surgery for his dominant extremity. On the basis of imaging of the affected area (Figs. 2 and 3), the entire scapula and the proximal humerus needed to be resected via a classic Tikhoff-Linberg procedure.

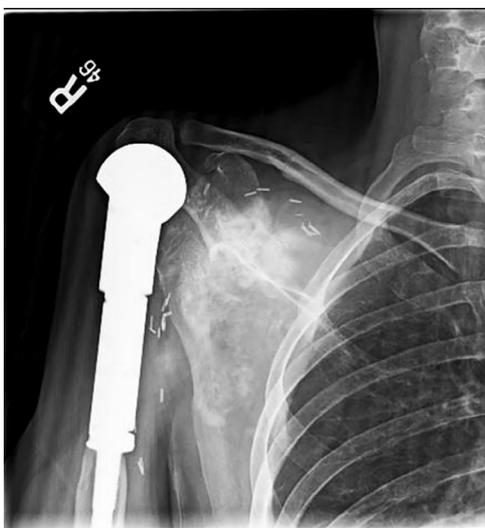
## Technique

A total scapulectomy was performed en bloc with the previous proximal humerus component. The anterior flap was dissected to the clavicle, and the clavicle was disarticulated at the acromioclavicular joint and underwent osteotomy,

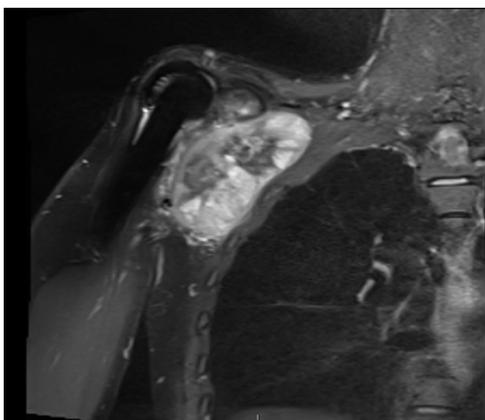
Institutional review board approval was not required.

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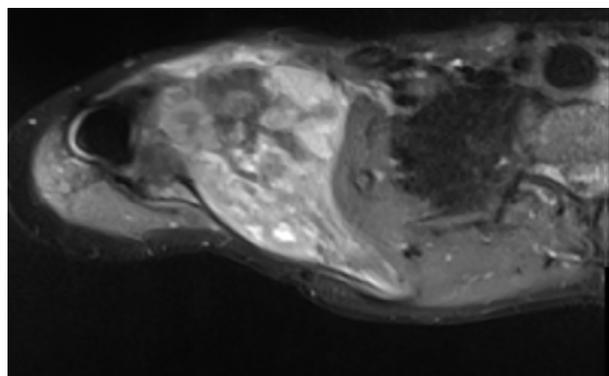
**Figure 1** Anteroposterior radiograph of the shoulder showing local recurrence of osteosarcoma of the shoulder girdle after proximal humerus resection and replacement.



**Figure 2** Magnetic resonance image of the shoulder (coronal reconstruction) showing the soft-tissue extent of the 9 × 7-cm mass from the anterior chest wall extending posteriorly into the axilla.

leaving 3 cm medially. The posterior flap was fashioned with the latissimus dorsi freed to allow for soft-tissue reconstruction. The serratus anterior was kept with the chest wall, but the scapula was excised en bloc off the chest wall and ribs. The axillary vessels and brachial plexus were spared, but part of the tumor was attached to the previous proximal humerus replacement. The proximal humerus segment was dissociated from the stem and removed with the tumor. The tumor was resected en bloc from the patient.

The original reconstruction plan had been to use a scapular allograft. The available allograft was found to be inadequately sized to reconstruct the defect and would not have resulted in a stable shoulder joint. Because the implanted proximal humerus prosthesis could accept a femoral head, a fresh-frozen hemipelvis readily available from the tissue bank was chosen for reconstruction. The allograft was thawed in warm saline solution. The best orientation of the hemipelvis

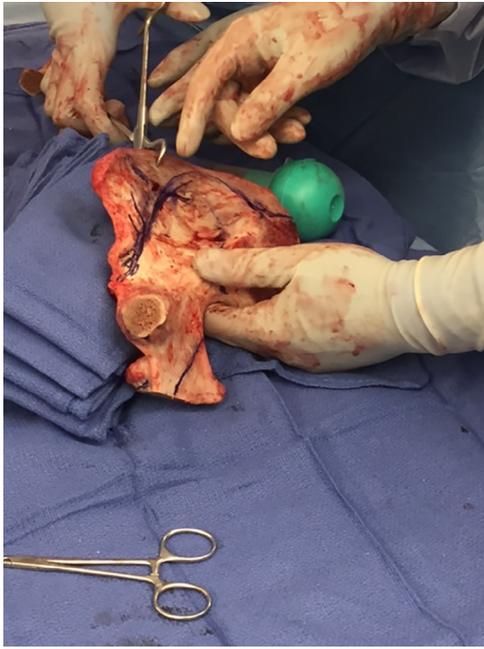


**Figure 3** Magnetic resonance image of the shoulder (axial reconstruction) showing the soft-tissue extent of the tumor encasing branches of the brachial plexus and abutting the proximal humerus prosthesis.

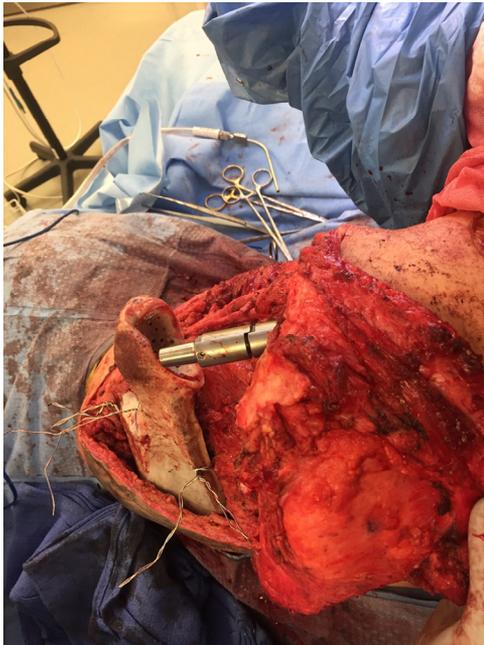


**Figure 4** Intraoperative photograph showing placement of the pelvis allograft along the chest wall to determine the best orientation for the graft.

that followed the natural curvature of the chest wall was the upside-down orientation (Fig. 4). A power saw was used to sculpt the graft, cutting part of the iliac crest and contouring it until it fit well along the patient's chest wall (Fig. 5). Drill holes were made through the pelvis, and 3 Luque wires were passed through and under the ribs, with care taken not to injure the pleura (Fig. 6). This secured the pelvis to the chest wall with the acetabulum in a position level with the contralateral glenoid. We then reconstructed the proximal humerus using a modular proximal humerus megaprosthesis. A constrained acetabular hip liner was cemented into the acetabulum where the glenoid would have been. A constrained femoral head was placed on the proximal humerus replacement and reduced into the liner (Fig. 7). This resulted in a

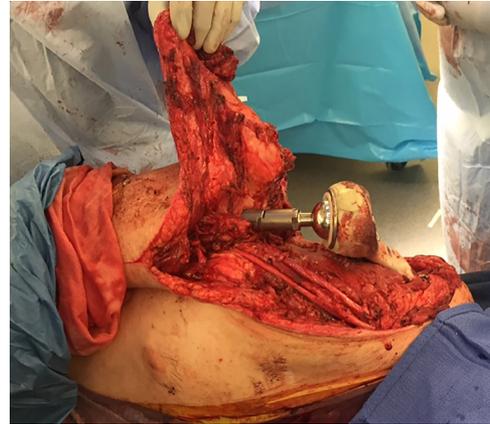


**Figure 5** Intraoperative photograph of the planned cuts on the allograft to achieve an adequate fit.



**Figure 6** Intraoperative photograph showing the hemipelvis allograft secured to the chest wall using 3 Luque wires passed through and under the ribs. The acetabular liner has not yet been implanted.

constrained shoulder with a range of forward flexion to 60° before dislocation of the head. Soft-tissue coverage was accomplished with a latissimus dorsi flap. A shoulder immobilizer was used after surgery to limit the range of motion of the shoulder and to prevent dislocation of the prosthesis. The patient had an uneventful postoperative course.



**Figure 7** Intraoperative radiograph of the shoulder with a proximal humerus prosthesis reduced into a cemented constrained acetabular liner in the allograft with the remaining brachial plexus and vessels crossing over the chest wall in the anterior part of the wound.

### Postoperative follow-up

At 6 months' follow-up, the patient was doing well with healed wounds and no pain with passive range of motion of the shoulder. He was able to lift at least 4.5 kg with the affected extremity. He had full strength in wrist flexion and extension, as well as in the hand intrinsic muscle. Anteroposterior radiographs showed breakage of the cerclage wires (Fig. 8). At 2 years' follow-up, the prosthesis remained intact, adequately positioned, and well integrated (Fig. 9). The patient was working full time as a farmer.



**Figure 8** Anteroposterior radiograph of the humerus 6 months after surgery showing the prosthesis was intact and adequately positioned.



**Figure 9** Anteroposterior radiograph of the shoulder at 2 years' follow-up showing the stable prosthesis. Broken Luque wires have been left in place.

## Discussion

Soft-tissue and bone sarcomas account for fewer than 1% of all adult malignancies, and only 13% of these are found in the upper extremity.<sup>7</sup> Limb-sparing surgery is the preferred treatment in most cases because of effective systemic therapy and advances in reconstruction options.<sup>4,7</sup> The Tikhoff-Linberg resection and its variations are surgical options for malignancies about the shoulder girdle. Historically, these resections were not followed by reconstruction, and the upper extremity was left flail.<sup>3</sup> This led to traction neurapraxia on the neurovascular bundle and left the patient with a poor cosmetic outcome while providing little in the way of function. The first attempts at reconstruction to provide a stable joint involved the use of a Küntscher nail within the remaining humerus and suspension from the distal clavicle or the chest wall.<sup>11,13</sup> Although this reconstruction was relatively stable and reduced the incidence of traction neurapraxia, there were frequent complications and patients were left with poor upper-extremity function and appearance.<sup>11</sup> Advancements and experience with reconstruction of other anatomic locations led to the investigation of alternative reconstructive techniques in the upper extremity. These include the use of endoprostheses as well as cadaveric allograft for reconstruction of the osseous defect after resection.<sup>2,5</sup>

Much of the literature on shoulder girdle reconstruction has focused on the use of endoprostheses. Several studies have shown good functional and cosmetic outcomes when using these prosthetic constructs, but instability is a concern.<sup>2,12</sup> A review of 59 patients by Asavamongkolkul et al<sup>2</sup> showed an 11% incidence of glenohumeral dislocation after reconstruction with an endoprosthesis. Newer generations of these endoprostheses have been designed with a constrained joint, but the stability and functionality of these constructs depend on the ability to maintain adequate soft-tissue balancing around the endoprostheses.<sup>2</sup> This varies between patients according to the unique characteristics of their malignancy and the tissue reserve that remains after resection of the mass.

Few reports have examined the use of allograft in the reconstruction of the upper extremity after total scapulectomy.<sup>3,14,15</sup> Mnaymneh et al<sup>8,9</sup> reported on 5 cases of upper-extremity reconstruction using scapular allograft in which all patients had good cosmetic and functional outcomes. They found that functionality after allograft reconstruction is directly proportional to the amount of rotator cuff musculature that can be salvaged. They concluded that allografts are a reasonable biological alternative for shoulder reconstruction and provide a stable functional joint while restoring shoulder contour. Lee et al<sup>6</sup> reported on 2 patients in whom an acetabular allograft was used for scapular reconstruction, leading to good functional and cosmetic outcomes. They stated that the ball-and-socket geometry of the acetabulum is inherently stable and maintains the center of rotation within the joint. The native glenohumeral articulation provides minimal static stability and relies on the rotator cuff musculature to provide dynamic stability and maintain the humeral head within the joint. In cases with extensive soft-tissue loss, the use of an acetabular allograft can increase the static stability of the joint and limit the risk of postoperative complications such as dislocation. In addition, the presence of a capsule and soft tissue on the allograft allows for easier reattachment of remaining shoulder soft tissue.<sup>6</sup>

Although several methods have been described for shoulder girdle reconstruction after oncologic resections, the type of reconstruction or prosthesis used may not affect outcomes. O'Connor et al<sup>10</sup> reported on 57 patients with various shoulder girdle resections and reconstructions and found that nearly all reconstructive methods, whether using metal or allograft, led to satisfactory outcomes regarding pain, appearance, and function. They concluded that the reconstruction method should be one that meets the needs and expectations of the patient.

Angelini et al<sup>1</sup> reviewed 54 patients with tumors around the shoulder treated with extra-articular shoulder resections and proximal humeral megaprosthesis reconstructions from 1985 to 2012. They found that the tumor stage and volume, as well as type of resection, were important predictors of patient survival. The survival rates of patients with malignant tumors were 47%, 38%, and 35% at 5, 10, and 20 years, respectively. The survival rates of reconstructions were 56% at 10 years and 48% at 20 years, with a high complication rate (55.5%), the most common being soft-tissue failure.

In the present case, the patient's desire was to avoid amputation and obtain a cosmetically acceptable outcome with some, if minimal, function. Given the extent of soft-tissue resection required to achieve negative margins, a stable shoulder reconstruction would be challenging. A constrained device is ideal in this setting. Constrained scapular devices must be custom made, which typically takes several weeks. Allografts are readily available, as are constrained hip components. This allo-prosthetic composite alternative is an attractive alternative to a custom device. This construct met the patient's expectations by providing an esthetically acceptable shoulder

contour and a stable post for elbow flexion against resistance while preserving hand function.

## Conclusion

To our knowledge, this is the first report of using a combination of a pelvic allograft with a constrained total hip prosthesis for upper-extremity reconstruction after malignancy resection. We believe that this construct is an attractive alternative to scapular implants because it is inherently stable and provides an esthetically pleasing result.

## Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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