

# Utilitarian Shoulder Approach for Malignant Tumor Resection

James C. Wittig, MD\*      Kristen L. Kellar-Graney, BS\$  
 Jacob Bickels, MDt      Isaac Meller, MDt  
 Felasfa Wodajo, MDT      Martin M. Malawer, MDT

*Malignant tumors involving the shoulder girdle can arise from four distinct locations: the proximal humerus, scapula, periscapular muscles, and axillary structures. This article describes a utilitarian shoulder approach that can be used to*

The utilitarian shoulder approach can be used to resect shoulder girdle tumors. It accomplishes wide exposure of all shoulder girdle tumors and the adjacent neurovascular structures, facilitating mobilization and protection of all key structures and enabling adequate tumor resection.

Malignant tumors involving the shoulder girdle can arise from four distinct locations: the proximal humerus, scapula, periscapular muscles, and axillary structures (eg, axillary lymph nodes, nerves, and vessels). Surgical resection often is technically challenging as most tumors in these locations

involve multiple muscles, and often require resection via anterior and posterior exposure (Figure 1). An adequate surgical margin and a safe resection are best facilitated by complete exposure of the tumor and axillary vessels/brachial plexus.

To reduce the surgical complexity and complications associated with limb-sparing surgery for tumors in this region, the senior author (M.M.M.) has developed an approach for resection, termed the utilitarian shoulder approach, which accomplishes safe exposure of the neurovascular structures; permits a reliable, wide excision of all tumors; and reduces morbidity associated with resections in this difficult anatomic area.<sup>1</sup>

The utilitarian shoulder approach is based on an incision with three arms: anterior (A), posterior (B), and anteroinferior (C) (Figure 2). The anterior approach (extended deltopectoral groove incision A) combined with detachment and mobilization of the pectoralis major and strap muscles (eg, coracobrachialis, short head of the biceps, pectoralis major), permits complete visualization of neurovascular structures (eg, the infraclavicular

*From the \*Department of Orthopedic Surgery, New York University Medical Center and the Hospital for Joint Diseases, New York, NY; the †National Unit of Orthopedic Oncology, Tel-Avi Sourasky Medical Center, Tel-Aviv, Israel; and the \$Division of Orthopedic Oncology, Washington Cancer Institute, Washington Hospital Center, Washington, DC.*

*Reprint requests: Martin M. Malawer, MD, Division of Orthopedic Oncology, Ste C-217-110 Irving St NW, Washington, DC 20010.*

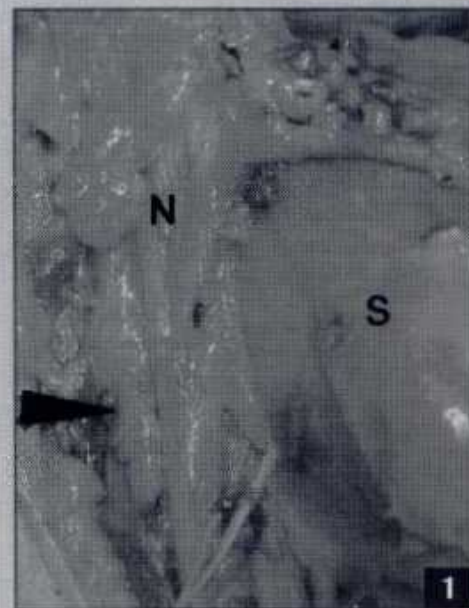
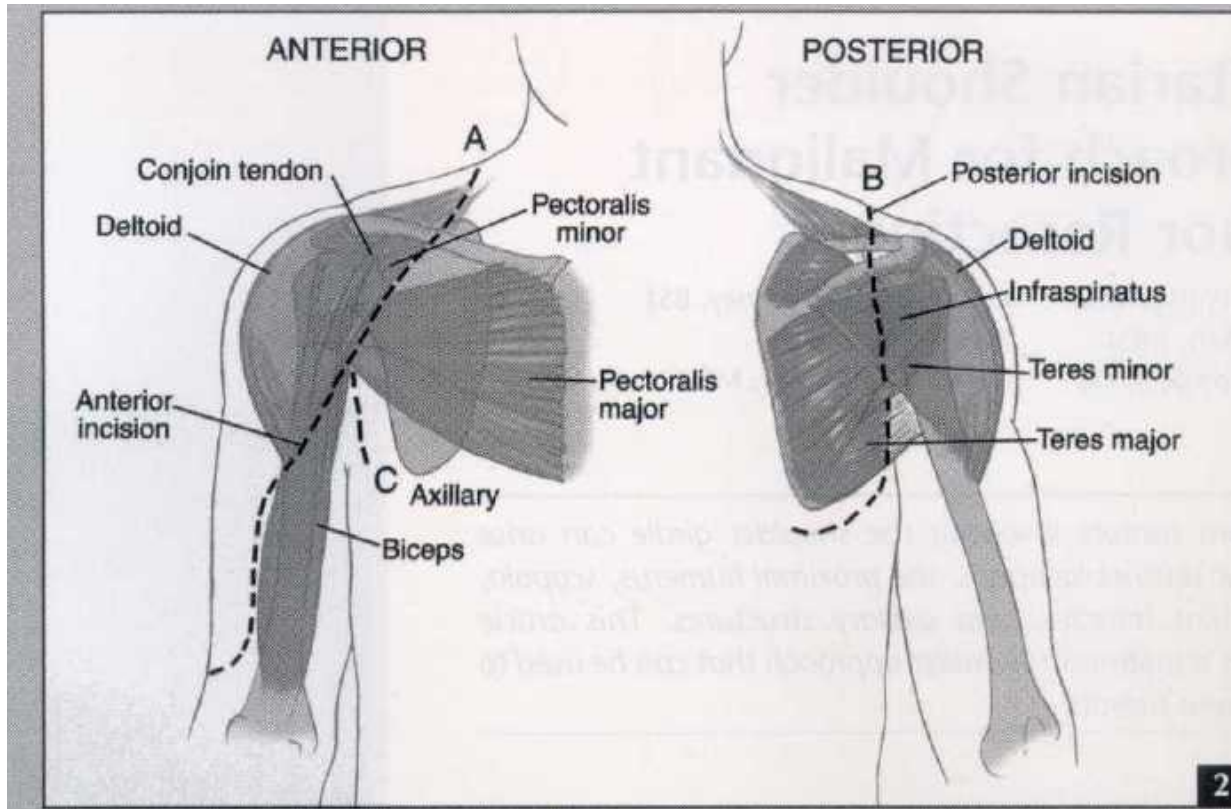


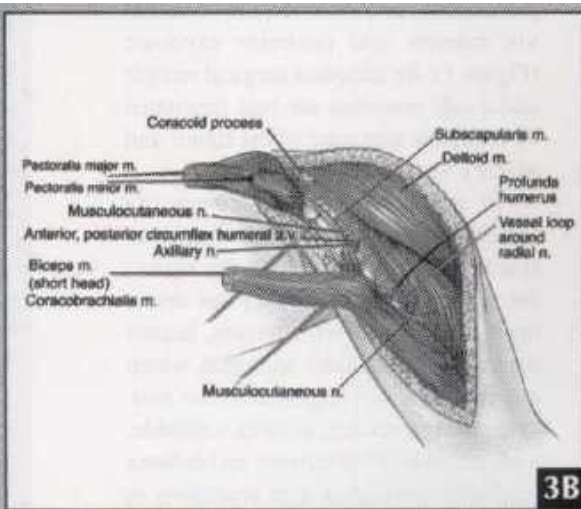
Figure 1: High-grade undifferentiated sarcoma arising from the subscapularis muscle. Sarcomas arising in the shoulder girdle region are frequently large and displace the neurovascular bundle (arrowhead demonstrates axillary fat; vessel loop surrounds the axillary nerve). Abbreviations: N=neurovascular bundle and S=subscapular tumor.



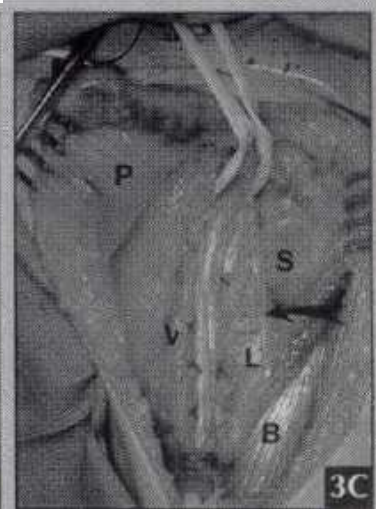
2



3A



3B



3C

brachial plexus and axillary vessels). The posterior approach (B incision) accomplishes wide exposure of the scapula, deltoid, trapezius, rhomboids, and latissimus dorsi. The anteroinferior axillary incision (incision C) is a modification of the anterior approach that extends medially from the deltopectoral groove and curves into the axilla. It provides wide exposure of the axillary contents and is useful for large tumors in this area.

The success of the utilitarian shoulder approach is based on wide exposure and exploration of the tumor, axillary vessels, and brachial plexus. This facilitates mobilization and protection of all key structures amenable to preservation. Anterior and posterior approaches can be combined, which is particularly useful for large scapular and proximal humeral tumors. For smaller or low-grade tumors, any portion of any arm can be used or extended, depending on the anatomic location and extent of the tumor. In instances where the tumor is deemed unresectable after anterior exploration, the approach can be converted to a forequarter amputation without unnecessary contamination of skin and muscle flaps.

## SURGICAL TECHNIQUES

### Utilitarian Incision

The utilitarian incision consists of three arms (A, B, and C) (Figure 2). Each arm of the incision results in the formation of a skin flap in which the base is at least as wide as the length of the flap. The anterior arm (A) is used primarily for proximal humerus resections and is modified for axillary tumors (C). The incision is extended posterolaterally over the shoulder (portion of B incision) for an extra-articular proximal humerus resection. A portion of the anterior incision (A) and the entire posterior incision (B) are used for extra-articular scapula resections and total scapulectomies. Any combination of incisions can be used for resecting soft-tissue sarcomas; this decision is based on the muscle of origin. Each arm is used to varying

### Take Home "Pearl"...

"The utilitarian incision consists of three arms (A, B, and C). Each arm of the incision results in the formation of a skin flap in which the base is at least as wide as the length of the flap. The anterior arm (A) is used primarily for proximal humerus resections and is modified for axillary tumors (C). The incision is extended posterolaterally over the shoulder (portion of B incision) for an extra-articular proximal humerus resection. A portion of the anterior incision and the entire posterior incision are used for extra-articular scapula resections and total scapulectomies."

degrees depending on the anatomic location and extent of the tumor.

We recommend an anterior approach be performed first so immediate exploration and mobilization of the brachial plexus can occur. At this point, if the tumor is deemed unresectable, the procedure can be converted to a forequarter amputation. Following the incision, skin flaps (fasciocutaneous, if possible) are raised to gain adequate exposure.

### Incision A: Anterior Approach

The anterior incision (extended deltopectoral incision) extends from the middle third of the clavicle and passes 1 cm medial to the coracoid process, across the axillary fold, and distally along the anteromedial aspect of the arm, following the course of the neurovascular bundle. Medial and lateral fasciocutaneous skin flaps are raised. The key step for exposing the neurovascular bundle is releasing the pectoralis major from its humeral insertion and releasing the strap muscles (eg, pectoralis minor, short head of the biceps, and coracobrachialis) from their insertions on the coracoid (Figure 3).

After the pectoralis major is released, the musculocutaneous nerve is dissected at the point where it enters the coracobrachialis and short head of the biceps (2-7 cm inferior to the coracoid). The

brachialis are then released from their coracoid insertions while protecting the underlying plexus and musculocutaneous nerve. The pectoralis minor is released from the coracoid (Figure 3). The entire neurovascular bundle from the clavicle to the proximal humerus can now be visualized.

Next, the axillary nerve, at the lower border of the subscapularis muscle, and the radial nerve, at the lower border of the latissimus dorsi muscle, are identified and surrounded with vessel loops. Anterior and posterior humeral circumflex vessels are isolated and doubly lig-

### Share Your "Pearls"

#### Do you have a technique or tip to share?

ORTHOPEDICS wants to hear from you. Send submissions to Steven F. Harwin, MD, % ORTHOPEDICS, 6900 Grove Rd, Thorofare, NJ 08086; or contact Robin J. Vadel, Managing Editor, at (856) 848-1000; fax (856) 848-6091; e-mail rvadel@slackinc.com; or www.slack-inc.com/ortho.htm.

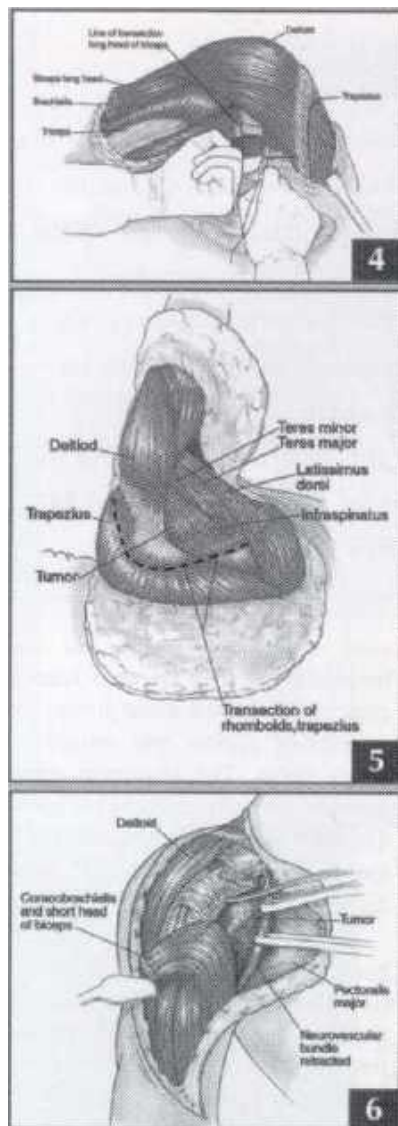


Figure 4: Extra-articular proximal humerus resection. (Reprinted with permission from Wittig JC et al. Limb-sparing surgery for high grade sarcomas of the proximal humerus. *Techniques in Shoulder and Elbow Surgery*. 2001; 2:54-69. Copyright © 2001, Lippincott Williams & Wilkins). Figure 5: Wide posterior exposure of the scapula. Figure 6: Resection of an axillary tumor. Releasing the pectoralis major and strap muscles using the anteroinferior incision provides wide exposure for axillary tumors and adjacent neurovascular structures. The curved arrow indicates the musculocutaneous nerve; the vessel loop is surrounding the axillary nerve. Mobilization of the neurovascular bundle is accomplished following ligation of humeral circumflex vessels and subscapular vessels (wide arrows show lateral thoracic and subscapular vessels). Abbreviations: B=retracted biceps (short head), P=pectoralis major, and S=subscapular sarcoma.

ated with #0 silk ties and metallic clips. This step is crucial for mobilization of the neurovascular bundle. The axillary nerve is ligated for proximal humerus tumors that require an extra-articular resection. Scapular and large axillary tumors may require ligation of any of the following structures: upper and lower subscapular nerves, subscapular artery, thoracodorsal nerve, lateral thoracic artery, and long thoracic nerve.

*Incision B: Posterior Incision*

The posterior incision begins superiorly over the shoulder, extending from the clavicular origin of the extended deltopectoral (anterior) incision. It follows the axillary border of the scapula to its tip and curves medially approximately 2-3 cm to permit construction of a large, medially-based flap. A fasciocutaneous (not subcutaneous) flap is used if deemed oncologically safe.

Traditional scapular incisions have been constructed obliquely across the body of the scapula and have not allowed for adequate visualization and mobilization of the periscapular muscles.<sup>11</sup> This medially-based flap not only fully exposes the scapula, rhomboids, levator scapulae, and trapezius muscles, but also permits entrance to the posterior axillary space. A lateral flap also is developed that exposes the deltoid, proximal triceps, and teres minor and teres major muscles. Thus, all appropriate muscles can be resected or preserved and later transferred during the reconstruction phase of the procedure. For scapular tumors, early exploration of the chest wall once the rhomboid muscles are detached is performed initially to determine chest wall involvement and hence operability.

*Incision C: Axillary Approach*

The axillary incision is useful for resecting large axillary tumors that fill the axillary space (Figure 2). The axillary incision is a 6-cm extension of the anterior incision. It courses medial and inferior to the pectoralis major toward the base of the axillary space. It permits complete visualization of the inferior

aspect of the axilla and lateral chest wall. The anterior component permits mobilization of the neurovascular structures whereas the axillary extension allows access to the axillary contents.

**TUMOR RESECTION**

*Proximal Humerus Tumors*

When an extra-articular resection of the proximal humerus is performed, anterior exposure of the neurovascular structure and ligation of the axillary nerve is performed first. Then the incision is extended posterolaterally (portion of B), over the top of the shoulder (Figure 4). A medially-based fasciocutaneous skin flap is developed. The trapezius is released from the scapula and lateral clavicle. An incision is then made through the rotator cuff medial to the coracoid, extending from the subscapularis and passing sequentially through the supraspinatus, infraspinatus, and teres minor muscles. The latisimus dorsi and teres major are then released from the proximal humerus.

Osteotomies are made through the humeral shaft at least 2 cm distal to the anatomic extent of the tumor, through the lateral one-third of the clavicle, and through the scapula medial to the coracoid. An extra-articular resection is completed (type VB resection, Malawer classification). Care must be taken at this point to avoid unnecessary traction on the axillary artery and the brachial plexus. The resected specimen consists of the proximal humerus removed en bloc with the lateral portion of the scapula, intact glenohumeral capsule, overlying rotator cuff, proximal portion of the long head of the biceps tendon, and the deltoid muscle. For an intra-articular resection (type IA resection, Malawer classification), only the anterior arm of the approach is used. The deltoid, rotator cuff, and capsule are released from the humerus. The axillary nerve is preserved. Humeral osteotomy is performed.

*Scapular Tumors*

In an extra-articular scapula resection, following neurovascular expo-

ration (A incision), the incision is extended posterolaterally to create a wide, medially-based skin flap (B incision) (Figure 5). All periscapular muscles, specifically the trapezius, rhomboids, levator scapulae, and latissimus dorsi, are sequentially released and tagged with a #0 nonabsorbable suture. An osteotomy is made through the proximal humerus at the inferior border of the subscapularis muscle (extra-articular osteotomy). A clavicular osteotomy is made through the lateral one-third of the clavicle. The scapula and tumor are removed en bloc with rotator cuff, capsule, and proximal humerus (Malawer type IVA resection).

#### Axillary Tumors

Incision C is used for axillary tumors. Release and mobilization of the pectoralis major muscle toward the chest wall provides excellent exposure of the entire axilla. Following dissection and mobilization of the brachial plexus and neurovascular structures from the tumor and ligation of the tethering neurovascular structures, the tumor can be removed en bloc (Figure 6).

#### Soft-Tissue Tumors

Soft-tissue sarcomas that arise in proximity to the neurovascular bundle are approached in a similar manner to that of axillary tumors. The utilitarian incision that is used depends on the muscle origin and the extent of the tumor. In general, at least the entire muscle of origin is resected for high-grade sarcomas. Soft-tissue sarcomas rarely invade adjacent bony structures and rarely require en bloc resection with a portion of the shoulder girdle. If bony invasion occurs, resection and reconstruction follow the principles outlined for scapular or proximal humerus tumors.

### RECONSTRUCTION AND CLOSURE

Following resection, bony reconstruction is performed for tumors that required a major bony resection. We recommend endoprosthetic reconstruc-

tion of the proximal humerus or scapula, although the utilitarian approach for resection described herein may be used in conjunction with any reconstruction method.

Following bony reconstruction, soft-tissue reconstruction commences. The short head of the biceps is tenodesed proximally to the coracoid (intra-articular proximal humerus reconstruction) or to the clavicle (extra-articular proximal humerus reconstruction) or pectoralis major (total scapula reconstruction). The pectoralis minor also is tenodesed back to its origin, when possible, or to the scapula to protect the neurovascular structures. The pectoralis major is repaired to its humeral insertion, or in cases requiring extra-articular proximal humerus reconstruction, transferred to cover the prosthesis with soft tissues. The latissimus dorsi may be transferred laterally to function as an external rotator following extra-articular proximal humerus resection.

In total scapula reconstruction, the periscapular muscles are tenodesed to the prosthesis with heavy nonabsorbable sutures or tapes. In total scapula reconstruction, the periscapular muscles are tenodesed to the prosthesis in a manner that covers the entire prosthesis with muscle. Following isolated axillary tumor resection, the distal (numeral) cut edge of the latissimus dorsi is rotated into the defect and sutured to the superficial surface of the subscapularis muscle to fill the dead space. Large-bore closed suction drains are routinely placed prior to skin closure (Figure 7).

### DISCUSSION

Traditionally, shoulder girdle tumors often have been resected through exposures that provide poor visualization of neurovascular structures.<sup>6</sup> Proximal

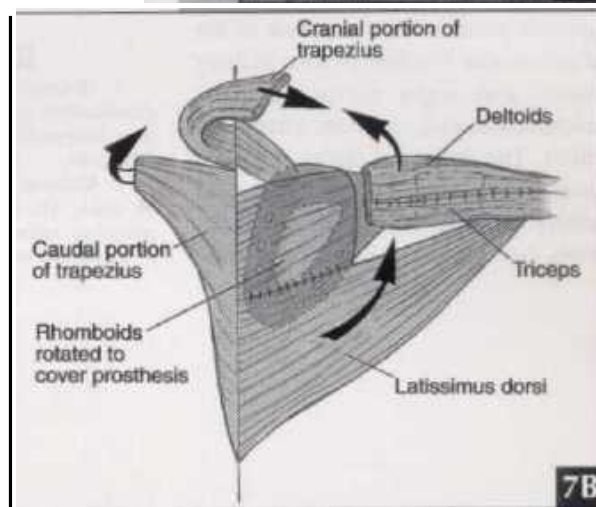
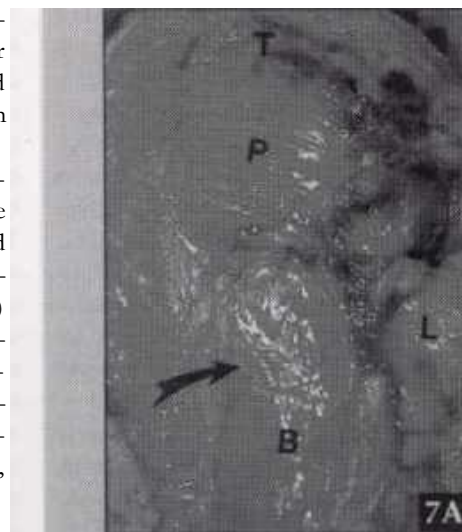


Figure 7: Reconstruction and closure. For an extra-articular proximal humerus reconstruction, the short head of the biceps is tenodesed to the clavicle (A). The pectoralis major is transferred to the lateral border of the scapula and provides excellent soft-tissue coverage. The trapezius muscle is transferred to the superior border of the pectoralis major and the latissimus dorsi is rerouted to restore external rotation. Abbreviations: B=short head of the biceps muscle, L=latissimus dorsi muscle, P=pectoralis major, and T=trapezius. An epineural catheter (curved arrow) is routinely inserted into the brachial plexus for postoperative bupivacaine infusion. (Reprinted with permission from Wittig JC et al. Limb-sparing surgery for high grade sarcomas of the proximal humerus. *Techniques in Shoulder and Elbow Surgery*. 2001; 2:54-69. Copyright © 2001, Lippincott Williams & Wilkins.) Schematic showing muscle transfers for soft-tissue coverage of a total scapular prosthesis (B).

humeral tumors have been resected through a limited anterior deltopectoral approach; scapular and periscapular tumors through a limited oblique surgical incision based over the posterior scapula.<sup>1</sup> Axillary tumors have been resected through a limited inferiorly-based axillary approach." In all cases, poor exposure of the brachial plexus and axillary vessels may result in unnecessary complications and the inability to resect the tumor with adequate surgical margins.<sup>8,9</sup>

We describe a utilitarian approach that has been used for surgical resection of proximal humerus, scapula, and axillary tumors in 155 patients. This approach permits wide exposure of the infraclavicular brachial plexus, axillary vessels, and major nerves, (axillary, musculocutaneous, median, ulnar, and radial). The incision consists of three components: anterior, posterior, and axillary. Any portion, or all three elements, can be used for resection of bone

and soft-tissue tumors of the proximal humerus, scapula, periscapular muscles, and axilla. Releasing the pectoralis major from the proximal humerus and the coracoid insertions of the strap muscles is the key to exposure of the brachial plexus and axillary vessels. This ensures safe mobilization of major neurovascular structures. Optimal surgical margins are facilitated, and unnecessary complications (eg, inadvertent neurovascular injury) and local recurrence are minimized. Pectoralis major, triceps, and biceps strength return with rehabilitation. This approach is recommended for major resection of bone and soft-tissue tumors of the shoulder girdle.

## REFERENCES

1. Malawer MM, Meller I. A new surgical classification system for shoulder girdle resection: analysis of 38 patients. *Clin Orthop*. 1981; 267:33-44.
2. Malawer MM, Sugarbaker PH, Lampert M, Baker AR, Geber NL. The Tikhoff-Linberg procedure: report of ten patients and presentation of a modified technique for tumors of the proximal humerus. *Surgery*. 1985; 97:518-528.
3. Malawer MM. Tumors of the shoulder girdle: technique of resection and description of the surgical classification system. *Orthop Clin North Am*. 1991; 22:73-75.
4. Malawer MM. Surgical techniques and results of limb-sparing surgery for high-grade bone sarcomas of the knee and shoulder. *Orthopedics*. 1985; 8:597-607.
5. Enneking WE. Shoulder girdle. In: *Musculoskeletal Tumor Surgery*. New York, NY: Churchill Livingstone; 1983:378-410.
6. Papiouannou AN, Francis KC. Scapulectomy for the treatment of primary malignant tumors of the scapula. *Clin Orthop*. 1965; 41:125-130.
7. Asavamongkolkul A, Eckardt JJ, Eithier FR, Dorey FJ, Ward WG, Kelly CM. Endoprosthetic reconstruction for malignant upper extremity tumors. *Clin Orthop*. 1999; 360:207-220.
8. Ivins D, Hoe AL, Podd TJ, Hamilton CR, Taylor I, Roye GT. Assessment of morbidity from complete axillary dissection. *Br J Cancer* 1992; 66:136-138.
9. Roses DF, Brooks AD, Harris MN, Shapiro RL, Mitnick J. Complications of level I and II axillary dissection in the treatment of carcinoma of the breast. *Ann Surg*. 1999; 230:194-201.

Section Editor: Steven F. Harwin, MD