CLINICAL ARTICLE

Functional Results and Emotional Acceptance after Scapulectomy for Malignant Shoulder Tumors

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Objectives: To demonstrate the functional results and emotional acceptance after scapulectomy for various malignant shoulder tumors.

Methods: Eight patients with malignant shoulder tumors who had undergone scapulectomy between April 2004 and March 2014 were retrospectively reviewed. They comprised seven men and one woman their mean age was 54 years (range, 24–69 years). All patients were diagnosed by pathological examination of biopsy specimens. The tumors were metastatic in four cases, having originated from a primary carcinoma of the liver in one patient, the lung in one patient and the kidney in two patients. The other four patients had primary malignant tumors in their scapulae, specifically, two scapular malignant fibrous histiocytomas, one scapular Ewing sarcoma and one soft tissue synovial sarcoma. The four patients with metastases were staged as III, and other four were staged as IIB. Six patients underwent total and two subtotal scapulectomy. The remaining soft tissues were sutured together directly in seven of the patients. The remaining patient, who had soft tissue synovial sarcoma, required transfer of a pedicle latissimus dorsi muscle flap. The functional results and emotional acceptance were evaluated by clinician using the Musculoskeletal Tumor Society (MSTS) scoring system.

Results: The average duration of follow-up was 22.8 months. Four patients were continuously disease-free, three patients developed metastases and died of disease within 12 months of surgery and one patient with a scapular metastasis from the kidney survived with pulmonary nodules. No major complications, including infection or dislocation, occurred during or after surgery. The mean MSTS score was 16.3 (54%), which is similar to that previously reported in other studies of scapulectomy. There were no local tumor recurrences and only one patient developed pulmonary metastases. These outcomes are similar to those reported for scapular prostheses and there were fewer complications than in patients treated with allografts. The mean emotional acceptance score was 3.6 (72.5%).

Conclusions: Performing scapulectomies on patients with malignant shoulder tumors without prostheses or allograft reconstruction achieves good functional results and emotional acceptance with a low rate of complications.

Key words: Emotional acceptance; Functional result; Malignant Shoulder tumors; Reconstruction; Scapulectomy

Introduction

The shoulder girdle is the third most common site for musculoskeletal tumors, including bone metastases¹. The most common tumors involving the scapula are chondrosarcomas, round cell tumors and metastatic tumors². The surgical treatment of scapular tumors can be extremely difficult, achieving clear resection margins being challenging because of anatomic constraints. Similarly, maintaining shoulder stability and arm function after surgery is difficult. Forequarter

amputation has been considered an appropriate treatment for malignant tumors of the scapula but is associated with significant morbidity, namely loss of the whole upper limb, a severe cosmetic defect, phantom limb sensations and devastating psychological effects. Now, limb-sparing surgeries can be performed in approximately 95% of these cases³.

Scapulectomy achieves acceptably wide margins of tumor resection without the need for amputation. Because the functional capacity of the upper limb is primarily

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centered on the hand, scapulectomy can be performed in carefully selected cases of tumors of the scapula. The limb-sparing strategy of scapulectomy is not a new technique, the first report of a subtotal scapular resection having been in 1819⁴. Since then, this technique has been widely used and undergone various modifications. Presently, scapulectomy is a well-described technique that is classified as either total or subtotal scapulectomy. Subtotal scapulectomy involves preservation of either the coracoid process or the acromion and glenoid fossa⁵. With careful and stringent patient selection, appropriate staging, complete imaging studies and a good knowledge of anatomy, simple scapulectomies can achieve relatively good functional outcomes⁶. Although prostheses and graft reconstruction provide acceptable function, these reconstruction procedures have not been shown to provide better function than scapulectomy alone⁷⁻¹³. Additionally, cancer treatment tends to produce troublesome long-term side effects and most studies still concentrate solely on oncological and functional results. We consider that assessment of the quality of life of survivors after scapulectomy is also very important.

This retrospective study aimed to assess both oncological and functional results and emotional acceptance after scapulectomy for various malignant shoulder tumors.

Materials and Methods

Inclusion and Exclusion Criteria

Scapulectomy was considered for patients with (i) primary scapular malignant bone tumors; (ii) sarcoma or skin carcinoma involving the scapula or scapular muscles; (iii) a solitary metastatic tumor in the scapula; (iv) and willingness and ability to actively cooperate with the treatment.

Scapulectomy was considered contraindicated in patients with (i) infection; (ii) severe radiation-related soft tissue damage; (iii) gross neurovascular invasion, such as that involving the brachial plexus and axillary vessels with involvement of the chest wall and inability to spare the required muscles and axillary nerve.

Patients and Materials

Eight patients who had been selected in accordance with the above criteria and had undergone scapulectomy between April 2004 and March 2014 were retrospectively reviewed (Table 1). They comprised seven men and one woman and were of average age 54 years (range, 24–69 years). All diagnoses were made by pathologic examination of biopsy specimens. Four patients had scapular metastases that had originated from a primary carcinoma of the liver in one patient, the lung in one patient and the kidney in two patients. The other four patients had primary malignant tumors, specifically, two scapular malignant fibrous histiocytomas, one scapular Ewing's sarcoma and one soft tissue synovial sarcoma. Three of the patients with metastases had presented with pathological fractures. The patients were surgically staged according to the Enneking system with plain

TABLE 1 Details of patients treated with scapulectomy

Case	Sex	Age (years)	Tumor type	Site	Pathological fracture	Enneking stage ¹	Malawer resection type ⁸	Follow-up (months)	MSTS function score ⁸	MSTS (%)	Emotional acceptance ⁸ (0–5)	Status
1	Male	56	Metastasis from lung carcinoma	Left scapula	Yes	III	IIIA	6	16	53	4	DOD 9 months postop.
2	Female	47	MFH	Left scapula	No	IIB	IIIA	47	17	57	2	CDF
3	Male	64	Metastasis from renal carcinoma	Right scapula	No	III	IIA	38	18	60	4	SWT
4	Male	40	Ewing sarcoma	Left scapula	No	IIB	IIIA	25	20	67	3	CDF
5	Male	66	Metastasis from renal carcinoma	Left scapula	Yes	III	IIIA	10	16	53	4	DOD 12 months postop.
6	Male	64	Metastasis from liver carcinoma	Right scapula	Yes	III	IIA	6	16	53	4	DOD 7 months postop.
7	Male	69	MFH	Left scapula	No	IIB	IIIA	8	15	50	3	CDF
8	Male	24	Synovial sarcoma	Left shoulder soft tissue	No	IIB	IIIB	7	12	40	5	CDF

CDF, continuously disease free; DOD, died of disease; MFH, malignant fibrous histiocytoma; SWT, survival with tumor.

radiographs, CT scans (Fig. 2) and MRI (Fig. 4)¹. The four patients with metastases were staged as III, and other four were staged as IIB. There was no evidence of tumor involvement of the brachial plexus or axillary vessels in the patients' preoperative imaging studies. Three patients received chemotherapy before their operations. The patients with Ewing sarcoma and malignant fibrous histiocytoma were treated with cisplatin, adriamycin and ifosfamide, and the one with synovial sarcoma with dacarbazine, adriamycin and vincristine¹⁴.

The retrospective collection of clinical data and publication of that data are in accordance with local guidelines for research ethics and were approved by the institutional review board. All patients were treated by the same chief surgeon (XCY) and his assistants (SFX and MX) in the same institute. All procedures were in compliance with the Helsinki Declaration.

Surgical Technique

The surgical techniques described by Malawer are classified into six types¹⁵. Each type is further subdivided into two categories according to whether the abductor mechanism is left intact (A) or partially or completely resected (B). Subtotal

scapulectomy can be classified into Types II and V procedures and total scapulectomy into Types III and IV (Fig. 1). Six patients underwent total scapulectomy. Specifically, five patients underwent type IIIA total scapulectomy (Figs 2 and 3), and one patient, in whom the synovial sarcoma had invaded the deltoid and supraspinatus muscle, underwent type IIIB total scapulectomy (Fig. 4). Two patients underwent type IIB subtotal scapulectomy.

The incision starts from the coracoid process, crosses the acromial process and spine of the scapula, then follows the medial border of the scapula to the inferior angle of the scapula. (Fig. 5). Optimum surgical margins with 3 cm of normal bone and 1–2 cm of normal soft tissue around the tumor were achieved. Osteotomies were performed with both total and subtotal scapulectomies. For subtotal scapulectomy, an osteotomy was performed through the neck of the scapula, retaining as much of the neck of the glenoid as possible to preserve the capsule of the glenohumeral joint and associated ligaments. Following resection, the remaining rotator cuff muscles were sutured to the chest wall where possible. For total scapulectomy, the residual humerus was suspended from the clavicle or a proximal rib by direct suturing. In

Fig. 1 Surgical classification of shoulder girdle resections¹⁵. In this study, all patients underwent either Type (2) or III (6) resections.

Fig. 2 A 47-year-old woman treated with total scapulectomy for malignant fibrous histiocytoma of the scapula (Case 2). (A) Preoperative X-ray film and (B) CT scan image showing wide bony destruction of the glenoid with tumor invasion into the muscles. (C) Total scapulectomy was carried out with wide resection of the tumor, including the surrounding soft tissue. (D) Postoperative X-ray film showing the tumor in the left scapula is no longer there. (E) The postoperative pathological diagnosis was malignant fibrous histiocytoma (hematoxylin and eosin; $\times 200$). The patient's MSTS score was 17 (57%) and emotional acceptance score 2 (40%) at the last follow-up of 4 years after the operation.

seven patients, the rest of the soft tissues were sutured together directly. The remaining patient (Case 8), who had soft tissue synovial sarcoma, underwent transfer of a pedicle latissimus dorsi muscle flap after 2 weeks of vacuum sealed drainage (Fig. 4).

Postoperative Management

None of the patients was treated with radiotherapy. Three patients who had received preoperative chemotherapy continued their regimens postoperatively.

A sling was used to immobilize shoulder movement for 4 weeks. Active movement and flexion of the hand, wrist and elbow were encouraged in the early postoperative period. Physical therapy was routinely encouraged for postoperative rehabilitation.

Postoperative Evaluation

The results of limb salvage were judged in terms of oncology, function and emotional acceptance¹⁶. The patients were followed up in the outpatient clinic and by telephone every 3 months in the first 2 years, and every 6 months subsequently. Functional results and emotional acceptance by patients was evaluated by physical examination, radiographs and a questionnaire based on the Musculoskeletal Tumor Society (MSTS) recommendations⁸. The modified MSTS scores for scapular surgery include six factors: motion, pain, stability, deformity, strength and functional activity, each factor scoring a possible maximum of five points, which represents normal or full function. Emotional acceptance was assessed based on the patients' emotional reaction to or perception of the functional result or both⁸.

Results

General Results

The average duration of follow-up was 22.8 months (range, 6–60 months). The clinical outcomes were as follows: four patients were continuously disease-free, three of the patients with metastatic tumors in their scapulae died of disease within 12 months of surgery and one of the two patients with a scapular metastasis from the kidney survived with pulmonary nodules. The 1-year survival rate was 62.5%. No major complications, including infection or dislocation, occurred during or after surgery.

Functional Results

Five patients reported postoperative pain, including the three with pathological fractures. The other two had minor symptoms, one of them requiring analgesia and the other reporting discomfort when lying on the shoulder.

The mean functional MSTs score was 16.3 points (range, 12–20 points) and 54% (range, 40%–60%), three patients noting difficulties in positioning their hands. Two patients who had undergone total scapulectomies (Cases 2 and 4) returned to the same level of activity in their occupations. One farmer reported no restriction of work, including driving his tractor, 1 year after surgery (Fig. 3). The mean MSTs score of the two patients who had undergone subtotal scapulectomy was 56%, which was higher than the 53% for patients who had undergone total scapulectomy. Four patients achieved 70° of flexion. Two patients who had undergone subtotal scapulectomy had full elevation of the shoulder. Of the remaining two patients, one had 50° of flexion, while the one who had undergone transfer of a pedicle latissimus dorsi muscle flap exhibited minimal active movement. All patients had full movement and strength in the

Fig. 3 A 24-year-old man treated with total scapulectomy for shoulder synovial sarcoma (Case 8). (A) Tumor is surrounding the shoulder girdle. (B) MRI showing the tumor has invaded the deltoid and supraspinatus muscles. (C) The patient underwent total scapulectomy with transfer of a pedicle latissimus dorsi muscle flap after 2 weeks of vacuum sealed drainage. (D) The postoperative pathological diagnosis was synovial sarcoma (hematoxylin and eosin; $\times 200$). At the last follow-up 7 months after the operation, the patient's MSTS score was 12 (40%) and emotional acceptance score 5 (100%).

Fig. 4 A 40-year-old man was treated with total scapulectomy for scapular Ewing sarcoma (Case 4). (A, B) Preoperative CT scan showing wide bony destruction of the glenoid with tumor invasion into the muscles. (C) Total scapulectomy was carried out with wide resection of the tumor, including the surrounding soft tissue. (D) The postoperative pathological diagnosis was Ewing sarcoma (hematoxylin and eosin; $\times 200$). (E) X-ray film showing nearly normal position of left humerus at the last follow-up 5 years after the operation. (F) The functional result is fairly good with flexion of nearly 90° , extension of 40° and abduction of 80° . The patient was able to drive his tractor and had no restrictions to his daily work. His MSTS score was 20 (67%) and emotional acceptance score 3 (60%).

Fig. 5 Diagrammatic representation of the incision. It starts from the coracoid process, crosses the acromial process and spine of the scapula, then follows the medial border of the scapula to the inferior angle of the scapula.

elbow and normal hand movement. These outcomes are similar to those reported with scapular prostheses but were associated with fewer complications than in patients treated with allografts.

Emotional Acceptance

The mean emotional acceptance score was 3.6 points (range, 2–5 points) and 72.5% (range, 40%–100%). Most interestingly, the scores of the four patients with metastatic disease, even those who had undergone total scapulectomy, were all 4 (80%), whereas the scores of patients with primary malignant tumors were 2, 3, 3 and 5 (Case 8). It is interesting that, in this study, the patients with metastases were more satisfied with the procedure than those with primary lesions.

Case 8, a 24-year-old worker (Fig. 4), had a 3-year disease history and his previous doctor had suggested forequarter amputation. Given that the lesion had been affecting his job and marriage for a long period of time, he was pleased to undergo limb-salvage total scapulectomy, even though he required two-stage soft tissue reconstruction. It is obvious that All patients who had undergone total scapulectomy clearly expressed acceptable emotional acceptance postoperatively.

Discussion

Over the last 30 years, various post-scapulectomy reconstructive procedures have been described, including total prostheses and allografts. Although satisfactory outcomes of scapular graft reconstruction have been reported,

resorption of structural allografts or irradiated autografts reportedly often occurs^{10–13}. Frozen glycerolized and extra-corporeal irradiated scapular allografts have been implanted^{11,17}. However, subtotal resorption of the scapula and consequently impaired shoulder function have been reported after follow-up for 2–10 years^{12,13}. The other main problems with bone grafts are infection and fracture¹⁶. Additionally, bone grafts are almost impossible to procure without a bone bank. Scapular endoprostheses are another reconstructive option for which acceptable clinical outcomes have been reported^{7,9,18,19}. Constrained shoulder prostheses have achieved stable, cosmetically acceptable reconstructions following scapulectomy surgery²⁰. Although prostheses offer the promise of superior function in a limited selection of patients in whom the required muscles can be retained, they have not yet been shown to offer better function than scapulectomy alone^{7,18}. In a study of 10 patients with constrained prostheses after total scapulectomy, although a 76.7% mean of MSTS 93 scores was achieved, the patients' range of active shoulder movement, especially abduction, was restricted⁹. Additionally, prostheses reconstructions require sufficient muscles, such as the rhomboids, deltoid and trapezius^{7,9,21}. The common complications are dislocation, skin ulceration, periprosthetic hematoma, wound necrosis and parasthesias²². Long-term follow-up is also needed after endoprosthesis reconstruction.

Scapulectomy

Scapulectomy is currently a good option for treating patients with tumors of the scapula¹⁶. The scapula essentially functions as a sesamoid bone in the shoulder girdle²³. The brachial plexus and subclavian vessels are not usually involved and the tumors are rarely fixed to the adjacent chest wall. The major goals after scapulectomy are to restore shoulder girdle stability, preserve a functional hand and elbow and prevent traction neurapraxia associated with a flail, hanging extremity⁷.

The following indications for scapulectomy have been suggested: (i) sarcoma or skin carcinoma involving the scapula or scapular muscles; (ii) primary malignant bone tumor in the scapula; (iii) solitary metastatic tumor to the scapula; (iv) chronic osteomyelitis; and (v) severe trauma²⁴. In our opinion, scapulectomy is indicated in include selected patients with malignant tumors of the scapula or periscapular soft tissue or with large metastatic lesions that have caused significant bone destruction. Furthermore, these patients should be in good condition, free of infection and able to co-operate with treatment. Contraindications include gross neurovascular invasion, such as that involving the brachial plexus and axillary vessels, involvement of the chest wall and inability to spare the required muscles and axillary nerve. Patients with severe radiation-related damage should also be excluded.

The treatment goal for shoulder reconstructions is a stable construct that enables effective functioning of the arm and hand. Scapulectomy achieves an excellent functional

result provided the glenohumeral joint is preserved. Resection of 80% of the scapula only has a modest effect on function and complete or partial preservation of the glenohumeral joint enables excellent functional results²⁵. Provided the deltoid is reattached to the scapular remnant and trapezius, the rotator cuff can be removed without resulting in a severe functional deficit²⁵. In fact, even when the deltoid is resected, the contributions of the remaining muscles, such as the cuff and pectoralis major and minor, are sufficient to maintain good shoulder function²⁶. Although various post-total scapulectomy reconstruction techniques have been developed, the optimal such technique has not yet been determined because the amount of remaining muscle and rotator cuff following scapulectomy varies with each surgery^{2,7,27-29}.

A few studies of total scapulectomy have been published, each of which only contain a small number of cases (Table 2)^{2,24,28,29,31}. In a study of 13 patients with malignant tumors and a mean follow-up of 44 months, total scapulectomy followed by humeral suspension was considered to be preferable to forequarter amputation, endoprosthesis reconstruction and allografting³⁴. Clarke *et al.* have described a surgical procedure that achieved glenothoracic fusion by performing a one-stage radical, near total scapulectomy for primary or secondary malignant lesions in six patients³⁵. Provided sufficient scapular neck can be retained, glenothoracic fusion can provide an acceptable functional outcome. In a study of 23 scapular lesions, retention of the glenohumeral articulation after (subtotal) resection achieved superior functional results². Even though patients with coracoid process tumors who underwent scapulectomy had significant limitations of motion, scapulectomy is considered a cosmetically and emotionally acceptable procedure that provides oncologically adequate resection³⁶. During this procedure, it is important to spare the glenoid process of the scapula and reconstruct the soft tissue^{2,24}. Despite their frequent presentation with locally advanced disease, patients with localized chondrosarcomas of the scapula reportedly have favorable long-term outcomes, most likely attributable to the unique anatomic features of this tumor type, which improve the likelihood of achieving wide surgical margins with limb-sparing surgery^{25,31,33,37}.

In this study, the functional results, specifically, an average MSTS score 54%, are similar to those reported for total scapulectomy by Hayashi *et al.* (57%)²⁸ and for scapulectomy by Kiss *et al.* (65%)³². Our low incidence of postoperative complications, absence of infection and local tumor recurrence and only one case of pulmonary nodules are also similar to those reported for scapular prostheses⁷. Our incidence of complications was lower than that reported for patients treated with allografts¹¹.

Soft Tissue Reconstruction

Post-scapulectomy reconstruction should aim to reestablish an efficient force couple⁵. Three common goals have been suggested for soft tissue reconstruction after the resection of any joint: to (i) restore muscle power, (ii) provide stability; and (iii) provide adequate soft tissue coverage³⁸. During

earlier limb-sparing surgeries for scapular tumors, no effort was made to reconstruct the shoulder girdle³⁸. The periscapular muscles, including the rhomboids, deltoid, trapezius and serratus anterior, were deemed to be of no functional value and were not used for reconstruction.

Scapulectomy can result in reasonably good functional outcomes provided the glenoid fossa and/or acromion have been preserved. The deltoid, trapezius, rhomboids, serratus anterior and latissimus dorsi muscles and the axillary nerve should be preserved if possible⁷. The serratus anterior also protects the chest wall from scapular abrasion. These muscles provide the important force couples needed to stabilize and motor the prosthesis and are required for sufficient soft tissue coverage and humeral suspension. The amount of active range of motion and isometric strength are associated with the integrity of the rotator cuff, which contributes to a force couple with the deltoid to elevate the arm. To achieve an efficient upward pull, it is essential to suture the parts of the trapezius and deltoid muscles that have lost their attachment to the scapula and clavicle to each other.

Reconstruction of the rotatory muscles of the shoulder is not always achieved but should nonetheless be attempted. Because, except for the clavicle, there are no bony attachments from the muscles arising from the scapula to the arm, the scapula is the key link to arm stability because of its attachment to the chest wall by the insertion of the periscapular muscles onto it. This linkage must be reconstructed to obtain a satisfactory upper extremity and a stable shoulder girdle, both of which are essential for normal elbow and hand function. The key surgical steps required for soft tissue reconstruction following limb salvage of the scapular have been described in detail by Malawer and Kellar-Graney³⁸. The deltoid, trapezius, rhomboids and latissimus should be retained. Secondary adhesion of the serratus anterior muscle to the posteriorly applied rhomboids and latissimus dorsi forms a muscle envelope that provides good scapular stability. A pedicle latissimus dorsi muscle flap with a split-thickness skin graft has also been suggested as a primary and reliable choice for soft tissue reconstruction after scapulectomy that can produce excellent functional and cosmetic results^{6,39}. In this study, a pedicle latissimus dorsi muscle flap was used to reconstruct the soft tissue defect in Case . Similarly, the complication rate of this procedure is low, mainly because most patients had preserved deltoid muscles, which provided sufficient soft-tissue coverage and elevated strength to prevent dislocation. Relevant studies are reviewed in Table 2.

Emotional Acceptance

Limb-saving surgery should not only aim to achieve good oncological and functional results but also to good psychological outcomes¹⁶. Because cancer treatment tends to produce troublesome long-term side-effects, assessment of quality of life after treatment is important¹⁶. Although most studies still concentrate solely on oncological and functional results, a few studies have assessed the quality of life in

TABLE 2 Review of reports of clinical evaluation after scapulectomy

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survivors after scapulectomy³². In the current study, the mean emotional acceptance score was 3.6 (72.5%). A number of patients with functional scores of less than 60% were satisfied with the procedure, their emotional acceptance being over 80% (Cases 1, 3, 5, 6 and 8). This is primarily because of the pain relief, good cost-effectiveness, acceptable limb function and a low level of acceptance of grafts or prostheses, especially in Asian countries.

In addition, involvement of rehabilitation therapists is integral to attaining acceptable emotional reactions to scapulectomy. Patients who have undergone total scapulectomy generally have a decreased shoulder range of motion (ROM), especially abduction, but usually retain normal elbow/hand ROM. A number of patients have gait abnormalities in leaning and walking and a higher risk of falling⁴⁰. We suggest that patients consult rehabilitation therapists for a personalized rehabilitation plan. The usual recommendations include a sling immobilization for 4 weeks and ongoing physical therapy.

Limitations of this Study

This study has several limitations. (i) Only a small number of patients were enrolled. (ii) The short-term follow-up makes the evaluation of long-term complications impossible. Five patients had a follow-up shorter than 12 months. Four patients had metastatic tumors and three of them died of disease within 12 months of surgery. (iii) This study is limited by its retrospective design and lack of statistical analysis.

Conclusion

Scapulectomy for malignant shoulder tumors without prosthesis or allograft reconstruction can achieve favorable functional results and emotional acceptance with a low rate of complications. Partial or total retention of the glenohumeral joint results in better function than total scapulectomy.

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