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Treatment of Bone Tumors around the Shoulder Joint by the Tikhoff-Linberg Procedure

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The Tikhoff-Linberg procedure is a limb-sparing surgical option to be considered for bony and soft tissue tumors in and around the proximal humerus and shoulder girdle. The authors reported 6 cases of the Tikhoff-Linberg procedure for tumors around the shoulder joint at the Department of Orthopedic Surgery of Severance Hospital from March 1988 to May 1989. The results of the study are as follows: The 6 cases were composed of: osteogenic sacroma 2 cases, chondrosarcoma 2 cases, chondroblastoma 1 case, and giant cell tumor 1 case. The tumors were completely removed by the Tikhoff-Linberg procedure without amputation or disarticulation of the upper extremity. The distal clavicle, upper humerus and part or all of the scapula were resected. The Tikhoff-Linberg procedure was performed for patients whose tumors did not involve the neurovascular bundle in the axilla. The function of the hand and forearm after the Tikhoff-Linberg procedure was nearly normal in all cases. The Tikhoff-Linberg procedure would be recommended as a limb-sparing operation for tumors around the shoulder joint that require wide resection without disarticulation or forequarter amputation of the upper extremities.

Key Words: Tumors, bone, shoulder, treatment, Tikhoff-Linberg Procedure

Ablative surgery, such as an interscapulothoracic amputation, produces a functionally and cosmetically poor result. The loss of the hand, as a result of a forequarter amputation for a lesion around the shoulder joint, is a physical and psychological catastrophe, and in addition, the patient may suffer from amputation neuromas and phantom pain.

The emphasis in the treatment of many musculoskeletal neoplasms is changing from radical ablative surgery towards limb salvage and therefore, this can be applied to shoulder lesions. As en bloc upper humeral interscapulothoracic resection, rather than amputation, can be used in selected cases. This does not compromise the surgical cure and leaves the patients with a fully functional hand and forearm; this, despite a flail shoulder, is infinitely better than any prosthesis.

Interscapulothoracic resection was first performed by Tikhoff in 1922, and Linberg, another Russian, reported three cases of en bloc upper humeral interscapulothoracic resection in 1928. The operation has since then been known as the Tikhoff-Linberg procedure. Only 27 further cases have been reported in the literature since 1928.

The authors herein reported 6 cases treated by the Tikhoff-Linberg procedure for bone tumors around the shoulder joint from March 1988 to May 1989.

MATERIALS AND METHODS

Six patients underwent the Tikhoff-Linberg procedure. The age range was from 17 years to 40 years. There were 2 cases of osteogenic sarcoma in the proximal humerus, 2 cases of chondrosarcoma, 1 case of giant cell tumor in the proximal humerus that was combined with a pathologic fracture; and 1 case of chondroblastoma in the proximal humerus that involved extensive soft tissue around the tumor (Table 1).

The main criteria for resection are that the neoplasm does not involve the axillary artery or the brachial plexus, and it is not fixed into the chest wall. Each patient underwent a detailed history and physical examination as well as a standard laboratory test. In addition, a skeletal survey, bone scan, tomograms,

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Table 1. Details of 6 cases treated by Tikhoff-Linberg procedure

Case	Age	Sex	Diagnosis	Site
1	40	M	Giant cell tumor	Lt. proximal humerus
2	20	M	Chondrosarcoma	Rt. scapula
3	31	F	Chondrosarcoma	Rt. Scapula
4	15	M	Osteogenic sarcoma	Rt. proximal humerus
5	27	M	Osteogenic sarcoma	Rt. proximal humerus
6	17	F	Chondroblastoma	Rt. proximal humerus

computed tomography and M.R.I. were done. Arteriography, both in the PA and lateral projection, was also performed. The importance of the biopsy cannot be overemphasized.

TECHNIQUE

The anterior skin incision was made obliquely from the medial one-third of the clavicle, it was extended obliquely and laterally and ended at the mid-axillary line (Fig. 1). The incision on the upper arm was made obliquely and laterally with enough distance from the tumor, but the incision was changed according to the characteristics and the site of the tumors.

The posterior skin incision was made from the medial one-third of the clavicle, it was extended laterally and ended at the mid-axillary line (Fig. 2). The skin insision on the upper arm was made with sufficient distance from the tumor and it was made obliquely and laterally.

The incision was made so that the biopsy scar and tract was excised with the specimen. The deltoid, pectoralis major and pectoralis minor were incised inferior to the clavicle and medial to the coracoid. The clavipectoral fascia was identified and the cephalic vein ligated. The axillary artery and the cords of the brachial plexus were then identified and traced distally. If the neurovascular bundle was free of tumor, then the mobilization continued. The anterior and posterior humeral circumflex vessels must be ligated in order to retract the axillary artery medially. The musculocutaneous and radial nerve could be identified and usually preserved. However, if the lesion involved the soft tissue in the nerve vicinity of the proximal humerus, the radial nerve might be sacrificed along with the musculocutaneous nerve.

The future site of the humeral osteotomy was planned just distal to the capsule of the joint in scapular lesions, but if the lesion was in the proximal humerus, then the osteotomy would have to be made

Fig. 1. *Anterior skin incision for a tumor around the left shoulder.*

at a point about 5cm distal to the tumor. Excessive shortening could be avoided and better elbow power and stability for flexion provided if a Goretex artificial ligament was used, and was later fixed into the proximal humerus and distal clavicle.

After the neurovascular bundle had been mobilized medially, the coracobrachialis, biceps, triceps, teres major and latissimus dorsi were all transected away from the tumor. The lateral clavicle was then isolated

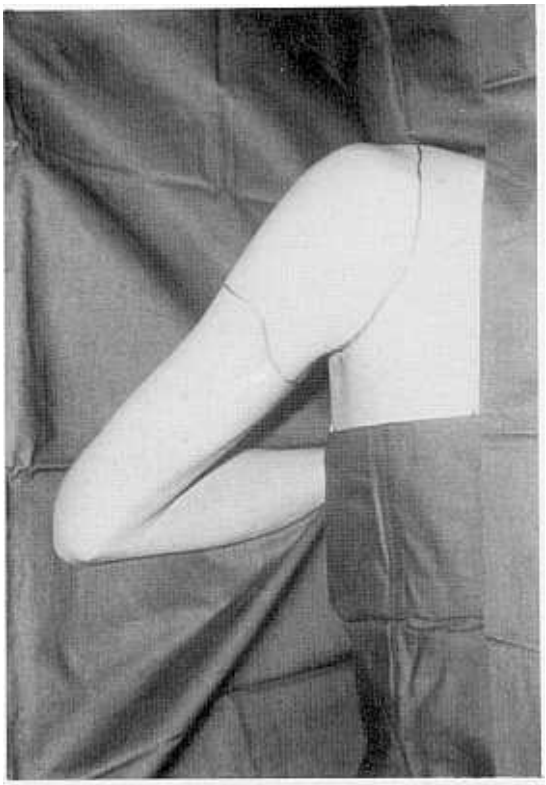

Fig. 2. Posterior skin incision for a tumor around the left shoulder.

and osteotomized. At this time, attention was paid to the second skin incision which originated at the lateral one-third of the clavicle line and was carried posteriorly and longitudinally along the mid scapula to the angle of the scapula. The inferior angle of the scapula was mobilized and then the entire vertebral border was resected from the chest wall, much the same as the plane which developed in the forequarter amputation. For lesions of the scapula, care must be given in maintaining a wide soft tissue margin. If the lesions were in the humerus, a scapular osteotomy could be done at the level of the coracoid. The skin from the initial incision was raised as a flap over the proximal humerus, leaving the delotoid intact with the specimen in the upper humeral lesion. Final mobilization of the scapula was completed by transecting the omohyoid and serratus anterior fibers with ligation of the subscapular, suprascapular and transverse cervical arteries.

The humerus was then osteotomized at the previously determined level. If this was to the deltoid tubercle, the deltoid, in toto, was removed with the specimen. Otherwise, if the osteotomy was proximal to the deltoid tubercle, part of the deltoid was transected. The specimen was then removed. Any questionable tissue from the margin of the resection, and marrow curettings, were then sent for pathologic examination by frozen section. The wound was copiously irrigated.

The hanging humerus could then be given more stability by attaching the residual resected ends of the biceps and triceps to the trapezius, a cut portion of the pectoralis major and latissimus dorsi. Another stabilizing aid was to connect the proximal humerus and distal clavicle by a Goretex artificial ligament. A post-operative Velpeau stockinette was applied for 1 week, and then a sling for another 3 weeks. After that, active motion of the shoulder and elbow was encouraged early in the post operative period.

RESULTS

The Tikhoff-Linberg procedure was performed in 6 patients. Of these, all are alive with no evidence of disease from 8 to 22 months post operatively. None of the patients showed pulmonary metastasis or recurrence. No chemotherapy or radiotherapy was performed for a giant cell tumor, chondrosarcoma, or chondroblastoma; but 7 or 8 cycles of adriamycin 90mg and cis-platinum 180mg were administered for two osteogenic sarcoma patients.

Lymph node dissections were done in 6 cases, but the pathologic results showed benign reactive hyperplasia. There were no vascular problems in any patients. Redundant vessels were resected and reanastomosed in 5 patients.

Function of the shoulder where the humerus was resected at about more than half of its length was poor. But the function of the shoulder where the humerus was resected at approximately its anatomical neck was useful. The elbow flexion was nearly normal. Furthermore, the wrist and hand function was normal.

CASE PRESENTATION

Case 1

A 40-year-old patient was admitted to this hospital because of pain in his left shoulder for 6 months. There was no tenderness in the left shoulder, but he complained of pain above 80 degrees of abduction. There

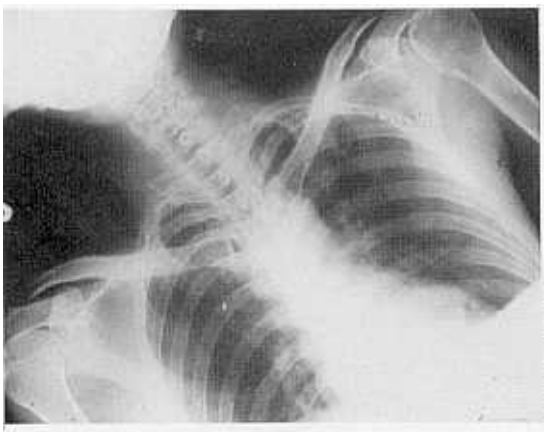

Fig. 3. The A-P x-ray of both shoulders shows an ill-defined osteolytic lesion involving the proximal metaphysis and epiphysis of the left humerus without sclerotic margin.

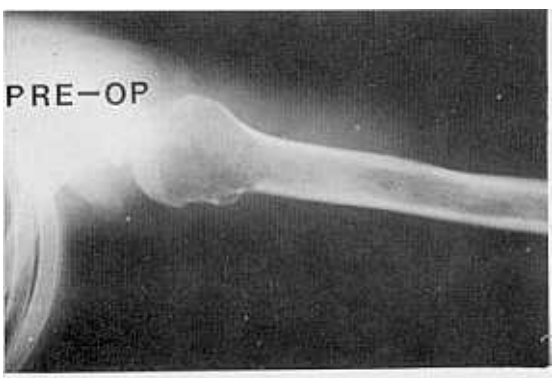

Fig. 4. The left shoulder axial x-ray shows the same finding as the A-P-x-ray.

was no neurologic disturbance.

On plain x-ray, there was an osteolytic lesion at the left metaphysis and epiphysis of the left proximal humerus without periosteal reaction or sclerotic margin, but it was combined with a pathologic fracture. In the bone scintigraphy there was a "hot uptake" at the left proximal humerus, and no other "hot uptake" was found (Fig. 3, 4).

For evaluation of the vascular supply of the left proximal humerus, angiography was done. The tumor was supplied by the circumflex humeral artery, and computed tomography showed that the size of the tumor was 5.5cm, and there was cortical breakdown and extensive soft tissue involvement (Fig. 5, 6).

Fig. 5. Angiography shows that the tumor was supplied by the circumflex humeral artery.

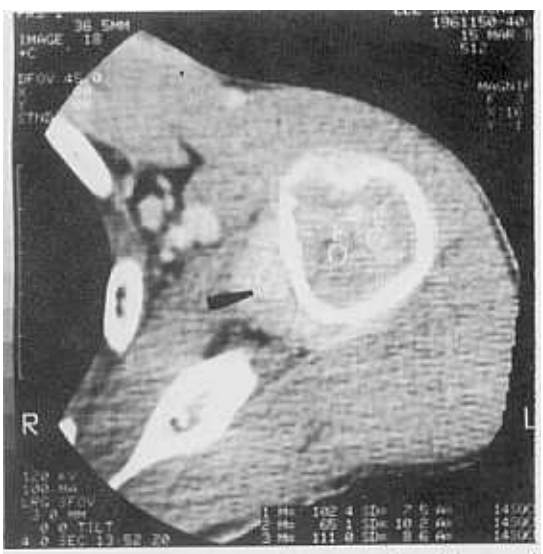

Fig. 6. Computed tomogram shows cortical breakdown and soft tissue extension of the tumor.

Fig. 7. During dissection, the neurovascular bundle was not invaded by the tumor.

Fig. 8. The tumor and surrounding soft tissue were completely resected. The figure shows the intact nuerovascular bundle.

A grade III giant cell tumor was confirmed by biopsy, and the Tikhoff-Linberg procedure was performed because there was no involvement of the neurovascular bundle by the tumor. After dissection, osteotomies were done at 12cm below the neck of the humerus, coracoid and glenoid of the scapula, and the distal clavicle. The tumor and surrounding soft tissue were completely resected and a hole was made at the proximal end of the humerus. The distal humerus fragment was connected to the acromion and the distal end of the remaining humerus by a Goretex artificial ligament, and the wound was closed after muscle closure (Fig. 7, 8, 9).

In the longitudinal section of the tumor, there were numerous hemorrhagic lesions, a cortical breakdown, and extensive soft tissue involvement (Fig. 10). The microscopic finding at a low power field revealed numerous giant cells. Under higher magnification, the nuclei of giant cells had the same cytologic features as stromal cells, and the stromal cells were spindle-

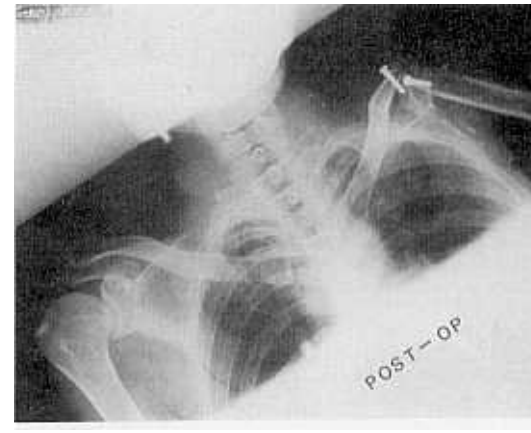

Fig. 9. Post-op. x-ray shows complete removal of the tumor of the proximal humerus and distal clavicle. The two screws were used to fix the Goretex artificial ligament.

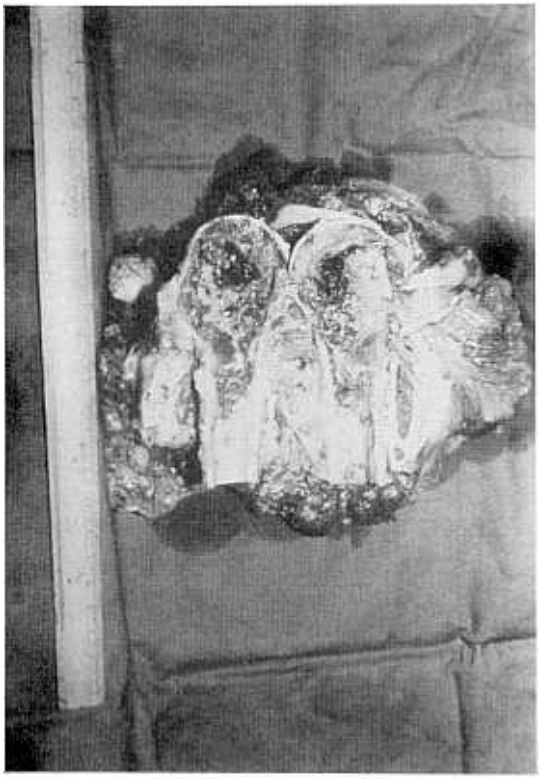

Fig. 10. In the sagittal section of the tumor, there were several hemorrhagic areas and cortical breakdown and soft tissue extension in the proximal humerus.

shaped. It was the finding of a typical giant cell tumor (Fig. 11, 12).

Postoperative immobilization was done with a Velpeau stockinette for 1 week, and then with a sling for a further 3 weeks. After that, early active motion was practiced for the elbow and hand function. At postoperative 3 1/2 weeks, there was no marked shortening of the left upper extremity in comparison to the right upper extremity. The left upper extremity did not have a grotesque appearance (Fig. 13, 14).

At present, postoperative 22 months, there is not any evidence of recurrence or distant metastasis. The range of motion of the left shoulder is as follows: flexion 80°, extension 30°, and abduction 30°. The grasping power of the left hand is 33.5kg, 75% of the normal hand, and the pinching power is 8.0kg, 82% of the normal hand. At postoperative 6 months, it was possible to fasten a button with the left hand, and at postoperative 10 months, it was possible to eat with the left hand (Fig. 15, 16, 17, 18).

Case 2

A 27-year-old patient was admitted to this hospital because of pain in his right shoulder for 4 months. There was tenderness with a limitation of motion of his right shoulder, and mild weakness of his right arm. he was diagnosed as having an osteogenic sarcoma at Chun Nam University Hospital, and he was transferred to this hospital for proper treatment.

Fig. 11. The microscopic finding at a low power field revealed numerous giant cells.

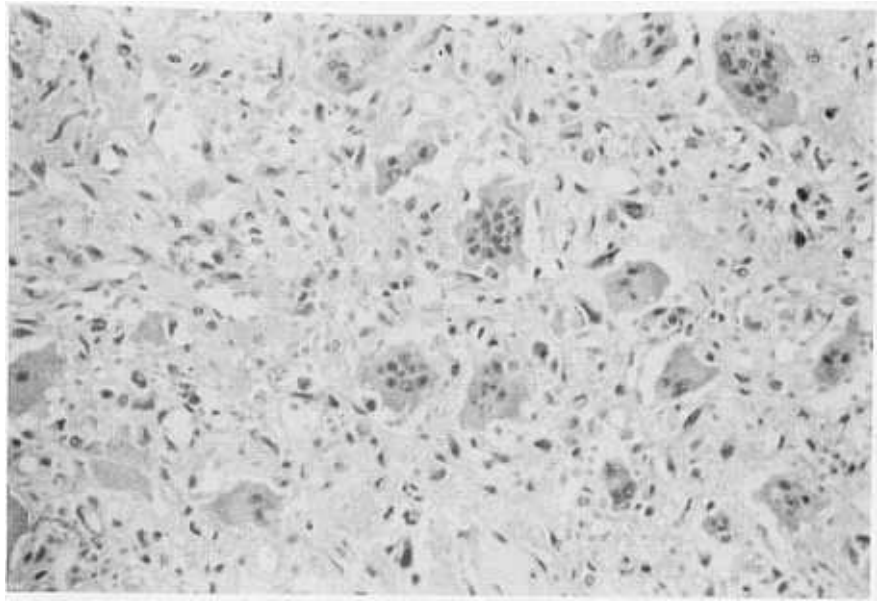

Fig. 12. *Under higher magnification, the nuclei of giant cells had the same cytologic features as stromal cells and the stroma cells were spindle-shaped. It was the finding of a typical giant cell tumor.*

Fig. 13. *At post-op. 3 weeks, there was no marked shortening of the left upper extremity in comparison to the right side.*

Fig. 14. *Posterior aspect of the patient at post-op. 3 weeks.*

Fig. 15. At post-op. 18 months, forward flexion of the left shoulder was about 80 degrees.

Fig. 16. Abduction of the left shoulder was about 30 degrees.

Fig. 17. At post-op. 10 months, it was possible to eat using the left upper extremity.

Fig. 18. At post-op. 10 months, it was possible to elevate a dumbbell of 4kg and the function of the left elbow was nearly normal.

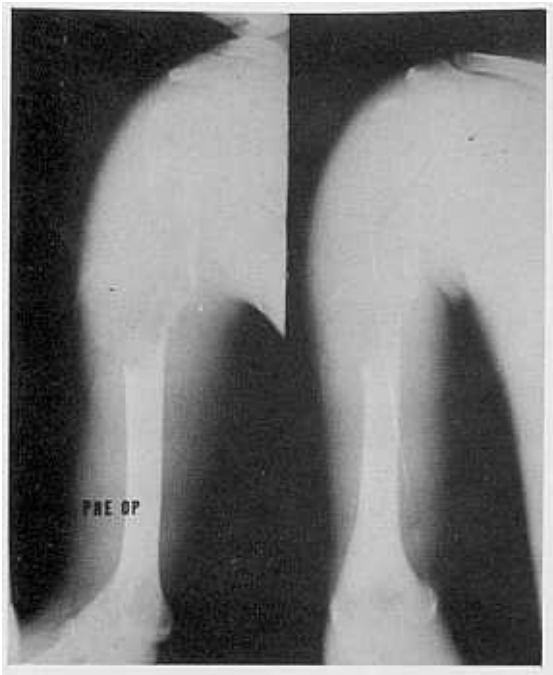

Fig. 19. *X-ray shows an ill-defined osteolytic lesion with periosteal reaction at the right proximal humerus.*

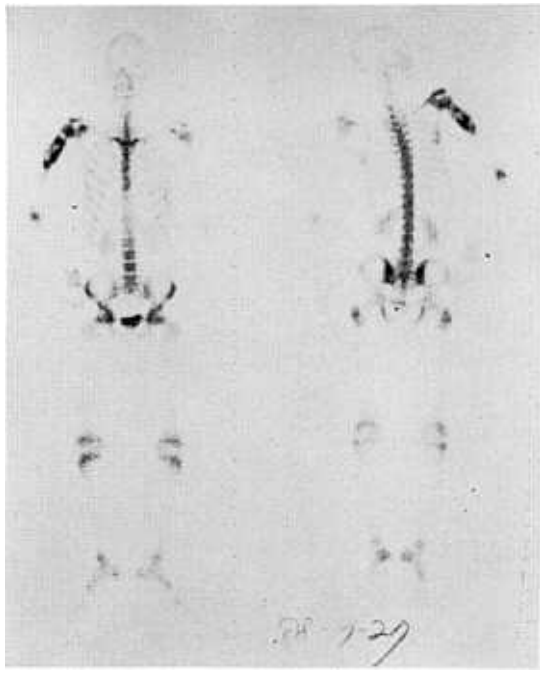

Fig. 21. *Bone scintigraphy shows the tumor was limited to the shaft of the right humerus and there was no metastasis to other sites.*

Fig. 20. *The tumor was supplied by the anterior and posterior circumflex humeral arteries.*

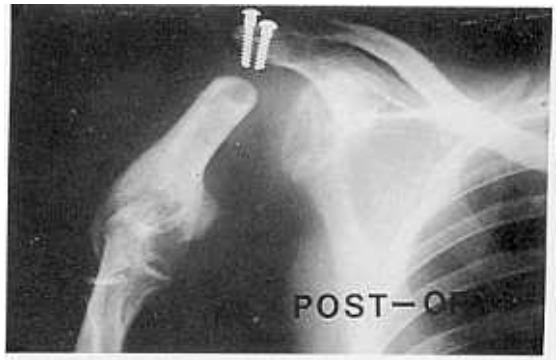

Fig. 22. *Post-op. X-ray shows complete removal of the tumor of the right proximal and shaft of the humerus. The two screws were used to fix the Goretex artificial ligament.*

On plain x-ray, there was an extensive osteolytic lesion on the mid-shft of the right humerus with a periosteal reaction and soft tissue extension (Fig. 19, 20), and on angiography, the tumor was supplied by anterior and posterior circumflex humeral arteries, and their vascular supply was rich (Fig. 21).

In order to evaluate pulmonary metastasis, the lung computed tomogram was performed and no meta-

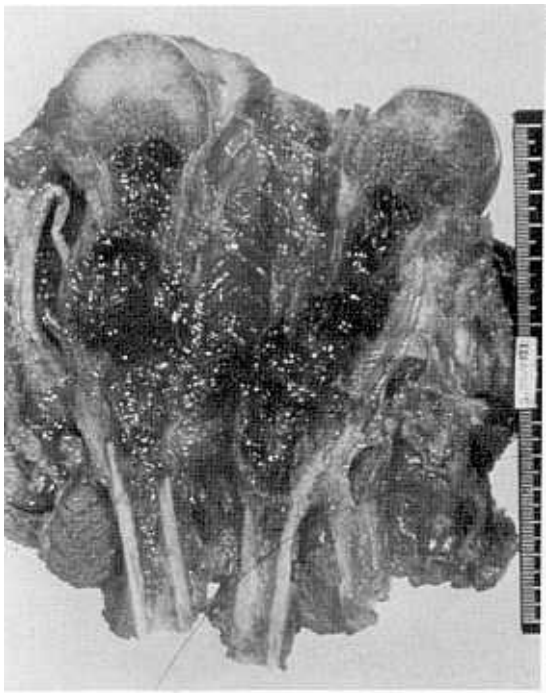

Fig. 23. In the sagittal section of the tumor, there were multiple hemorrhagic areas and cortical breakdown in the shaft of the humerus.

stasis was found. So 1 cycle of chemotherapy, adriamycin 90mg and cis-platinum 180mg was given, and the Tikhoff-Linberg procedure was performed. Because the tumor did not invade the neurovascular bundle, an arthrotomy of the right shoulder and an osteotomy of the right humerus, at 5cm below the tumor, were done.

After that, proximal and distal fragments were connected by a Goretex artificial ligament, and the wound was closed after muslce suture (Fig. 22).

In the longitudinal section of the tumor, there were numerous hemorrhagic lesions, cortical breakdown, and extensive soft tissue involvement; but there was no extensive sclerosis that exited at the aneurysmal bone cyst (Fig. 23). The microscopic finding at a low power field showed multiple dilated cystic lesions that were divided by multiple septas composed of hypercellular stroma. Under higher magnification, the cystic lesions were lined by malignant cells and there were numerous malignant oteoblasts, tumor giant cells and also intervening osteoid. It was a typical finding of a telangiectatic osteogenic sarcoma (Fig. 24, 25, 27).

Postoperative immobilization was done as in the first case and chemotherapy of adriamycin 90mg and cis-platinum 180mg was performed. At 3 months postoperatively his right hand functioned well (Fig. 27).

At present, postoperative 14 months, there is not any evidence of local recurrence or pulmonary

Fig. 24. The low power microscopic finding showed several dilated cystic lesions that were divided by hypercellular stromal septas.

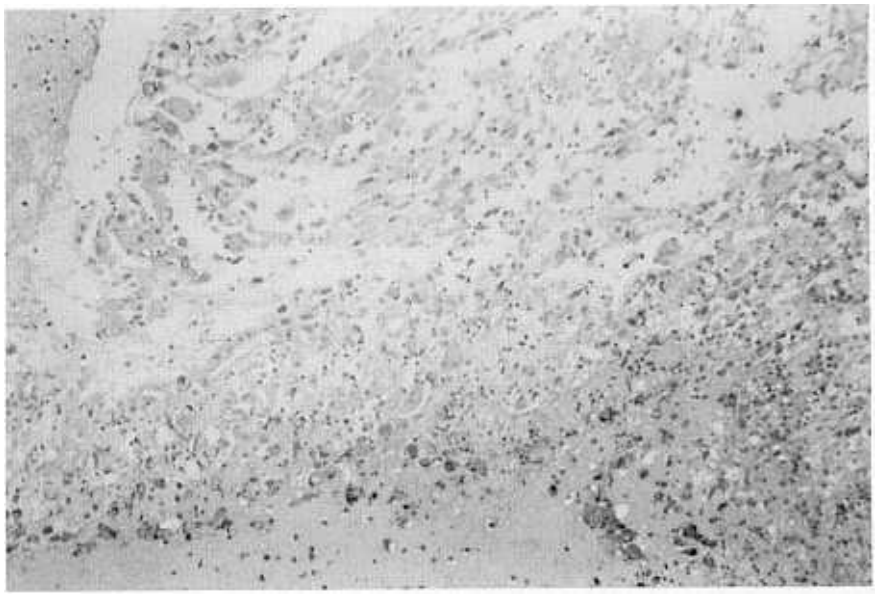

Fig. 25. The dilated cyst was lined by malignant cells in contrast to the aneurysmal bone cyst.

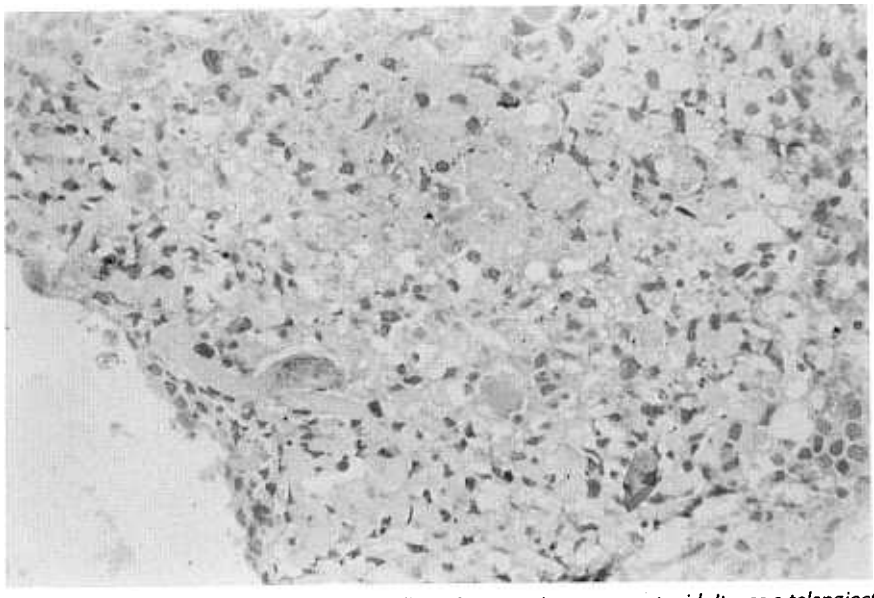

Fig. 26. There were numerous osteoblasts, tumor giant cells and intervening tumor osteoid. It was a telangiectatic osteogenic sarcoma.

metastasis. The grasping power of the right hand is 27.5kg, 73% of the normal hand, and the pinching power is 7.5kg, 81% of the normal hand.

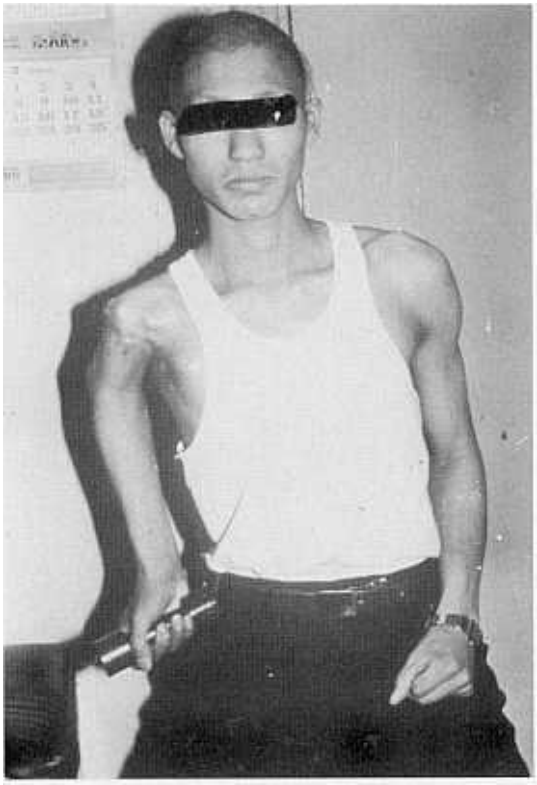

Fig. 27. The right hand functioned well at 3 months postoperatively.

DISCUSSION

High grade sarcomas of the shoulder girdle have traditionally been treated by forequarter amputation. The technique of resection and reconstruction requires thorough knowledge of the regional anatomy and musculoskeletal reconstruction techniques. Essential aspects of the treatment plan should be emphasized. The initial biopsy should be performed through the anterior portion of the deltoid muscle for a lesion of the proximal humerus. The deltoid-pectoral interval should not be used, since biopsy here would contaminate the deltoid-pectoral fascia and subscapularis, and an adequate resection through uninvolved tissue planes is impossible. In performing the definitive resection, the initial incision extends along the medial aspect of the biceps muscle, divides the pectoralis major, and exposes the neurovascular structures; thereby enabling one to determine resectability early in the dissection. This incision does not jeopardize construction of an anterior skin flap in patients who will require forequarter amputation (Malawar *et al.* 1985).

The length of the bone resection is determined before surgery from a bone scan. To avoid a positive margin at the site of humeral transection, the distal osteotomy is performed 6cm distal to the area of abnormality on the scan. Segmental reconstruction of the resultant humeral defect is necessary if resection is performed distal to the deltoid tuberosity. Reconstruction is necessary to maintain the length of the arm and to create a fulcrum for elbow flexion. Marcove *et al.* (1977) reported use of a Küntscher nail inserted into the medullary canal of the distal humerus for this purpose. Whitehill *et al.* (1982) fixed the Küntscher nail to a U-shaped flange attached to the second rib, to maintain proximal stability of the interposition device. Malawar *et al.* (1985) used a Vitallium prosthesis. This prosthesis was fixed distally with methyl methacrylate into the remaining humerus, and proximally with Dacron tape to the clavicle and the remaining scapula was combined with muscle transfer. This was important to facilitate the muscle transfers and the re-attachment of the long head of the biceps to the pectoralis major muscle.

The length of the remaining distal humerus is variable. If the shortest segment is 5cm, this may be a potential site of loosening.

Proximal soft tissue reconstruction is essential to cover the prosthesis and recreate shoulder stability. This is accomplished through a technique of "dual suspension" through static and dynamic reconstruction. In this study, the Goretex artificial ligament was used to perform static suspension, and the muscle transfer was done to perform dynamic suspension. The long head of the biceps brachii was secured to the pectoralis major muscle. Preservation and transfer of the pectoralis major, trapezius, supraspinatus, infraspinatus, teres minor, teres major, and latissimus dorsi muscles were perofrmed to provide mobility at the shoulder. Soft tissue coverage is essential in preventing skin problems and secondary infection (Malawar *et al.* 1985).

The Tikhoff-Linberg procedure is preferred over a forequarter amputation when there is no involvement of the neurovascular bundle and when arteriography demonstrates resectability. The obvious benefit of this procedure is that the hand is preserved and there is usually good elbow function. Furthermore, from recent treatment with aggressive pulmonary resections and chemotherapy, these patients, especially, those with osteogenic sarcoma, are exhibiting prolonged disease-free intervals as well as a possible increased

cure rate. The shoulder is always more or less flail, but painless. Cosmesis is a less important consideration in cancer surgery. Patients who had this resection all gave a very distinctive shoulder contour, but the appearance is markedly improved if the clavicle can be left long (Mackinnon *et al.* 1988).

The Tikhoff-Linberg procedure is recommended as a limb-salvage procedure for tumors around the shoulder joint without amputation, disarticulation or forequarter amputation of the upper extremity.

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