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ORIGINAL ARTICLE

Surgical options in cases of tumorous destruction of the proximal humerus: Twenty-one patients followed from 4-9 years

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Summary

Purpose: *To compare the postoperative outcomes of several techniques of reconstructive surgery for malignant and aggressive benign tumors of the proximal humerus.*

Patients and methods: *Twenty-one shoulder reconstructions following tumor resection were studied. Nine cases with an intracompartmental tumor were treated with endoprosthetic reconstruction. Three cases with the tumor involving the glenoid were treated with a typical Malawer VB shoulder girdle resection. In 5 patients with extracompartmental resections including the rotator cuff or the deltoid muscle a modified Tikhoff-Linberg procedure using polypropylene mesh was performed. In 4 patients with extracompartmental excision the authors proceeded to skeletal reconstruction using a modular endoprosthesis, while soft tissue reconstruction was undertaken using monofilament polypropylene mesh in order to enforce joint stability.*

Results: *All patients achieved stable shoulders. In cases where the technique was modified with mesh the functional outcome was fairly improved and the cosmetic result was excellent.*

Conclusion: *For extracompartmental excisions including the deltoid or the rotator cuff the authors recommend a modified Tikhoff-Linberg procedure. Using polypropylene mesh they aim to achieve a static suspension in order to avoid the excessive traction of the neurovascular bundle, which is the most common complication of this procedure. Substitutionally such cases may be treated by reconstruction with a modular endoprosthesis. They recommend stabilization of the prosthesis with the use of mesh implant, avoiding in this way instability.*

Key words: mesh, proximal humerus, salvage surgery, tumor

Introduction

Limb salvage surgery has replaced amputation as the treatment of choice for sarcomas of the extremities. In the region of the shoulder girdle, endoprosthetic reconstruction has become increasingly popular [1,2].

Malignant tumors of the proximal humerus are frequently large at presentation, juxtaposed to the neurovascular bundle and often present with a cortical breakthrough and a large extraosseous component. Intracompartmental tumors are mostly treated with limb salvage surgery with allograft or endoprosthetic reconstruction of the intercalary defect with satisfactory functional and oncological outcome [3].

In cases of extracompartmental tumors that do not involve the axillary artery or brachial plexus (with indication for limb salvage surgery) treatment requires *en block* resection of bone with a large amount of the surrounding soft tissues. In cases where tumor resection includes the deltoid muscle and the rotator cuff the functional outcome of the limb salvage procedure is questionable [4]. In these cases endoprosthetic reconstruction carries out in addition a high risk of prosthetic instability [5,6]

The authors report techniques and tricks used for reconstruction of the humerus following primary tumor resection.

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Patients and methods

Twenty-one cases that underwent reconstructive surgery for malignant and aggressive benign tumors at the proximal humerus between 1997 and 2003 and having a follow-up period of more than 4 years were selected as the subjects of this study. Preoperative pathological diagnosis was made in 15 cases with incision biopsy and in 6 cases with needle biopsy. The diagnosis included 8 chondrosarcomas, 4 osteosarcomas, one malignant fibrous histiocytoma, one Ewing's sarcoma, one fibrosarcoma, one malignant giant cell tumor, one stage III giant cell tumor and 4 metastatic carcinomas (Table 1).

In all patients we performed routine laboratory tests, plain radiographs and computed tomography (CT) of the lesion and chest, bone scan with Tc^{99m} and magnetic resonance imaging (MRI) of the lesion. Patients with osteosarcoma, malignant fibrous histiocytoma and Ewing's sarcoma received adjuvant or neoadjuvant chemotherapy.

According to Enneking's staging system preoperative evaluation confirmed that the tumor was intracompartmental in 9 cases (group A), whereas imaging techniques confirmed extracompartmental extension of the tumor in 12 patients (group B); in those patients we performed additional arteriography.

All cases selected as the subjects of this study had no invasion of the axillary artery or the brachial plexus. Resection margins were decided based on the preoperative imaging evaluation. A frozen biopsy of the soft tissues and the bone marrow at the resection margins as well as an intraoperative cytological examination of the bone marrow were also carried out and taken into consideration. On postoperative pathological reports of the excised tumor mass negative margins were obtained in all resections with 17 cases having a wide excision and 4 having a marginal excision at the site of the artery.

After tumor resection the next phase of the operative procedure consisted of skeletal reconstruction.

Table 1. Diagnosis, stage, type of reconstruction and outcome in 21 patients with tumor of the proximal humerus

Patient No.	*Sex*	*Age (years)*	*Diagnosis*	*Stage*	*Type of surgery*	*Complications -Outcome*
1	F	20	GCT (benign)	III	Endoprosthetic reconstruction with allograft	
2	F	52	Osteosarcoma	IIA	Endoprosthetic reconstruction	Dislocation
3	M	36	Osteosarcoma	IIA	Endoprosthetic reconstruction	
4	F	49	Chondrosarcoma	IIA	Endoprosthetic reconstruction	Local recurrence
5	M	72	Chondrosarcoma	IA	Endoprosthetic reconstruction	Deep infection
6	F	23	Malignant fibrous histiocytoma	IIA	Endoprosthetic reconstruction	
7	F	51	Fibrosarcoma	IIA	Endoprosthetic reconstruction	
8	F	17	Ewing's sarcoma	IIA	Endoprosthetic reconstruction	
9	M	70	Metastatic (multiple myeloma)		Endoprosthetic reconstruction	
10	F	19	GCT (malignant)	IB	T-L procedure (modified)	
11	M	46	Chondrosarcoma	III	T-L procedure (modified)	
12	M	69	Chondrosarcoma	IB	T-L procedure (modified)	
13	M	55	Chondrosarcoma	IIB	T-L procedure (modified)	Local recurrence
14	M	63	Chondrosarcoma	IIB	T-L procedure (typical)	
15	F	69	Chondrosarcoma	IIB	T-L procedure (typical)	
16	F	52	Metastatic (breast)		T-L procedure (modified)	
17	M	79	Metastatic (multiple myeloma)		T-L procedure (typical)	
18	M	73	Metastatic (kidney)		Endoprosthetic reconstruction + soft tissue reconstruction with mesh	
19	M	56	Chondrosarcoma	IIB	Endoprosthetic reconstruction + soft tissue reconstruction with mesh	
20	M	27	Osteosarcoma	IIB	Endoprosthetic reconstruction + soft tissue reconstruction with mesh	Pulmonary metastasis (no local recurrence)
21	M	24	Osteosarcoma	IIB	Endoprosthetic reconstruction + soft tissue reconstruction with mesh	

GCT: giant cell tumor, T-L: Tikhoff-Linberg, F: female, M: male

Surgical techniques

Group A - 9 patients (resection does not sacrifice rotator cuff, deltoid muscle or axillary nerve)

Eight cases with an intracompartmental malignant tumor were treated with endoprosthetic reconstruction.

The stage III benign giant cell tumor case was treated with a combined implant (endoprosthetic reconstruction + allograft)

Group B - 12 patients (resection does sacrifice rotator cuff and part of the deltoid muscle or axillary nerve)

Imaging techniques showed that a large amount of soft tissues essential for shoulder stability (rotator cuff and part of the deltoid muscle) were involved. Local tumor control was feasible but surgical treatment required resection of bone along with all the muscles and the soft tissues inserting and originating from the involved bone. With the joint capsule, the rotator cuff and part of the deltoid muscle absent, ordinary endoprosthetic reconstruction of the intercalary defect would give a high dislocation rate and was a contraindication [7,8]. The alternative therapeutic solution would be a shoulder girdle resection, such as the Tikhoff-Linberg procedure [9,10].

In 3 patients of this group the glenoid was involved too, and a typical Tikhoff-Linberg (Malawer VB) shoulder girdle resection was performed as the only surgical option [10-13].

In 5 patients of group B we performed a modified Tikhoff-Linberg procedure. We believe that in cases which require resection of a large amount of the surrounding soft tissues, the Tikhoff-Linberg procedure gives a satisfactory functional outcome avoiding the risk of dislocation which is high in endoprosthetic reconstruction. The most serious problem concerning this technique is the traction of the neurovascular bundle caused by the weight of the upper extremity. Owing to this aspect we modified the typical Tikhoff-Linberg procedure by using monofilament polypropylene mesh implant which was placed between the scapula, the acromion and the clavicle on the proximal side, and the remaining part of the humerus on the distal side was secured by drill holes. The goal was to achieve a static suspension in order to avoid excessive traction of the neurovascular bundle.

In 4 patients of group B after resection of the tumor and the soft tissues which included the capsule, the rotator cuff and part of the deltoid muscle, we decided to proceed to skeletal reconstruction using a modular endoprosthesis. We selected those 4 patients because they were young, were cooperative and their occupation were no hand-demanding. Soft tissue reconstruction was undertaken using monofilament polypropylene mesh in order to enforce joint stability. In this aspect the mesh was placed with sutures in the remaining part of the joint capsule, was secured with drill holes at the glenoid crest and distally passed through holes of the prosthesis (Figures 1-4). The remaining muscles and soft tissues were sutured on the mesh and the holes of the endoprosthesis to cover the prosthesis and to enforce shoulder stability. In one

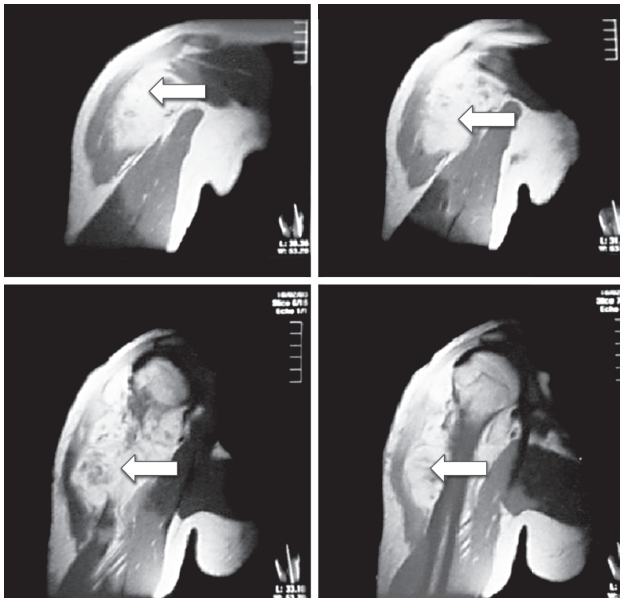

Figure 1. Case No. 20 was referred to us with an osteosarcoma of the proximal humerus. As shown at MRI (arrows), the tumor is involving the deltoid muscle after inappropriate biopsy undertaken elsewhere.

Figure 2. Resection of bone with the surrounding soft tissues (part of the deltoid muscle and the rotator cuff) and skin (excision of the biopsy tract).

Figure 3. Skeletal reconstruction was achieved with a modular endoprosthesis. Mesh is used for soft tissue reconstruction to enforce joint stability.

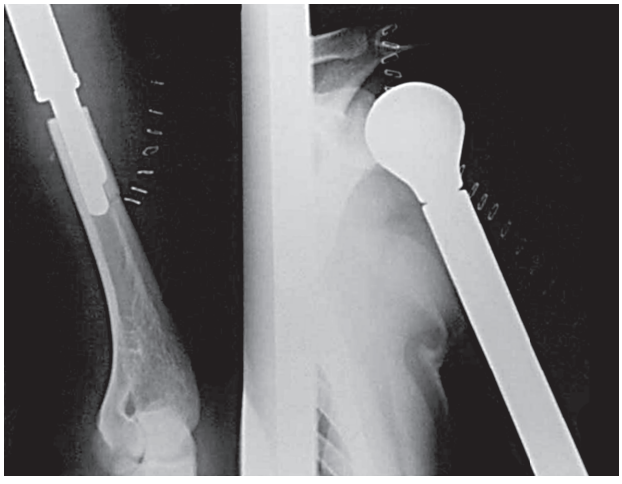

Figure 4. Postoperative plain radiographs.

case (a patient with osteosarcoma) we additionally transferred part of the trapezoid muscle to improve the functional outcome.

Results

The mean follow-up period was 6.2 years (range 4-9 years). Related to the stability of the prosthesis, no major complications in group A patients treated with endoprosthetic reconstruction were observed.

The group B patients, treated with the typical Tikhoff-Linberg procedure had an excellent elbow and hand function and were satisfied with the functional outcome. In cases where the technique was modified with the mesh, strength and ability of weight-bearing were improved compared with patients treated in the past with the traditional procedure.

In patients of group B treated with endoprosthetic reconstruction and soft tissue reconstruction with mesh implant the result-related to the stability of the prosthesis-was excellent. With a mean follow-up of 5.7 years (range 4-7) no dislocation or subluxation were encountered. The functional outcome compared with patients with a shoulder girdle resection, which was the alternative therapeutic solution, was fairly improved. The cosmetic result was excellent. All patients were satisfied, and returned to their previous occupations. All patients are able to drive car.

Discussion

The functional result of limb sparing procedures for tumors of the proximal humerus depends mostly on the size of the tumor and the extent of the resection [5,13]. The choice of reconstruction technique should also be based on the extent of the resection and the needs of the patients.

If local disease control can be achieved with preservation of the surrounding soft tissues and especially the rotator cuff and deltoid muscle, endoprosthetic reconstruction is the most preferred approach with a satisfactory functional result, as shown in the literature [3].

In cases where the resection removes the rotator cuff and the deltoid muscle or the axillary nerve, then functional result is poor and endoprosthetic reconstruction carries out a high rate of instability [5,6,14]. In this study we treated such cases with a modified Tikhoff-Linberg procedure using polypropylene mesh implant. We believe that this technique is the most appropriate in such cases, giving a fair functional result but a poor cosmetic outcome. In 4 patients reconstruction with a modular prosthesis and soft tissue reconstruction was achieved with monofilament polypropylene mesh. In this way we avoided complications such as dislocation or subluxation of the prosthesis. The cosmetic result was excellent and the functional outcome, compared with cases treated with a Tikhoff-Linberg procedure, was fairly improved, especially concerning abduction.

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