

# More than 20-year Follow-Up After Vascularised Fibula Head Graft for Oncological Shoulder Joint Reconstruction

TADAHIKO KUBO, TAISUKE FURUTA and MITSUO OCHI

*Department of Orthopaedic Surgery, Graduate School of Biomedical Sciences,  
Hiroshima University, Hiroshima, Japan*

**Abstract.** *Background:* In our Department, the vascularized fibula head has been the preferred option for proximal humerus reconstruction for approximately 30 years. The purpose of the present study was to analyze the long-term functional outcome for oncological shoulder reconstruction. *Patients and Methods:* The vascularized fibula head was transferred in 3 patients; 2 with giant cell tumor and 1 with low-grade chondrosarcoma. Functional results were evaluated using the rating system of the Musculoskeletal Tumor Society. We obtained information by means of a telephone questionnaire in 1 patient and by direct examination in 2 patients. The mean follow-up period was 24 years and 4 months. *Results and Conclusion:* Absorption of the transferred fibula head was not observed in any of the examined patients. The mean overall functional rating was 75.6%. Results with regard to pain, positioning of the hand, and manual dexterity were more satisfactory than those of function and lifting ability. The present long-term study demonstrated that the reconstructed shoulder joint was clinically and radiologically maintained for more than 20 years after surgery.

Limb reconstruction options after tumor extirpation include custom-made endoprosthesis, conventional allograft, processed autograft reconstruction, vascularized autograft, bone distraction, and rotationplasty (1, 2). Among them, the vascularized fibular graft is the first choice for biological reconstruction of long bone defects, because of its durability. The vascularized fibula head is particularly useful for joint reconstruction of the upper limbs. After a report of the first successful use of a vascularized fibula head for wrist joint

reconstruction in 1979, many micro-surgeons expressed confidence in the potential of biological reconstruction for joint reconstruction of the upper limbs (3, 4). Moreover, a major characteristic of this vascularized fibula head graft procedure is the fact that postoperative bone growth can be expected, since the epiphyses are transferred at the same time. For this reason, a growing child is the ideal patient for vascularized fibula head graft transfer. In our Department, the vascularized fibula head has been the preferred choice for reconstruction of the proximal humerus for approximately the past 30 years.

On the other hand, there exists concern that the small articular surface of the fibula head does not fit into the large glenoid fossa, causing poor joint congruity and stability. Therefore, the reconstructed shoulder joint might undergo degenerative change over time, causing omalgia and loss of function. The aim of the present study was to analyze the long-term functional outcome after vascularized fibula head graft transfer for oncological shoulder reconstruction.

## Patients and Methods

Before 1993, the vascularized fibula head was transferred in 3 patients at our Institute to reconstruct the shoulder joint following tumor resection in the proximal humerus. The mean age at the time of surgery was 41.7 years. All patients were females. Cases included 2 patients with giant cell tumors and 1 patient with low-grade chondrosarcoma.

Wide resection was performed in the 2 patients with giant cell tumors and in 1 patient with chondrosarcoma without invasion of the surrounding soft tissue. The whole proximal humerus affected by a tumor was successfully resected. The shoulder girdle muscles attached to the humerus were preserved as much as possible. Bony defects were reconstructed with a vascularized fibula head graft including a preserved cuff of the biceps femoris and the lateral collateral ligament, which were sutured to the short head of the biceps humerus in patient 1 and to the remaining rotator cuff in the other patients. The vascular pedicle of the graft included peroneal vessels and the recipient vessels were circumflex humeral vessels in all patients. For knee instability, the sectioned lateral collateral ligament was augmented using artificial ligament as a prophylactic procedure in patients 2 and 3 (Table I).

The present retrospective study was approved by the Institutional review board. The postoperative course of the transferred bone was

*Correspondence to:* Tadahiko Kubo, MD, Department of Orthopaedic Surgery, Graduate School of Biomedical Sciences, Hiroshima University, 1-2-3 Kasumi, Minami-ku, Hiroshima, 734-8551, Japan. Tel: +81 822575232, Fax: +81 822575234, e-mail: kubot@hiroshima-u.ac.jp

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Table I. Patients' characteristics.

Patient	Age (years)	Gender	Diagnosis	Humerus resection*	Fibula graft†	Follow-up
1	53	Female	GCT	12 cm	15 cm	32 year 8 month
2	46	Female	CS	9 cm	14 cm	20 year 3 month
3	26	Female	GCT	11 cm	16 cm	20 year 1 month

GCT: Giant cell tumor; CS: chondrosarcoma. \*Length of resected humerus. †Length of grafted Fibula.

examined with plain radiography and computer-assisted tomography (CT). Functional results were evaluated with the rating system of the Musculoskeletal Tumor Society (5). Clinical and pathological characteristics of patients are listed in Table I. The mean follow-up period was 24 years and 4 months.

## Results

We obtained information by means of a telephone questionnaire in patient 3 (Table I) and by direct examination for all other patients. All vascularized fibula head grafts were transferred successfully and there was no post-operative morbidity either on the donor or the recipient site. During the follow-up period, absorption of the transferred fibula head was not observed on plain X-ray and CT in any patient. Mild osteoarthritis of the glenohumeral joint occurred in patient 1 and partial remodeling was maintained in patient 2 (Figure 1). The mean overall functional rating score of the Musculoskeletal Tumor Society was 75.6%. Results with regard to pain, positioning of the hand, and manual dexterity were satisfactory. However, the lifting ability was the least satisfactory and the lowest degree of range of motion (ROM) was flexion or abduction (Figure 2). The functional outcome and ROM of the patients are listed in Tables II and III, respectively.

## Discussion

Shoulder arthroplasty using the vascularised fibular graft has a non-anatomic joint alignment between the small fibular head and large glenoid fossa, resulting in degenerative change with time. Several studies have reported on good functional outcomes of shoulder arthroplasty using a vascularised fibular graft, but no studies have included 20 years of follow-up data (6-16). This prompted us to conduct this long-term follow-up study. The total functional scores for all patients were satisfactory. However, elevation and muscle strength of the shoulder joint remains unsatisfactory, which caused a reduction in the functional score. No physical limitation of the elbow joint and wrist joint compensated for this disability of the shoulder joint. Furthermore, radiological examination showed a maintenance of the remodeled shoulder joint with mild

osteoarthritis of the glenohumeral joint in patient 1 and without osteoarthritis in patient 2. Our long-term results after reconstruction of the proximal humerus were similar to those of the other short- and medium-term studies (6-16).

There exist certain limitations to the present study. Firstly, the patient number is small. The results are promising, yet further investigation is warranted to confirm our findings. Secondly, this investigation was based on the rating system of the Musculoskeletal Tumor Society and the functional outcome was defined as satisfactory. However, this evaluation system does not necessarily reflect specific problems or the ability of the reconstructed upper limb to perform activities of daily living (ADL) and other tasks, since kinetic mobility does not necessarily have a direct correlation to daily functions. Perhaps the use of the outcome measure based on ADL or other shoulder-specific outcome measures may be more appropriate when evaluating the results of this type of significant alteration of the upper limb (17, 18).

When the fibular head is transplanted to replace a resected head of the humerus, the small fibular head, with its lack of broad articular surface, is relatively unstable in the glenoid fossa. In order to stabilize the grafted head, we sutured a preserved cuff of the biceps femoris and the lateral collateral ligament to the short head of the biceps humerus in patient 1 and to the remaining rotator cuff in the other patients. Several authors have described various glenohumeral stabilizing techniques. For example, Tag *et al.* (16) described that the long tendon of the biceps brachii was cut at the level of the surgical neck of the humerus. The proximal end of the cut tendon was then led through an oblique hole drilled through the fibular head at an angle of 30 to 45 degrees and reattached to the distal cut end. Gao *et al.* (12) used suspensory loops of 1-0 braided sutures passed through a single drill hole in the acromion and a second drill hole in the fibular head to stabilize the fibula in the glenoid fossa.

In addition, the partial removal of the shoulder girdle musculature influenced glenohumeral joint stabilization and the recovery of strength. The extent of the excision of muscles adjacent to the shoulder depends on the location of the lesion and its pathology. In the present study defects are amenable to intra-articular shoulder resection with preservation of the rotator cuff and deltoid, because all patients are of benign or

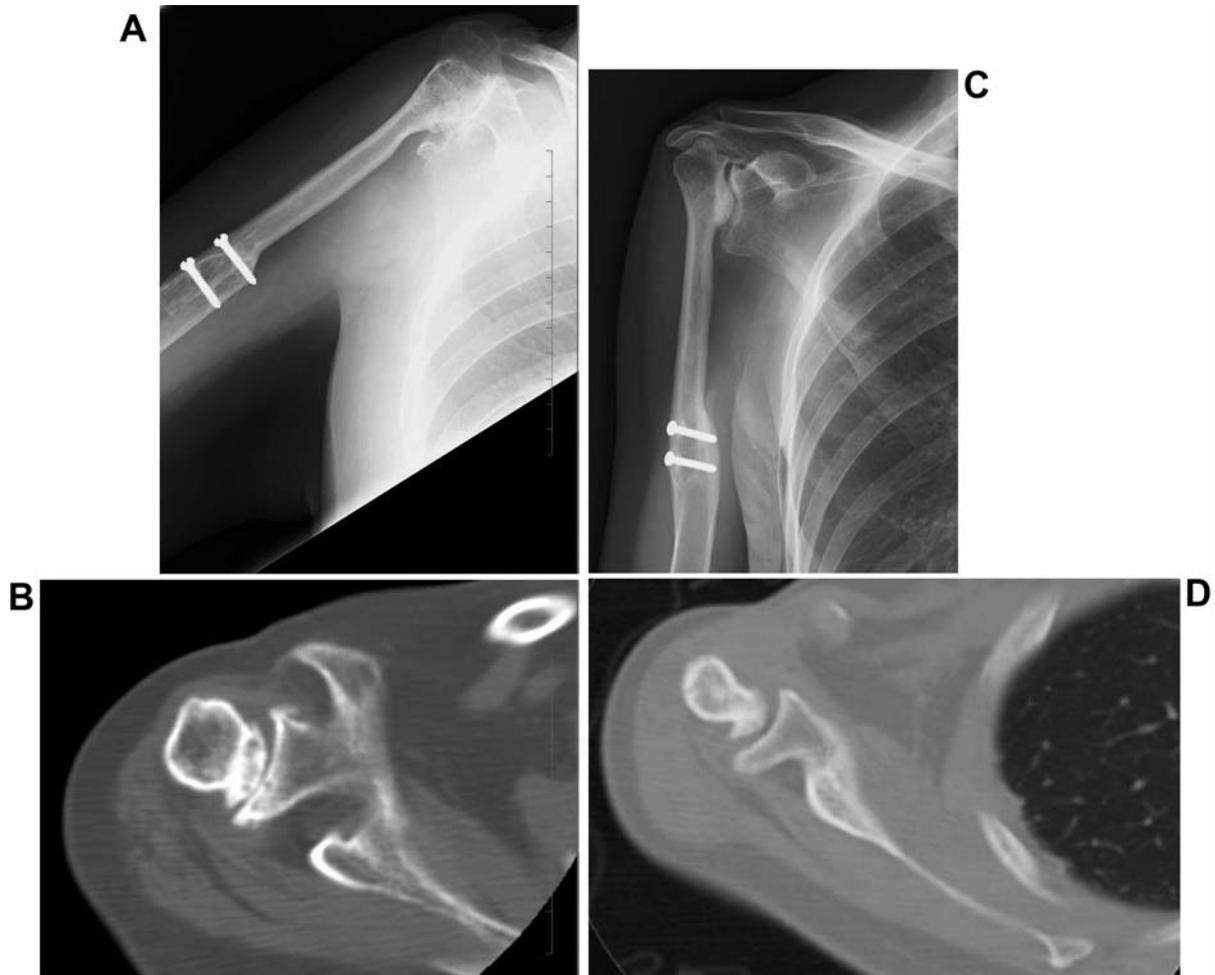


Figure 1. Radiographs and computer-assisted tomographs at the last follow-up show a mild degenerative change of the glenohumeral joint in Patient 1 (A and B) and maintained remodeling of the shoulder joint in Patient 2 (C and D).

Table II. Functional rating system of the musculoskeletal tumor society.

Patient	Pain	Function	Emotional acceptance	Hand positioning	Manual dexterity	Lifting ability	Overall rating
1	4	3	3	3	4	3	67%
2	4	3	3	4	5	3	73%
3	4	4	4	5	5	4	87%

low-grade malignancy. Although the stumps of the deltoid muscle and rotator cuff were easily sutured with transferred bone to increase postoperative function, the elevation of the shoulder joint was still unsatisfactory. Further surgical improvements are required in order to secure increased stabilization and a stronger power source for shoulder elevation. For example, Ferrier *et al.* suggested a pedicled latissimus dorsi transfer to the deltoid position to provide good stability and function for a shoulder hemiarthroplasty (19).

Table III. Range of motion of the shoulder joint.

Patient	Flexion	Abduction	Extension	External rotation	Internal rotation
1	50°	40°	30°	10°	90°
2	65°	45°	35°	20°	90°
3	NA	NA	NA	NA	NA

NA: Not available.



Figure 2. Patients 1 and 2 demonstrated limited flexion (A and C) and unfavorable abduction (B and D) of the shoulder joint, respectively.

In the present study, the peroneal artery was used to provide fibula vascularization nutrition, and the fibular head seemed to remain well-vascularized and retained its shape radiographically until the latest follow-up. The peroneal artery is supposed to be the dominant blood supply of the fibula and good blood flow to the fibular head was recognized intraoperatively in articles where the peroneal vessels were used as a vascularized pedicle (8, 16). On the other hand,

some authors reported that absorption or collapse of the fibula head occurred for a while after reconstruction (12, 14). The choice of nutrient vessels is a matter of discussion, especially for infancy and adolescence. The discrepancy of the limb length due to the subsequent growth of contralateral limbs is a major problem for skeletally-immature patients. Transferring the epiphyses of the vascularized fibula head graft is the prominent characteristic of this procedure that preserves axial

limb growth. Restrepo's (20) study of fibula vascularization led to a more detailed investigation of the anatomical territory of the vascular pedicle of the fibula head graft in the 1980s. Taylor *et al.* (21) have reported that the anterior tibial artery provided a reliable blood supply to the proximal epiphysis and to the proximal two-thirds of the fibula diaphysis. Menezes-Leite *et al.* (22) demonstrated that an epiphyseal graft vascularized by the anterior tibial artery alone could on average be extended to almost 12 cm of the shaft. Mozaffarian *et al.* (23) found anatomic variations in the circumflex fibular neck artery, making preoperative angiography a prerequisite. Ad-El *et al.* (13) have reported that a sufficient blood supply was obtained both in the diaphysis of a long fibular graft and in the fibular head by using both the peroneal artery and the specific branch to the fibular head as a bipediced free flap. Further studies are required to clarify the best donor vessel for the vascularized fibular head graft, especially where epiphyseal transfer is expected.

In conclusion, for approximately 30 years, the vascularized fibula head has been the preferred option for the biological reconstruction of the shoulder joint. This long-term study demonstrated that the reconstructed joint clinically and radiologically is maintained for more than 20 years after surgery. However, because of the small number of patients, further studies are required to confirm our results.

### Conflicts of Interest

No potential conflicts of interest were disclosed by any of the Authors.

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