

# A New Method of Limb Salvage and Functional Upper Limb Reconstruction

Ruka Shimizu<sup>1</sup>, Kazuo Kishi<sup>1</sup>, Hideo Morioka<sup>2</sup>, Hiroo Yabe<sup>2</sup>

<sup>1</sup>Department of Plastic and Reconstructive Surgery, Keio University School of Medicine, Tokyo, Japan; <sup>2</sup>Department of Orthopaedic Surgery, Keio University School of Medicine, Tokyo, Japan.

Email: [kkishi@a7.keio.jp](mailto:kkishi@a7.keio.jp)

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## ABSTRACT

Amputation is frequently used to treat malignant tumors invading into the shoulder joint. When the vessels and major nerves of the upper arm are preserved, however, the limb may be salvaged with a combined osseous, myocutaneous flap. We reconstructed large defects, which included the shoulder joint, using a vascularized rib-latissimus dorsi combined flap. Ribs were connected via the ninth or tenth posterior intercostal artery. Several slits were cut in the ribs, and the rib was glass stick fractured to straighten it. The thoracodorsal nerve was preserved and the latissimus dorsi muscle was transferred to the defect previously occupied by the biceps humerus. The ribs were connected to the residual clavicle via a Leeds-Keio artificial ligament. The flaps completely engrafted. The patient was able to flex her elbow relatively early postoperatively. The function of the hand was preserved intact. In conclusion, the combined vascularized rib-latissimus dorsi flap is useful for patients who require functional or bony reconstruction of large defects involving the shoulder joint.

**Keywords:** Shoulder; Vascularized Rib; Latissimus Dorsi; Elbow Flexion; Limb Salvage

## 1. Introduction

Amputation is frequently used to treat malignant tumors invading into the shoulder joint. When the vessels and major nerves of the upper arm are preserved, however, the limb may be salvaged with a combined osseous, myocutaneous flap. In cases where limb salvage is chosen, various tissues including muscle, skin, and bone may be required depending on the extent of the defect.

In such cases, flaps based on the thoracodorsal artery will fulfill most of the closure requirements. Large flaps may be created around this artery, which supplies the latissimus dorsi (LD) muscle, serratus anterior muscle, and ribs. Flaps from this area may be structured to incorporate varying amounts of bone and muscle as indicated by the defect. The ribs are primarily supplied by the intercostal artery, which anastomoses with the thoracodorsal artery in the LD muscle [1,2]. The option to incorporate bone and soft tissue in a single pedicle has made flaps from the thoracodorsal system popular in reconstruction of the maxillofacial region [3,4]. The LD is also frequently used to functionally reconstruct the elbow joint [5-10].

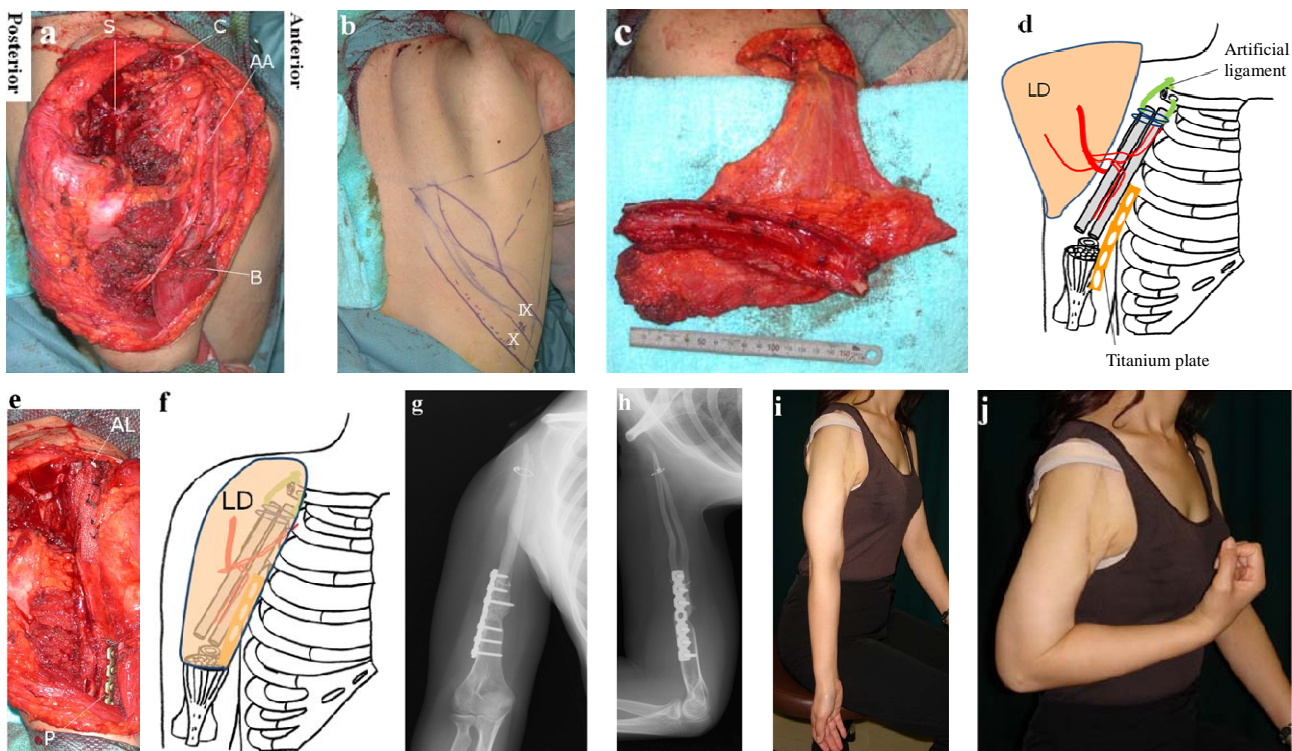
In the present report, we describe a patient in whom a large defect involving most of the upper arm and glenohumeral joint was reconstructed with the combined vas-

cularized rib-latissimus dorsi flap, resulting in successful limb salvage.

## 2. Case Report

A 33-year-old woman with a right proximal humeral chondrosarcoma underwent a radical tumor resection that included the proximal half of the humerus, the shoulder, the lateral one third of the clavicle, the deltoid muscle, the triceps brachii muscle, the proximal two thirds of the biceps brachii muscle, and the overlying skin (**Figure 1(a)**).

We planned the reconstruction using a vascularized rib-latissimus dorsi flap based on the thoracodorsal artery system (**Figure 1(b)**). The ninth and tenth ribs were raised with the ninth intercostal artery (**Figure 1(c)**). The ribs were partially cut with a bone saw to straighten them and placed facing each other, then fixed with surgical wire. They were then fixed to the residual humerus with a titanium plate and sutured to an artificial ligament (Leeds-Keio ligament). The other side of the artificial ligament was fixed to the remnant of the clavicle (**Figures 1(d)** and **(e)**). The insertion of the LD was sutured to the remnant of the biceps brachii, and the origin of the LD was sutured to the dissected shoulder with 3 - 0 polyglactin 910 (Vycryl, Ethicon Inc., Somerville, NJ)



**Figure 1.** (a) Defect following resection of the tumor. The axillary artery, axillary vein, and axillary nerve were maintained. The distal one third of the biceps brachii was preserved. C: clavicle, S: scapula, AA: axillary artery, B: biceps brachii; (b) Design of the flap. The ninth and tenth ribs were included in the flap; (c) View from the deep side after raising the flap; (d) Schematic view of the reconstruction. The ribs and residual clavicle were sutured to the Leeds-Keio ligament; (e) The ribs and residual humerus bone were fixed with a titanium plate. AL: artificial ligament. P: titanium plate; (f) Schematic view of the setting of the LD. The thoracodorsal nerve was preserved and the origin of the LD was sutured to the remnant of the shoulder. The insertion of the LD was sutured to the remnant of the biceps brachii; (g), (h) Front and side views five years postoperatively. X-ray image of the reconstructed upper arm. The fused ribs are nearly straight; (i), (j) The maximum flexion of the elbow was 120 degrees, and function of the hand was almost completely intact.

(**Figure 1(f)**). The flap healed without any necrosis. The flexion of the elbow recovered shortly after the surgery. Six months postoperatively, non-union was observed between the ribs and the humerus. Thus a free bone graft was added around the non-union. Five years after the primary operation, the ribs were nearly straight (**Figures 1(g)** and **(h)**). The function of the hand was preserved, and the flexion of the elbow was possible to 120 degrees (**Figures 1(i)** and **(j)**).

### 3. Discussion

This is the first report describing the use of a combined vascularized rib-LD flap for the reconstruction of a muscle and bone defect simultaneously following a radical resection involving most of the upper arm and glenohumeral joint.

If the shoulder joint is preserved, its function may be improved by multiple muscle transfer [11]. It is still not possible, however, to completely reconstruct a functional shoulder joint at the time of radical resection involving the joint. In such cases where some distal neuromuscular function in the arm or hand may be possible, merely re-

storing the function of elbow flexion results in significant improvements in a patient's quality of life. In an upper limb reconstruction, the LD muscle is frequently used to restore elbow flexion [5-10,12]. In the cases requiring reconstruction of the biceps brachii, transfer of the LD without disrupting its innervation will restore elbow flexion. In the present case, the functional recovery of the biceps brachii muscle was observed in the early postoperative period. Only one third of the patient's biceps brachii muscle was retained. Therefore, much of the elbow flexion was mediated by the transposed LD muscle.

When reconstructing the long bones, the fibula is frequently used [8,13,14]. The lower leg, however, lacks sufficient soft tissue to reconstruct large muscular defects that may also be present. The vascularized rib is also sometimes chosen for reconstruction of the long bones [15,16]. Use of a rib permits the concurrent reconstruction of soft tissue defects with the LD muscle, particularly when restoration of elbow flexion is also desired. The curve of the rib sometimes limits its use in long bone reconstruction. The rib may be straightened, however, by

creating a glass stick fracture and suturing the rib together in a fashion that straightens it but does not compromise its strength.

The ability of the reconstructed shoulder joint to support the weight of the arm was another concern in our case. The Leed-Keio ligament is made of polyester woven into an open mesh-like structure [17]. After implantation, longitudinally aligned collagen-fiber bundles with spindle-shaped nuclei form over the polyester matrix [18,19]. Use of this material permitted the strength of the artificial joint to be preserved even after five years in our case.

Our report illustrates that the combined vascularized rib-LD flap is useful in the reconstruction of large soft tissue and bony defects that involve the upper limb and the glenohumeral joint.

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