

Functional reconstruction of the knee extension mechanism following wide resection for a prepatellar soft-tissue sarcoma: A case report

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Abstract. Functional reconstruction following a wide resection for a malignant musculoskeletal tumor is often challenging, particularly for juxta-articular tumors. The current study describes a novel surgical procedure for the functional reconstruction of the knee extensor mechanism with a pedicle frozen auto-bone and -tendon graft, in a case of prepatellar clear cell sarcoma. The active range of motion of the knee was from 0-135°, and the extension muscular strength of the knee was evaluated as 5/5 by a manual muscle test at 14 months post-surgery (International Society of Limb Salvage score, 73%); this was improved compared with a similar procedure previously described by Muramatsu *et al.* This procedure must be considered following the wide resection of juxta-articular malignant musculoskeletal tumors.

Introduction

Biological reconstruction of the knee extensor mechanism following a wide resection for a juxta-articular musculoskeletal malignancy is a challenging procedure (1). Although some surgical options including latissimus dorsi (LD) free flap (2), allografting (3), free grafting of the fascia lata with the iliac bone (4) and a pedicle medial gastrocnemius flap (5), have been reported to date, to the best of our knowledge, only one case report in which the knee extensor mechanism was biologically reconstructed with a free frozen autograft has been published (6).

The present study reports a new surgical procedure for the functional reconstruction of the knee extensor mechanism with a pedicle frozen autograft, following the wide resection

of a prepatellar clear cell sarcoma. This case is discussed with reference to the previously reported procedure. Written informed consent was obtained from the patient.

Case report

Case presentation. A previously healthy 45-year-old male presented to the Department of Orthopaedic Surgery, Fukushima Medical University Hospital (Fukushima, Japan) with a two-year history of pain in the right knee and a three-month history of painless soft tissue mass on the surface of the right patella. Magnetic resonance imaging revealed a soft-tissue tumor growing on the surface of the quadriceps femoris tendon and patella, measuring 57x50x29 mm (Fig. 1). The tumor was diagnosed as clear cell sarcoma following an incisional biopsy. An additional radiological examination (chest computed tomography and whole-body thallium scintigraphy) revealed no other tumorous regions throughout the body.

Surgical technique. One month later, the patient underwent surgical treatment for the removal of the tumor. An en-bloc wide resection of the tumor and circumferential tissues, including the quadriceps femoris (vastus medialis, intermedius and lateralis) tendon, patella, patellar tendon and tibial tubercle, was performed. The rectus femoris as a pedicle of the knee extensor mechanism was spared (Fig. 2A). The quadriceps tendon, patella, patellar tendon and tibial tubercle were soaked in liquid nitrogen and frozen, maintaining the continuity of rectus femoris muscle (Fig. 2B). Following thawing, the tumor was resected and the tibial tubercle was reattached to the tibia using two screws and spike washers (Fig. 2C). The surface of the patella and patellar tendon was covered with a medial gastrocnemius flap and full-thickness skin graft.

Postoperative course. The knee was immobilized with a splint and was kept non-weight-bearing for one week, followed by full-weight bearing with straight-knee orthosis for three weeks. Mobilization of the knee commenced concurrently. The patient began walking without orthosis or a cane at four months post-surgery. Two courses of adjuvant chemotherapy with cisplatin (200 mg, day 1), doxorubicin (60 mg/m², days 1 and 2) and caffeine (4,500 mg/m², days 1-3)

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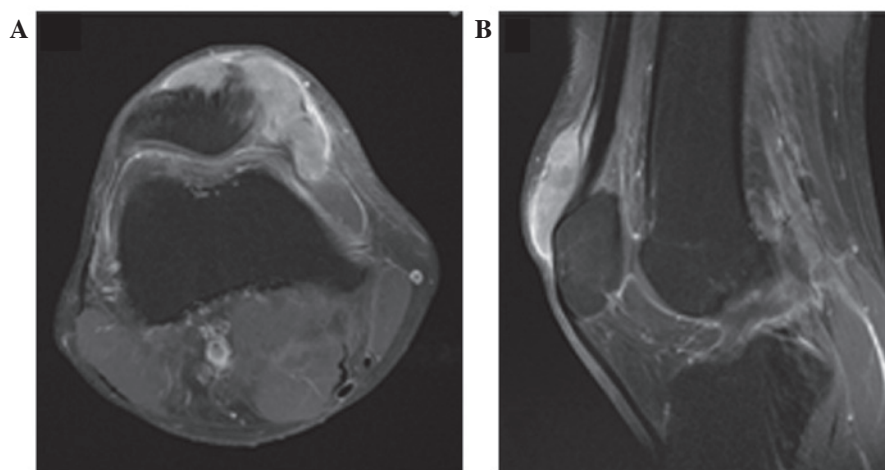


Figure 1. Initial magnetic resonance imaging revealed a prepatellar soft tissue tumor, exhibiting diffuse enhancement on gadolinium-enhanced T1-weighted fat-suppression imaging. (A) axial view; (B) sagittal view.

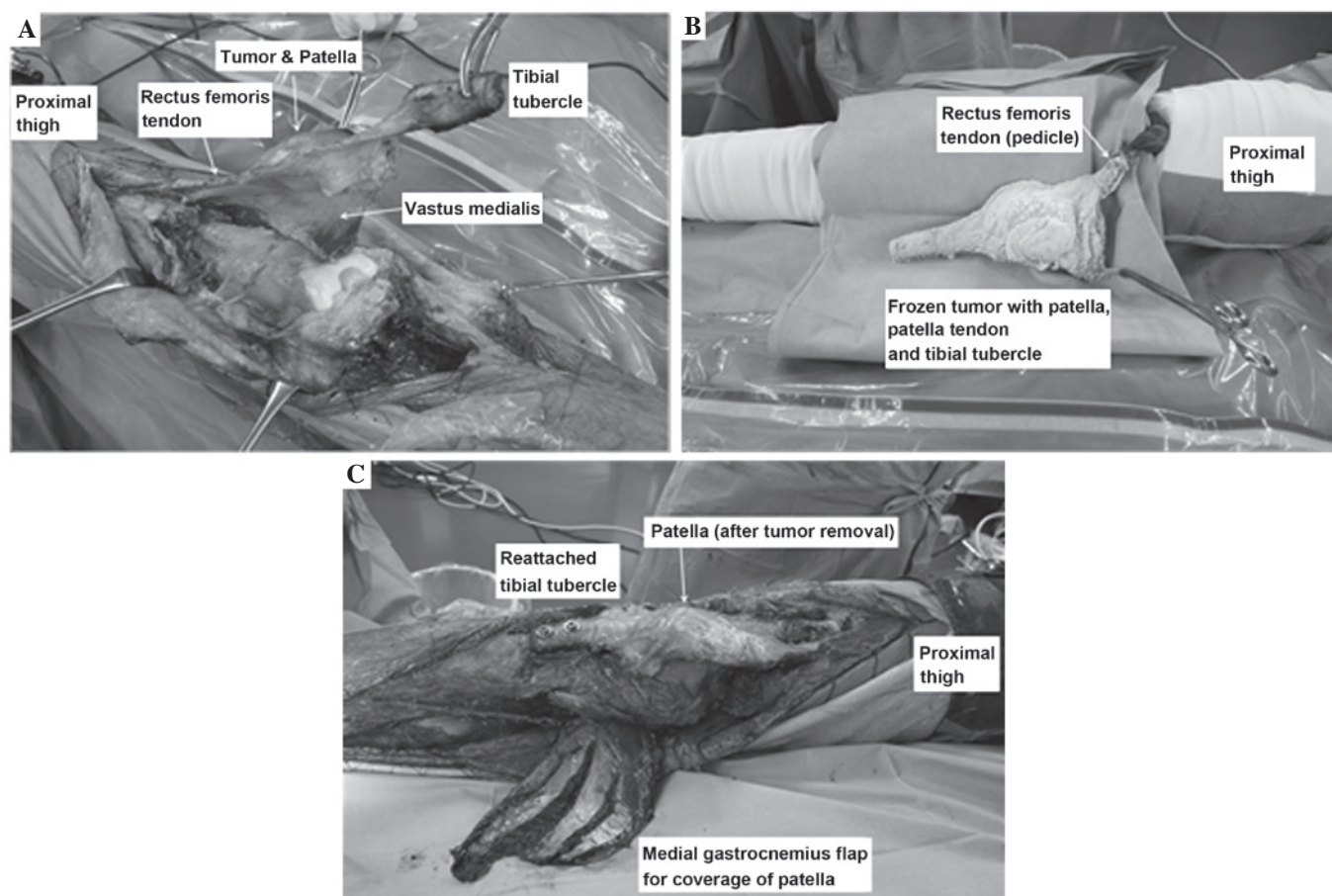


Figure 2. Intraoperative photographs. (A) The tumor and circumferential tissues were widely resected and the tibial tubercle was osteotomized, however, the rectus femoris was spared as a pedicle of the knee extension mechanism. (B) The quadriceps tendon, patella, patellar tendon, and tibial tubercle were turned over consecutively, soaked in liquid nitrogen and frozen, maintaining the continuity of the rectus femoris muscle. (C) The tumor was resected following thawing, and the tibial tubercle was reattached to the tibia with a pair of screws and spike washers.

were administered every three weeks, however, the patient declined continuation of chemotherapy due to the adverse events experienced (nausea, G1; malaise, G2; white blood cell reduction, G2) (7). Plain radiographs taken six months following the surgery revealed complete bone union of the site of the osteotomy (tibial tubercle), and vertical fracture of the

patella without trauma. The patellar fracture was diagnosed as an insufficiency fracture and was treated conservatively with the use of a straight-knee orthosis for four weeks; the patient's knee function recovered without problem.

The physical examination at 14 months following surgery showed that the active range of motion (ROM) of the knee was

Table I. The characteristics of the Muramatsu's procedure (6) and the current procedure.

	Muramatsu's procedure (6)	Current procedure
Blood supply	Discontinued	Preserved via rectus femoris muscle
Reconstruction of extensor mechanism	Tendon to bone (patella tendon to tibial tubercle)	Bone to bone (tibial tubercle to tibial shaft)
Procedure of freezing	Simple (outside of the body)	Complex (continuous with the body)
Risk of frostbite	No	Yes (protection of the skin and soft tissue is required)
Coverage	Latissimus dorsi free flap and split-thickness skin graft	Medial gastrocnemius flap and full-thickness skin graft
Final functional outcome [active ROM (extension/flexion) and MMT]	Active ROM: $-10^{\circ}/110^{\circ}$ MMT: 4+/5	Active ROM: $0^{\circ}/135^{\circ}$ MMT: 5/5

ROM, range of motion; MMT, manual muscle test.



Figure 3. Physical examination at 14 months post-surgery. (A) The surface of the patella and patellar tendon was covered with a medial gastrocnemius flap and full-thickness skin graft. The extension muscular strength of the knee was evaluated as 5/5 in a manual muscle test. (B) The patient was able to extend his knee without lag. (B and C) The active range of motion of the knee was from $0-135^{\circ}$.

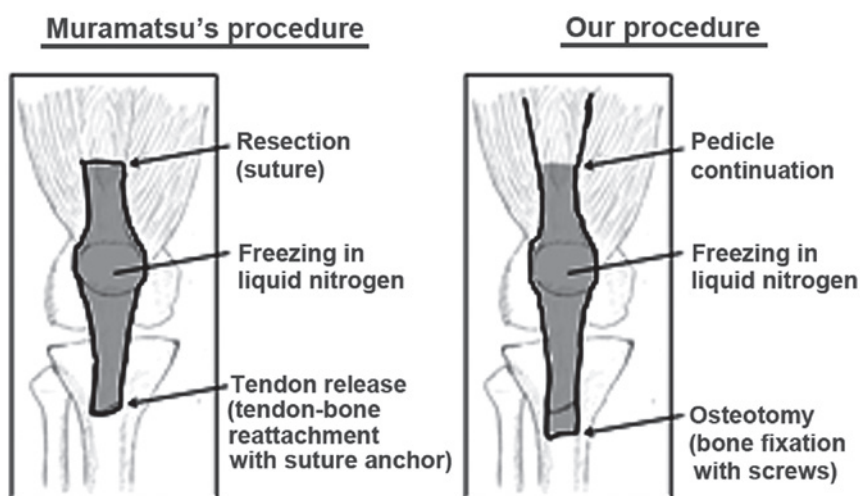


Figure 4. The characteristics of Muramatsu's procedure (6) and the current procedure. The predominant differences between these procedures were (i) maintaining the continuity of the rectus femoris muscle, (ii) osteotomy of the tibial tubercle followed by bone-to-bone reattachment, and (iii) covering the frozen autograft with latissimus dorsi free flap.

from $0-135^{\circ}$, and the extension muscular strength of the knee was evaluated as 5/5 by a manual muscle test (MMT) (Fig. 3). The patient was able to walk without the assistance of a cane or a brace. Limb function was determined to be 73% according

to the International Society of Limb Salvage (ISOLS) (8). Although there was no indication of local recurrence, a small nodule was detected in the left lung lobe (S10) 18 months postoperatively, and right inguinal lymph node metastasis was

discovered 24 months postoperatively. The patient underwent a partial left lobectomy and a right inguinal lymph node dissection at seven months following the diagnosis of lung metastasis. The final follow-up was at 26 months after the initial surgery for the knee and one month following the left lobectomy and right inguinal lymphoidectomy. At that time, the patient planned to receive additional chemotherapy.

Discussion

A similar surgical procedure was previously described by Muramatsu *et al* (6). The quadriceps tendon, patella, and patella tendon were resected with a prepatellar soft tissue sarcoma (myxofibrosarcoma). Following the removal of the tumor, these tissues were frozen in liquid nitrogen and subsequently reattached to the remaining quadriceps muscle and tibial tubercle. The soft tissue defect was covered by a LD free flap. The differences in the reconstruction of the knee extensor mechanism in the current study, compared with Muramatsu's procedure (6) are as follows: (i) The continuity of the rectus femoris muscle is maintained in the current procedure, conversely the muscle of the quadriceps is resected and sutured after freezing in Muramatsu's procedure; (ii) an osteotomy of the tibial tubercle was followed by bone-to-bone reattachment in the current procedure, a patellar tendon release was followed by tendon-bone reattachment with a suture anchor in Muramatsu's procedure; and (iii) the frozen autograft was covered with a medial gastrocnemius flap in the present study whereas an LD free flap is used in Muramatsu's study. The characteristics of these procedures are summarized in Fig. 4 and Table I.

An advantage of the current procedure when compared with Muramatsu's procedure (6), is the continued blood supply to the frozen tissue through the preserved rectus femoris muscle, which may lead to a shorter period of bone union and fewer postoperative complications (9). Another advantage is the firm fixation of the patellar tendon by bone-to-bone fixation with screws. However, Muramatsu's procedure (6) used a simple method for tissue freezing (outside of the body without continuity), which has the advantage of preventing frostbite. Although Muramatsu *et al* (6) did not report their patient's ISOLS score, the final limb function of the patient in the present study is thought to be superior, based on the wider active ROM and stronger MMT scores.

For the coverage of the liquid nitrogen-treated patella in the present case, a medial gastrocnemius flap was used, whereas Muramatsu *et al* (6) utilized the LD free flap. Although the use of an LD free flap requires a more complicated method than a gastrocnemius flap, its use may be considered depending on the location of the tumor and the size of soft tissue defect.

In the present study, a patellar vertical fracture caused by insufficiency occurred in the patient six months following the surgery. As bone revival following freezing with liquid nitrogen typically takes a longer period than bone union (10), it is possible, given the timing of the fracture, that the patient's patella had not revived yet.

In conclusion, functional reconstruction of the knee extensor mechanism following a wide resection for a prepatellar soft tissue sarcoma may be achieved using a pedicle frozen auto-bone and -tendon graft. This technique allows for the preservation of good limb function following surgery, even in patients with juxta-articular malignant musculoskeletal tumors. However, further study with a large number of patients treated using this procedure is required in order to evaluate the whether this is a feasible technique.

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