Total en bloc spondylectomy is a radical surgery designed to achieve complete resection of an aggressive benign spinal tumor or a malignant spinal tumor, including spinal metastasis, in addition to providing an adequate tumor margin. This procedure has been reported to decrease the rate of local recurrence and prolong survival. In this surgery, it is necessary to harvest a large amount of autograft from the ilium or fibula, the resected lamina and vertebral body from the total en bloc spondylectomy are used as graft bone for spinal reconstruction.

The authors report the development of a new reconstruction technique that does not require bone harvesting. Instead of harvesting autograft from the ilium or fibula, the resected lamina and vertebral body from the total en bloc spondylectomy are used as graft bone for spinal reconstruction.

**Materials and Methods**

This study was approved by the ethics committee of Kanazawa University. Since May 2010, the authors performed total en bloc spondylectomy using this new reconstruction technique on 56 patients. A retrospective review was performed of the 56 patients (29 men and 27 women). Mean age at the time of surgery was 54.9 years (range, 16-73 years). Of the 56 patients, 49 had metastatic tumors and 7 had primary tumors. Of the 49 patients with metastatic tumors, the primary organs involved were the kidney (n=13), thyroid (n=8), breast (n=8), lung (n=3), colon (n=2), and various other organs (n=13); the other 2 patients had primary unknown tumors. Of the 7 patients with primary tumors, 4 had giant cell tumors and 3 had malignant tumors (1 each of osteosarcoma, synovial sarcoma, and pleomorphic carcinoma).

The level of total en bloc spondylectomy included the thoracic (n=33), thoracolumbar (n=7), and lumbar (n=16) spine. Computed tomography scans or magnetic resonance images were taken postoperatively in all patients to evaluate local recurrence. Average follow-up was 14 months (range, 3-29 months).

**Surgical Technique**

For all patients, after en bloc excision of the vertebra (or vertebrae), the resected lamina and vertebral body (including the tumor) were used for the bone graft in the spinal anterior reconstruction. After en bloc laminectomy and en bloc corpectomy, the tumor and soft tissues (such as the ligament, disk, and cartilage) were curetted away from the resected spine. The spine was then placed into liquid nitrogen (2196°C) for 20 minutes. The frozen spine was crashed and packed into a titanium cage.
cage. The cage was placed between the adjacent healthy vertebral bodies. Finally, spinal shortening was performed to stabilize the cage (Figure 1).

RESULTS
Nine patients died due to progression of the metastases. Three patients had local recurrence postoperatively (1 metastasis of gastric cancer, 1 of colon cancer, and 1 of uterine cancer) that occurred from tissues around spinal column. Recurrence was not detected in the grafted bone inside a cage. In all patients, no failures of the cage or adverse effects from the use of frozen autograft were observed.

CASE REPORT
A 62-year-old woman with metastatic breast cancer at T1-T3 was referred to the authors’ hospital. She had undergone a mastectomy 17 years previously. Then, spinal metastasis of T2 was detected, and radiation at a dose of 50 Gy was performed 2 years later. She reported upper back pain with bilateral paralysis of her lower limbs. Her Frankel grade was C, and she could not walk without supports. Metastasis of T2 had invaded into the adjacent vertebrae above and below (T1 and T3), and the spinal cord was severely compressed (Figure 2).

Total en bloc spondylectomy of T1-T3 was performed (Figures 3-5). The excised en bloc laminae and en bloc vertebral bodies of T1-T3 were placed into liquid nitrogen for 20 minutes. Then, the frozen laminae and vertebral bodies were crushed and packed into a titanium cage. The cage was placed between C7 and T4 for spinal anterior reconstruction.

Muscle weakness of the bilateral lower extremities improved postoperatively. Solid bony fusion between the adjacent vertebral bodies and the frozen bone inside the cage was achieved 6 months postoperatively (Figure 6). Her Frankel grade was E at 12 months postoperatively.

DISCUSSION
Although a tumor-bearing spine was used as grafted bone for spinal anterior reconstruction, tumor cells are completely eradicated by being placed into liquid nitrogen for 20 minutes. Tsuchiya et al reported bone reconstruction for malignant tumors in the extremities and pelvis that were treated using tumor-bearing autograft that had been frozen in liquid nitrogen. Their results offer some proof that reconstruction using frozen tumor-bearing bone is a safe and effective method. Moreover, local recurrences from tumor-bearing autograft have not been reported. In the current series, no recurrence was detected in the grafted bone inside a cage.

Figure 1: Schema of the reconstruction technique using tumor-bearing frozen autograft.

Figure 2: Preoperative sagittal (A) and axial (B) magnetic resonance images. This patient had a metastasis invading the spinal canal at the T2 (red line).

Figure 3: Intraoperative photograph after en bloc corpectomy, which was performed in 2 stages (T1 corpectomy and T2-T3 corpectomy) to preserve the T1 nerve roots bilaterally.

Figure 4: Frozen tumor-bearing vertebral body of T1.
Total en bloc spondylectomy using frozen autograft inside a cage, as presented here, has the benefits of no pain at the bone harvest site, shortened operative time, and decreased blood loss. Because it is less invasive than previous techniques, recovery time from total en bloc spondylectomy surgery is also decreased. In addition, the frozen autograft inside a cage seems to offer promise for biological healing because the bone is both osteoinductive and osteoconductive. A proteins, such as bone morphogenic proteins, are preserved in frozen autograft. Tanzawa et al 10 reported biological healing of frozen bone pathologically.

Another benefit of the technique is the additional antitumor immune response. Previous reports have suggested immune system activation brought about by cryosurgery. 6-9 Nishida et al 10,11 reported that reimplantation of tumor tissue frozen using liquid nitrogen induces antitumor activity against murine osteosarcoma 10 and the serum levels of INF-γ and IL-12 increased after treatment. 11 Moreover, they reported a patient with metastases from renal cell carcinoma involving the lungs and bone (femur), whose lung metastases disappeared after femoral reconstruction using the resected femur treated by liquid nitrogen for the bone metastasis. 12 This antitumor effect could enhance the systemic immune reaction and reduce tumor growth and metastases.

Although the current authors did not collect clinical data, reconstruction using frozen tumor-bearing bone as presented here is a novel procedure that avoids bone harvesting and provides the possibility of antitumor immunity.

REFERENCES