

Free Vascularized Fibula Graft with Femoral Allograft Sleeve for Lumbar Spine Defects After Spondylectomy of Malignant Tumors

A Case Report

Michiel E.R. Bongers, MD, John H. Shin, MD, Sunita D. Srivastava, MD, Christopher R. Morse, MD, Sang-Gil Lee, MD, and Joseph H. Schwab, MD, MS

Investigation performed at Massachusetts General Hospital, Boston, Massachusetts

Abstract

Case: We present a 65-year-old man with an L4 conventional chordoma. Total *en bloc* spondylectomy (TES) of the involved vertebral bodies and surrounding soft tissues with reconstruction of the spine using a free vascularized fibula autograft (FVFG) is a proven technique, limiting complications and recurrence. However, graft fracture has occurred only in the lumbar spine in our institutional cases. We used a technique in our patient to ensure extra stability and support, with the addition of a femoral allograft sleeve encasing the FVFG.

Conclusions: Our technique for the reconstruction of the lumbar spine after TES of primary malignant spinal disease using a femoral allograft sleeve encasing the FVFG is viable to consider.

The treatment of primary malignant neoplasms of the spine currently mainly relies on surgery, often in conjunction with radiotherapy¹⁻³. Total *en bloc* spondylectomy (TES) is a widely accepted surgical technique and has lower reported recurrence rates compared with patients who undergo intralesional surgery^{3,4}.

Free vascularized fibula autograft (FVFG) is a viable reconstruction method for the large segmental defects of the mobile spine as a result from TES⁵⁻⁹. However, in the lumbar spine where forces exceed that of the cervical and thoracic region, we have noted fractures of the vascularized grafts, leading to instrumentation failure and further revision surgery. For this reason, we elected to reinforce the FVFG with a femoral allograft. The aim of this article was to provide a detailed overview of the reconstruction technique using the FVFG with a femoral allograft sleeve in the lumbar spine after TES for tumor resection.

The patient was informed that data concerning the case would be submitted for publication, and he provided consent.

Case Report

History and Presentation

A 65-year-old man was referred to our institution with complaints of lower back pain for 7 months with 5 months of bilateral leg pain, without weakness or loss of sensation. He was initially evaluated by his primary care provider who recom-

mended a magnetic resonance imaging (MRI), but the request was denied by the insurance company, and the patient underwent a course of physical therapy with no benefit and progression of back pain and radiculopathy. Four months later, computed tomography (CT) showed a lytic mass in the L4 vertebral body (Fig. 1).

He underwent lumbar MRI to better characterize the lesion, and it showed a lobular mass within the L4 vertebral body (Figs. 2-A and 2-B). CT-guided biopsy was performed,



Fig. 1
Axial computed tomography image of the L4 lytic lesion.

Disclosure: The Disclosure of Potential Conflicts of Interest forms are provided with the online version of the article (<http://links.lww.com/JBJS/B214>).

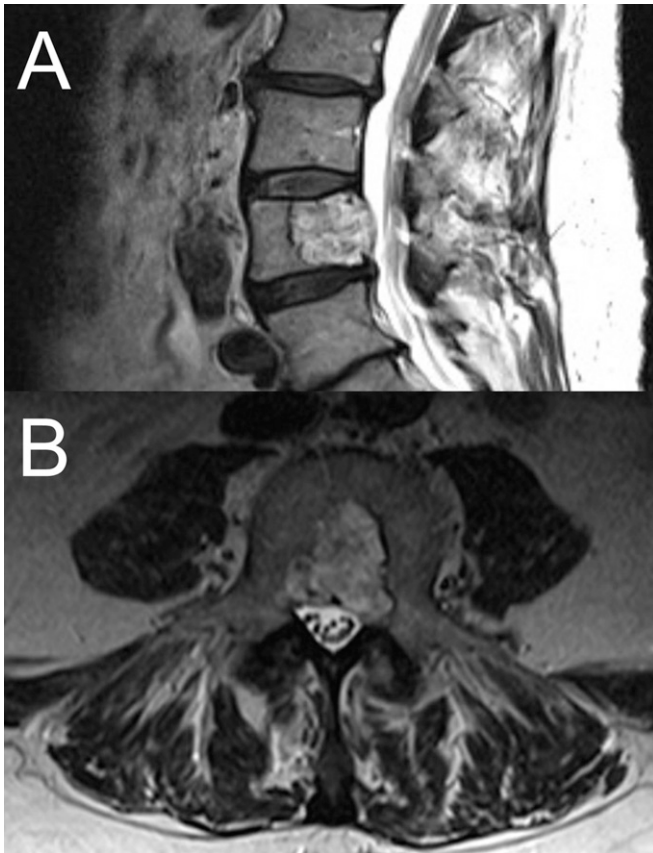


Fig. 2
Fig. 2-A Sagittal T2-weighted magnetic resonance imaging image of the lytic L4 lesion. **Fig. 2-B** Axial T2-weighted magnetic resonance imaging image of the lytic L4 lesion.

and histologic analysis confirmed the diagnosis of conventional chordoma.

The patient's case was reviewed in our multidisciplinary chordoma clinic where it was decided that neoadjuvant proton-based radiation of 50.4 Gy (Gray) should be started. This would be followed by en bloc resection, and, once the soft tissues healed, adjuvant radiation of 19.8 Gy. This protocol has been shown to be associated with improved local control¹⁰.

Importantly, preoperative radiation includes the gross disease as seen on preoperative MRI images, but it also includes the vertebrae above and below the area of gross disease per the Massachusetts General Hospital protocol¹⁰.

Surgical Technique

A 2-staged approach was used in our patient for tumor resection and reconstruction. The technique used for en bloc resection follows the modified en bloc spondylectomy method, as described by Shah et al.¹¹. The first stage of the operation is performed in the prone position and is designed to optimally position thread wire saws around the diseased vertebrae, ventral to the dura, and dorsal to the great vessels to allow for precise osteotomies above and below of the involved level. Posterior stabilization with cement augmentation above and

below the L4 level was performed to improve fixation. Removal of the posterior elements of the L4 vertebrae allowed dissection of the tumor off the ventral surface of the dura. It also facilitated safe placement of the thread wire saws (Figs. 3-A and 3-B).

One week later, the second stage was performed through an anterior retroperitoneal approach. The patient was placed in the right lateral decubitus position, and a left flank incision was made. Retroperitoneal dissection was performed, taking caution to avoid entering the peritoneal cavity. Reflecting the



Fig. 3-A

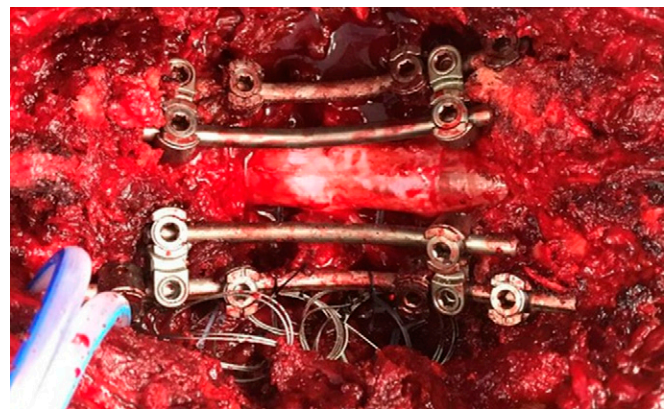


Fig. 3-B

Fig. 3-A After mobilization of the great vessels, nonlatex Penrose drains are passed around the vertebral body at the level of the discs above and below. The thread wire saws are then passed through the Penrose drains. The Penrose drains are used as a conduit for safe passage of the thread wire saws and removed once the saws are safely passed around the vertebral body. **Fig. 3-B** The thread wire saws are passed ventral to the dura. To avoid dural tear and injury to the nerve roots, the epidural plane ventral to the dura is first dissected to ensure a clear path for passage of the saws. Careful dissection is performed to avoid entering the tumor capsule. Once the plane between the dura and the posterior longitudinal ligament has been dissected, the thread wire saws are passed then anchored to the adjacent rods. The saws are anchored to the rods on side of the approach for the second stage so that they can be easily retrieved.



Fig. 4
Axial x-ray image of the resected specimen.

peritoneal contents medially, the psoas muscle is identified, and the great vessels are further separated from the lumbar spine. The psoas muscle is then elevated off the L3-5 vertebral bodies,

and the thread wire saws and their attachment to the posterior rods are visualized¹¹. The saws are then used to complete the cuts through the L3-4 and L4-5 disc spaces, completing the osteotomies and freeing the L4 vertebral body from all soft-tissue and bony attachments. The diseased vertebrae is then mobilized carefully away from the dura, nerve roots, and great vessels and subsequently removed *en bloc*. An x-ray of the specimen was obtained (Fig. 4) and was then sent for pathologic analysis¹¹. Because the tumor was abutting the dura ventrally at the L4 level, a dural plaque imbued with P32 was applied to the dura intraoperatively delivering 10 Gy of radiation¹².

Concurrently, the FVFG was harvested and sized to the desired length once the size of the spinal defect was known. Once resected, heparinized saline was abundantly injected into the vasculature of the sized graft for the prevention of clots¹¹.

The femoral allograft was cut and contoured to the appropriate length to maximize the fit between the endplate of L3 and the endplate of L5. The inside of the femoral allograft was hollowed out with a high-speed burr to accept the FVFG without compression of the vascular components, and a notch was created in one end of the femoral allograft to allow the vascular leash of the FVFG to exit the femoral allograft (Figs. 5-A, 5-B, 5-C, and 6-A). After determining the allograft and autograft fit nicely together (Figs. 5-D, 5-E, 6-B, and 6-C), we used a

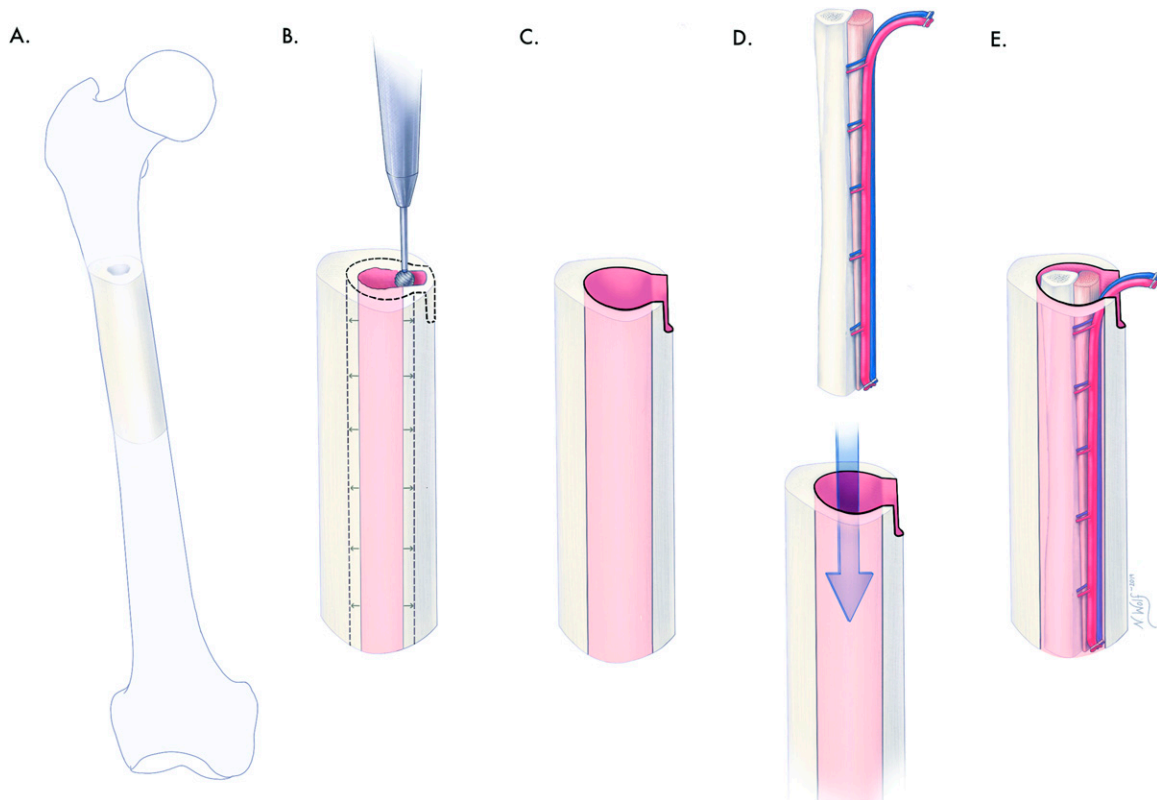


Fig. 5
Fig. 5-A A femoral allograft is harvested. **Fig. 5-B** The femoral allograft is hollowed out and a notch is created using a high speed burr to allow sufficient vascular flow. **Fig. 5-C** Prepared femoral allograft for reception of the vascularized fibula graft. **Fig. 5-D** The vascularized fibula graft is introduced into the femoral allograft. **Fig. 5-E** Completion of the encasing grafts. (Illustration by Nicole Wolf, MS, ©2019. Printed with permission.)

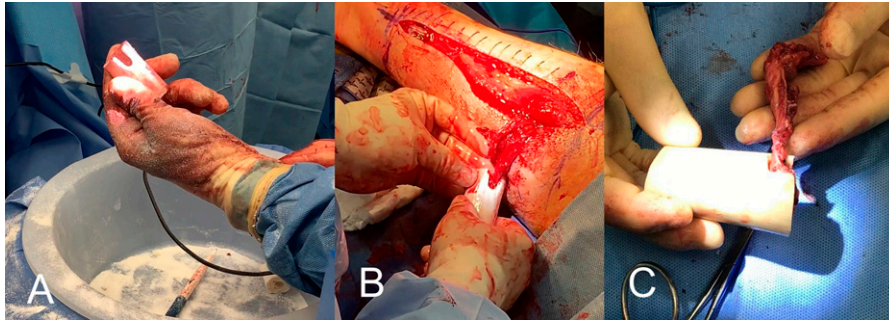


Fig. 6

Fig. 6-A Hollowed out femoral allograft with created notch. **Fig. 6-B** Fitting of the femoral allograft around the vascularized fibula graft, which is still attached to the peroneal vessels. **Fig. 6-C** Femoral allograft sleeve around the vascularized fibula graft ready for insertion.

Verbrugge clamp to hold the encasing grafts and then gently tapped the grafts between the L3 and L5 vertebrae using a Penfield probe to facilitate its insertion (Fig. 7). Once the encasing grafts were stable between the end plates, we gradually impacted them into position (Fig. 8). We confirmed the position of the graft by obtaining AP and lateral radiographs (Figs. 9-A and 9-B).

We then placed anterior spinal instrumentation to L3 and L5. This was done by placing 6.0×40 mm polyaxial screws into the bodies of L3 and L5 through vertebral body staples. We then contoured a rod to fit between these pedicle screws, finally tightening only at L5. The encasing grafts were compressed into

position by compressing on a heavy rod holder at both L3 and L5 before tightening the set screws. Adequate securing of the encasing grafts was then manually checked. The vascular leash was then microscopically reanastomosed to a branch from the aorta for arterial blood flow and a branch from the inferior vena cava for venous return (Figs. 10 and 11-A). At the conclusion of the surgery, hemostasis was obtained, and subsequent closure was performed.

Postoperative Outcome

In the first week after surgery, our patient had been doing very well, although then developed a fever, a urinary tract infection,

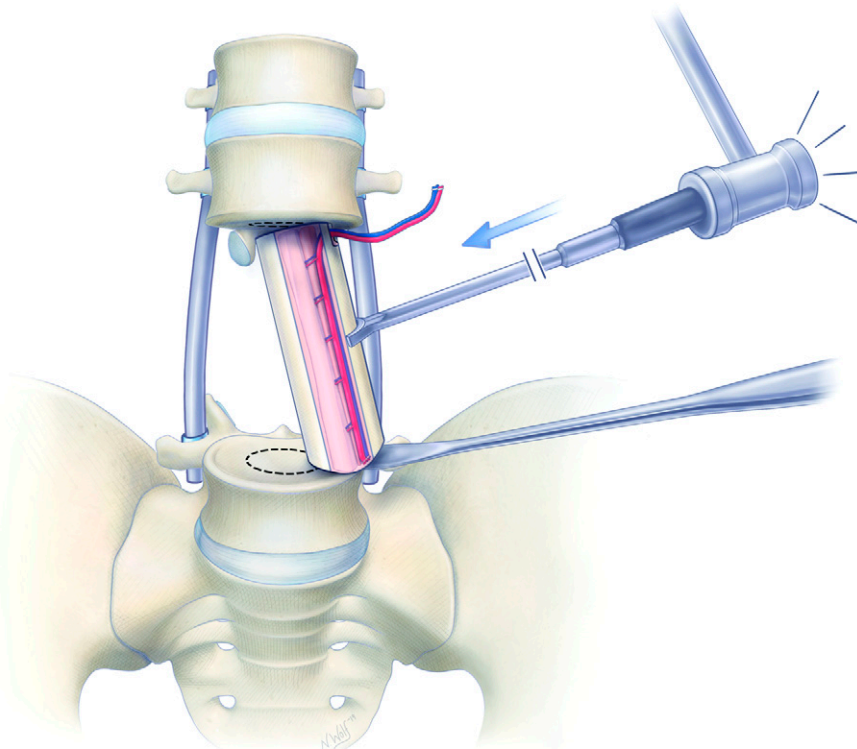


Fig. 7

Shoeing the encasing grafts between the endplates of the L3 and L5 endplates. (Illustration by Nicole Wolf, MS, ©2019. Printed with permission.)

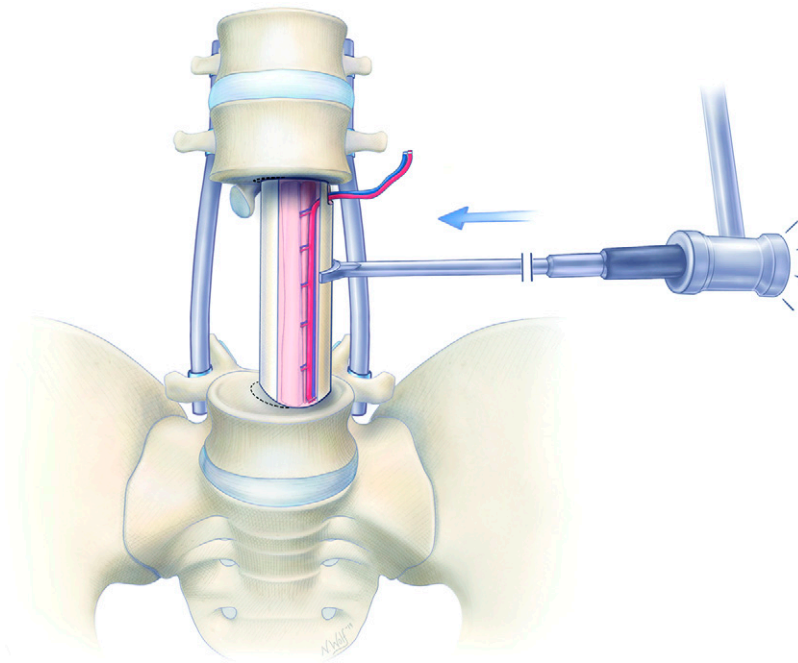


Fig. 8
Gently impaction of encasing grafts. (Illustration by Nicole Wolf, MS, ©2019. Printed with permission.)

and drainage of the inferior aspect of the posterior wound. He therefore underwent incision and debridement, with evacuation of fluid which was not purulent. At 1 month after surgery, the wounds have healed to satisfaction, and he is walking with a rolling walker. The patient had persistent hip flexor weakness bilaterally and knee extension weakness on the left side. The hip flexor weakness improved after 12 months, but the knee extension weakness remained. At the most recent follow-up, 18 months after surgery, CT images show a healed FVFG and femoral allograft with union (Fig. 11-B), and no signs of recurrence or metastases have been seen during follow-up. The patient states he is

doing well and has manageable discomfort with some left leg weakness (hip flexion 4/5 and knee extension 3/5). No nerve roots were resected during the surgery, but intra-operative tension on the nerve roots might have caused this weakness.

Discussion

This is the first report to provide a detailed overview of the surgical technique, functional, and disease outcomes of the reconstruction multiple levels of the lumbar spine using a femoral allograft encasing a FVFG after TES for tumor resection. We have now performed this reconstruction in 3

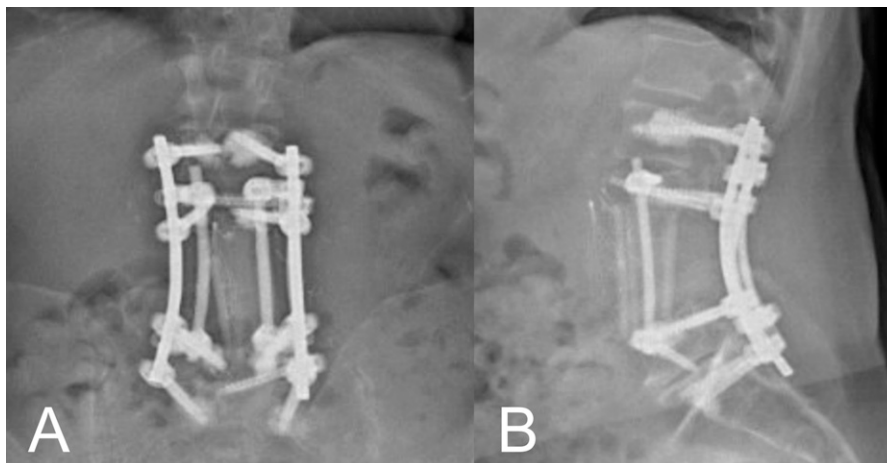


Fig. 9
Fig. 9-A Anteroposterior radiograph of the completed reconstruction. Fig. 9-B Lateral radiograph of the completed reconstruction.

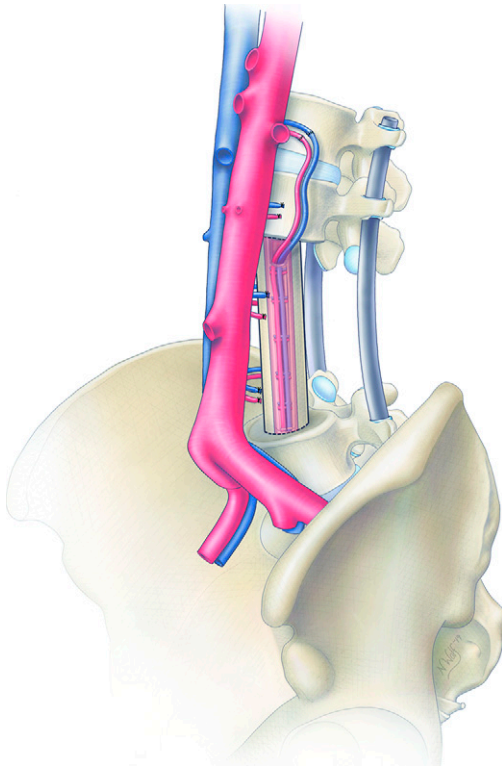


Fig. 10
Completed reconstruction with anastomosed vascularized fibula graft encased in the femoral allograft. (Illustration by Nicole Wolf, MS, ©2019. Printed with permission.)

subsequent patients. To our knowledge, there are no other known cases described in the current literature using this technique.

TES is a preferred technique for tumor excision in patients with nonmetastatic primary spinal disease, with reported increased survival and decreased local recurrence rates compared with intralesional surgery^{1,11,13-16}. Numerous reconstruction techniques exist for the reconstruction of lumbar defects after TES, including mesh cages made of various materials and vascularized and nonvascularized allografts and autograft, which all have been reported with favorable outcomes^{6,17-19}. However, from our previous experience, we know that the FVFG is a reliable method for the reconstruction of the spine in these cases and may have biological advantages in previously irradiated or operated areas in the spine⁵⁻⁹. In our cases, mechanical complications were most common in the lumbar spine. All the fractured grafts and more than half of the instrumentation failure has occurred in the lumbar spine. Accordingly, we sought a method to strengthen the structural support of the reconstruction method, still retaining the osteogenic environment of the vascularized graft.

Capanna et al.²⁰ first described the reconstructive surgical technique for bony defects of the extremities after tumor resection using large allografts encasing a vascularized fibula graft and has proved to be a viable reconstruction method for several reasons^{21,22}. First, the allograft decreases the stress on the FVFG, avoiding displaced or stress fractures. Second, when nonunion occurs of the FVFG, the allograft will aid in mechanical support and weight-bearing. Third, the short- and long-term outcomes of this technique used in the extremities are desirable for success and reoperation rates²². However, operative times might increase because the harvesting of the FVFG and the vascular reconstruction require microvascular skill. In addition, no spinal and appendicular skeleton reconstruction reports have been published on encasing a vascularized graft in a cage, which proposes an avenue for future research.

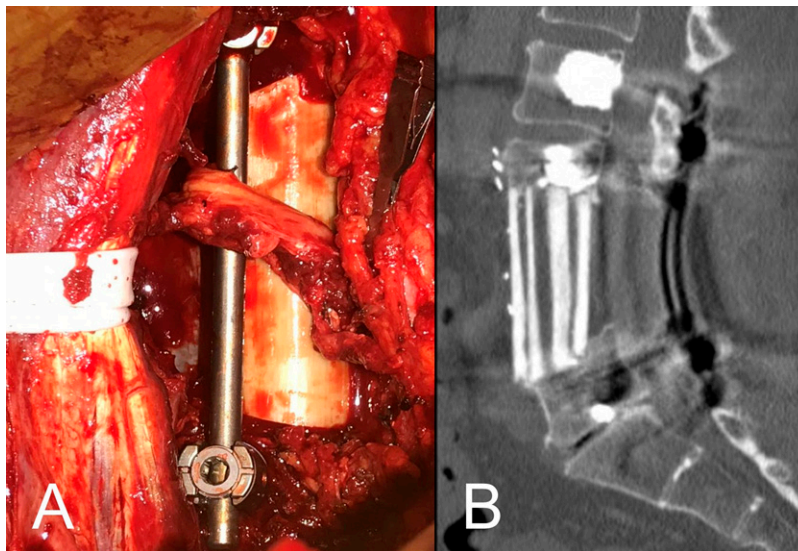


Fig. 11
Fig. 11-A Intraoperative picture of completed reconstruction with anastomosed vascular leash. **Fig. 11-B** Sagittal computed tomography image of reconstruction with encasing grafts anteriorly and posterior stabilization using cement augmentation.

In conclusion, when a patient presents with a primary malignant tumor in the lumbar spine, reconstruction of the created defect using the described technique, with a femoral allograft and an intramedullary FVFG, should be considered a sound and robust option to account for the increased mechanical issues of the lumbar spine. ■

Michiel E.R. Bongers, MD¹
John H. Shin, MD²
Sunita D. Srivastava, MD³
Christopher R. Morse, MD⁴
Sang-Gil Lee, MD⁵
Joseph H. Schwab, MD, MS¹

¹Department of Orthopedic Surgery, Orthopedic Oncology Service, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts

²Department of Neurosurgery, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts

³Department of Vascular Surgery, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts

⁴Division of Thoracic Surgery, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts

⁵Department of Orthopedic Surgery, Hand and Upper Extremity Service, Orthopedic Oncology Service, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts

E-mail address for M.E.R. Bongers: michielbongers@gmail.com

ORCID iD for M.E.R. Bongers: [0000-0003-4628-4793](https://orcid.org/0000-0003-4628-4793)

ORCID iD for S.D. Srivastava: [0000-0001-5618-8688](https://orcid.org/0000-0001-5618-8688)

ORCID iD for S.-G. Lee: [0000-0002-7642-4518](https://orcid.org/0000-0002-7642-4518)

ORCID iD for J.H. Schwab: [0000-0003-1156-3864](https://orcid.org/0000-0003-1156-3864)

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