Pelvic reconstruction after subtotal sacrectomy for sacral chondrosarcoma using cadaveric and vascularized fibula autograft

Technical note


1Combined Neurosurgical and Orthopedic Spine Program, and 2Department of Surgery—Division of Neurosurgery, University of British Columbia, Vancouver, British Columbia, Canada

A novel method of spinopelvic ring reconstruction after partial sacrectomy for a chondrosarcoma is described. Chondrosarcoma is one of the most common primary malignant bone tumors, and en bloc resection is the mainstay of treatment. Involvement of the pelvis as well as the sacrum and lumbar spine can result in a technically difficult challenge for en bloc resection and for achievement of appropriate load-bearing reconstruction.

After en bloc resection in their patient, the authors achieved reconstruction with a rod and screw construct including vascularized fibula graft as the main strut from the lumbar spine to the pelvis. Additionally, a cadaveric allograft strut was used as an adjunct for the pelvic ring. This is similar to a modified Galveston technique with vascularized fibula in place of the Galveston rods. The vascularized fibula provided appropriate biomechanical support, allowing the patient to return to independent ambulation. There was no tumor recurrence; neurological status remained stable; and the allograft construct integrated well and even increased in size on CT scans and radiographs in the course of a follow-up longer than 7 years.

A novel method of spinopelvic ring reconstruction after subtotal sacrectomy for sacral chondrosarcoma using autogenous vascularized fibula allograft is described. The patient may be left with a major anatomical defect within the primary transition zone between the pelvis and the lumbar spine, thus leading to significant functional and biomechanical implications. During lumbar spondylectomy and sacral resection, preservation of the lumbar nerve roots is important to maintain the patient's ability to ambulate. His or her urinary bladder, rectosigmoid colon, and sexual function, however, are often markedly altered due to required and preplanned resection of the sacral nerve roots. The extent of resection required to achieve clear margins for each specific tumor then dictates residual spinopelvic stability and thus the requirements for local reconstruction.

Spinopelvic reconstruction after tumor resection is a controversial issue. First there is the argument regarding whether to perform reconstruction. There are reports of reasonable functional success with nonreconstructive techniques, which include prolonged non-weight-bearing bed rest, allowing the pelvis to rotate posteriorly and heal, scarring into a position that will allow the patient to mobilize. Proponents of reconstruction argue that this...
option allows for earlier ambulation and a shorter time frame for the patient to start rehabilitation.14 Second, multiple reconstructive techniques have been described, and the optimal technique has not yet been established.16,17

Spinopelvic reconstruction techniques previously reported in the literature include sacroiliac joint screw fixation, iliac-sacral screw fixation, posterior iliosacral plating and screw fixation, iliac screws, transiliac rods, Galveston rod fixation, and custom-made prostheses.7,12,15,17 In addition to the immediate mechanical reconstruction, obtaining reliable bony fusion is equally if not more challenging. Autograft (either structural or nonstructural, free or vascularized), allograft, and various bone graft expanders have been used to induce fusion, with varied success.15 We present a novel form of spinopelvic reconstruction and bone grafting in a case of pelvic chondrosarcoma with more than 7 years of clinical and radiological follow-up.

Case Description

History and Examination. The patient was a 30-year-old man who presented with a 9-month history of right lower-extremity and right sacroiliac pain. On physical examination he had an antalgic, Trendelenberg gait on the right side. The pelvis was horizontal without tilt, and leg lengths were equal. He had nerve root tension signs with positive straight leg raise at 30°. Motor function, using the Medical Research Council scale, was graded as 4/5 in L-4, 3/5 in L-5, and 3/5 in S-1 on the right. Motor function in the left leg was normal. Sensation was diminished in the S-1 dermatome on the right with loss of the right Achilles reflex.

Neuroimaging. Computed tomography and MRI studies were performed (Fig. 1). The imaging demonstrated a 9 × 9 × 6–cm tumor at the inferior aspect of the right sacroiliac joint. The tumor extended through the greater sciatic foramen; a portion of the right sacral wing was destroyed; the right sacroiliac joint was widened by tumor; and the erector spinae muscles were grossly involved. The tumor was noted to have typical elements of “speckled” calcification on CT. There was a slightly Gd-enhancing peripheral margin with a necrotic center. The tumor was noted to be adjacent to and probably involving the S-2 and S-3 nerve roots on the right side, with the S-1 nerve coursing along the lateral border of the tumor. A CT-guided biopsy sample was obtained, informing us that this was a low-grade chondrosarcoma. In discussion with the patient and his family, the decision was made to perform en bloc resection to achieve clear margins and the best chance for local tumor control given the lack of benefit of radiotherapy and chemotherapy.

Operation. The surgery was divided into 3 stages: posterior, anterior, and lateral approaches. Resection began with identification of the midline of the sacrum, and using that as an anatomical landmark, the sacral foramen and sacroiliac joint on the right side were exposed. The dissection was continued laterally to the greater trochanter. The gluteus maximus, piriformis, and obturator externis were removed from the posterior column of the acetabulum and dissected to expose the sciatic notch. The sciatic nerve was identified below the inferior aspect of the gluteus maximus but the sciatic notch was not entered. The tumor was palpable through the soft tissue in the sciatic notch. For en bloc resection, removal of the right hemisacrum, the right posterior ilium, and the right sacroiliac joint was required. The L-5 and S1–4 nerve roots along with the sciatic nerve were sacrificed on the right side, given that they were involved with tumor and were within the boundaries for achieving clear margins of resection. The intervertebral disc was taken at L4–5 and L5–S1.

In reconstruction, pedicle screws were placed from L-3 to L-5 bilaterally and into the sacrum on the left side. Two fixation plates were placed across the symphysis pubis anteriorly. A rod was placed from the tulips of the pedicle screws on the right side starting at L3–5 and anchored distally into both sacral and iliac screws. A vascularized fibula graft was used as a strut from the L5–S1 disc down to the ischium on the right side, ventral to the

Fig. 1. Preoperative MRI studies of the pelvic chondrosarcoma. Gd demonstrating a slightly contrast-enhancing rim (compare with panel C) and necrotic core. There is involvement of the tumor to the sacrum up to the inferior aspect of the L-5 vertebral body. A: Sagittal T1-weighted image obtained after addition of necrotic tumor core. This cut shows the lesion ventral to the sacrum. B: Sagittal T2-weighted image demonstrating hyperintense lesion in the right side of the pelvis, including the ischium and sacroiliac joint. The lesion is T1 hypointense in the necrotic core.
rod. The fibula was fixed into place through rod compression, with tension longitudinally along the graft. A cadaveric fibula graft was used as a strut connecting the ilium to the L-5 vertebral body on the right; this provided additional support in a triangular configuration (see Figs. 2–4). The cadaveric graft was held in place by fastening a 100-mm screw into the ilium. At L4–5 a spring cage was placed in the intervertebral space, and at L5–S1 a bone autograft alone was placed (Fig. 2). The soft-tissue defect was closed using a latissimus dorsi flap.

Postoperative Course. The surgical margins were microscopically negative, and the tumor pathology was consistent with the CT-guided biopsy result of a low-grade chondrosarcoma. At 2 months postsurgery the patient’s physical examination demonstrated the following Medical Research Council scores: 1/5–2/5 strength in L2–4 and 0/5 in L5–S2 in the right lower extremity. On the left side, strength was 4/5 in L2–4 and S1–2, and 3/5 in L-5. On right lower-extremity sensory examination L-3 and L-4 sensation was intact, and there was diminished sensation in the L5–S2 distribution. His sensation was intact throughout on the left.

At last follow-up the patient was getting about independently with the aid of an ankle-foot orthosis brace and a cane. He has persistent neurological deficits, in keeping with sacrifice of the sciatic nerve. He has independent bladder and bowel function. There has been no clinical or radiographic recurrence after 7 years.

Approximately 7 years postoperatively the patient underwent removal of the spinal hardware due to pain and issues with chronic infection related to the soft-tissue closure. With the hardware removed, the patient continued
to remain biomechanically stable. There was no decline in functional status, neurological status, or issues with the reconstruction. The vascularized fibula graft remained well integrated. The patient was last seen at 1 year following the hardware removal (8 years after the original surgery). On latest follow-up radiographs and CT scans, bony fusion was achieved across the L4/5 and L5/S1 disc spaces, with excellent integration of the allograft, which has expanded in size in comparison with early postoperative imaging (Figs. 3 and 4).

Discussion

The use of vascularized fibular graft for pelvic ring reconstruction has been described in the plastic surgery literature. Iwakiri et al. described a case in which lumboasacral reconstruction was performed after spondylitis, by using a soft-tissue total leg flap combined with vascularized tibia and fibula grafts. The vascularized bone was used in this case due to the presence of infection but provided stability across the lumbosacral junction, allowing the patient to return to wheelchair mobility. Use of nonvascularized fibular grafts for reconstruction across the sacroiliac joint was reported in a series by Wang et al., including double- and triple-barrel grafts to restore spinopelvic stability across the sacroiliac joint. The comparison by Wang et al. of patients with nonvascularized fibula reconstruction to patients without reconstruction found an improvement in functional outcome without significant morbidity. The successful use of vascularized fibular grafts for spinal reconstruction, without pelvic reconstruction, after tumor resection has been described by Moran et al. as part of a series. We describe a novel technique in which both a nonvascularized and a vascularized fibula are used as struts in spinopelvic reconstruction after partial sacrectomy. This technique allows for reconstruction of the pelvic ring and the lumboasacral junction as well as restoration of function of the spinopelvic junction.

Our use of the nonvascularized fibula strut across the sacroiliac portion of reconstruction is similar to that described by Wang et al.; however, only a single fibula was used. The use of the vascularized fibula is similar to the modified Galveston technique. Instead of Galveston rods, fibula graft was used in addition to a standard spinal fusion rod; the rod was also used to help compress the vascularized fibula in position, with good fixation. The vascularized fibula graft has integrated well, as demonstrated on postoperative radiographic and CT imaging (Figs. 3 and 4), and has provided a good functional outcome for the patient. The delayed hardware removal also demonstrates that the graft had integrated very well and was able to support the spinopelvic fixation stress and mobilization without the assistance of the screw and rod construct.

This novel technique is useful for achieving a solid fusion and fixation, limiting the instrumentation required and using human bone autograft and allograft. In a biomechanical study looking at the stresses exerted across the spinopelvic joint with differing instrumentation techniques, Kawahara et al. showed that significant stress is
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centrated on the rod constructs used. They also noted clinical observations in which posterior instrumented constructs have settled and the instrumentation has failed and broken.

Using vascularized autograft allows the bone to heal in a physiological manner similar to a fracture, with quicker remodeling, minimal resorption of the bone, and secondary remodeling along areas of increased stress, thus providing a biomechanically superior construct. The donor-site morbidity associated with the use of a vascularized fibula graft is acceptable, and with biomechanical remodeling a single graft rather than multiple barreled grafts can be used. A vascularized autograft encompasses all of the key factors for bone repair: osteogenesis, osteoinduction, and osteoconduct; cadaveric autograft was also used, which provides osteoconduct. The ability of the bone to remodel secondarily is clearly exhibited in this case—the vascularized graft has expanded in caliber as it has integrated into the spinopelvic junction; in contrast, the non-vascularized fibula decreased in size despite integrating well. This expansion is most likely the result of the bone remodeling response to the stress placed across the graft through the patient’s mobilization (Figs. 3 and 4).

Although this case was one of chondrosarcoma resection, the technique can be expanded for use after resection of any sacral tumor requiring spinopelvic reconstruction.

Conclusions

We describe a novel and useful technique in tumor reconstruction in which vascularized fibular autograft is used for the spinopelvic junction and nonvascularized fibular allograft is used for reconstruction of the pelvic ring. The technique is similar to the modified Galveston technique, with the fibula used instead of Galveston rods. The use of both the vascularized and nonvascularized grafts has been previously described, and such use was successful for each facet of the reconstruction but not in combination. As in previous descriptions, the grafts are able to integrate well and provide superior biomechanical support across this high-stress area. We have used this technique successfully, with more than 7 years of patient follow-up and excellent radiographic and clinical outcome.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Fisher, Gillis, Street. Acquisition of data: Boyd. Analysis and interpretation of data: Fisher, Gillis. Drafting the article: Fisher, Gillis, Boyd. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Fisher. Study supervision: Street.

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Address correspondence to: Charles G. Fisher, M.D., M.H.Sc., F.R.C.S.C., Blusson Spinal Cord Centre, 6th Floor, 818 W. 10th Ave., Vancouver, BC V5Z 1M9, Canada. email: charles.fisher@vch.ca.

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