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Technique

En bloc sacrectomy and reconstruction: technique modification for pelvic fixation

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Abstract

Background: When the management of sacral tumors requires partial or complete sacrectomy, the spinopelvic apparatus must be reconstructed. This is a challenging and infrequently performed operation, and as such, many spine surgeons are unfamiliar with techniques available to carry out these procedures.

Case Description: A 34-year-old man presented with severe low back pain, mild left ankle dorsiflexion weakness, and left S1 paresthesias. Imaging revealed a large sacral mass extending into the L5/S1 and S1/S2 neural foramina as well as the presacral visceral and vascular structures. Needle biopsy of this mass demonstrated a low-grade chondrosarcoma. A 2-stage anterior/posterior en bloc sacrectomy with a novel modification of the Galveston L-rod pelvic ring reconstruction was carried out. Our modification takes advantage of new materials and implant technology to offer another alternative in reconstruction of the spinopelvic junction.

Conclusion: Understanding the anatomy and biomechanics of the spinopelvic apparatus and the lumbosacral junction, as well as having a familiarity with the various techniques available for carrying out sacrectomy and pelvic ring reconstruction, will enable the spine surgeon to effectively manage sacral tumors.

Keywords: Sacrectomy; Sacrum; Spinal tumor; Spine surgery; Spinopelvic reconstruction

1. Introduction

The treatment of primary sacral tumors can be challenging, both because of the anatomy of the spinopelvic complex and the frequently large tumor size on presentation. For tumors unresponsive to radiation and/or chemotherapy, radical resection has been shown to prolong disease-free survival [2,3,16]. The extent of sacral resection depends on the location and character of the tumor. Subtotal sacral resection caudal to the midportion of the S1 vertebral body does not destabilize the pelvis [12]. Total sacrectomy results in dissociation of the spine and pelvis and requires reconstitution of the pelvic ring.

Various techniques for pelvic ring reconstruction after total sacrectomy have been described [4,18,19,21]. Our technique is derived from the work of Gokaslan et al [11], who initially used a Galveston L-rod technique. To improve biomechanical stabilization, particularly between the L5 pedicle screw and the ilium, they modified their technique to make use of a transverse threaded rod (transiliac bar) [10].

Our modification to the technique exploits newer materials, such as segmentally fixated carbon fiber cages, and extrapolates the observation of improved fusion rates in the thoracolumbar spine to the problem of pelvic ring reconstruction.

2. Case report

A 34-year-old man presented to the emergency department with a 1-year history of low-back pain and a sacral

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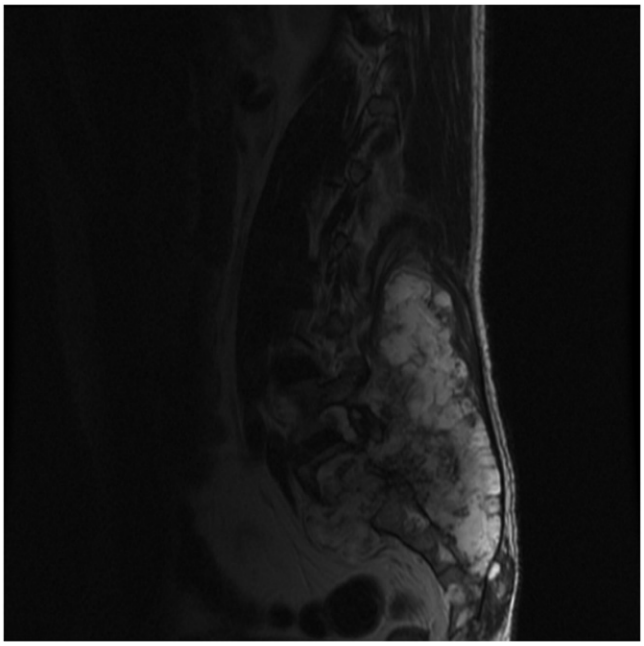

Fig. 1. Preoperative T2 sagittal magnetic resonance image of the lumbosacral spine, demonstrating a large heterogeneous sacral mass.

mass. The mass was incidentally discovered during the work-up of a work-related accident at an outside hospital approximately 1 year before presentation. The patient elected not to pursue additional care at that time because of lack of health care insurance.

Plain films of the lumbar spine demonstrated a complex large left lumbosacral mass. Magnetic resonance images of the lumbar spine and pelvis were then obtained, which revealed a large heterogeneous tumor centered at the left superior sacroiliac joint with extension into the left L5/S1 and S1/S2 neural foramina and the retroperitoneum and paraspinous muscles from L3 to the inferior sacrum (Fig. 1). A core needle biopsy was performed, which confirmed the diagnosis of aggressive chondrosarcoma.

On physical examination, the patient reported mildly decreased sensation to light touch and pinprick in the left S1 dermatome. He had slight weakness (4+/5) in the left ankle plantar flexion but otherwise had full strength in proximal and distal muscle groups bilaterally. His muscle stretch reflexes were nonpathologic. He exhibited an unremarkable station and gait. He did not report a history of urinary incontinence or constipation; however, he did state that he had been unable to achieve an erection for more than 1 year.

3. Operation

A standard 2-stage en bloc sacrectomy was carried out as has been previously described [10,11]. The anterior portion of the procedure was carried out first. A laparotomy was performed, and the colon and iliac vessels were mobilized off of the sacrum by our vascular surgery colleagues. The tumor was readily identifiable at this time as a mass on the midline sacral promontory. Care was made not to disrupt the tumor capsule. The left iliolumbar vein was ligated for ventral access to the tumor. Having successfully mobilized and safely retracted all adjacent visceral and vascular structures, an L5 through S1 anterior discectomy was performed. An anterior sagittal osteotomy was performed in the normal bone of the left ilium, providing for adequate tumor margin. The right sacroiliac joint was used to demarcate the other lateral border, and this was curetted free. Gore-Tex mesh was then placed on the anterior border of the sacrum, and the posterior portion of the operation was carried out. The rectus muscle was then mobilized by plastic surgery and placed in the presacral space.

For the posterior portion of the procedure, the skin incision was carefully planned with the assistance of plastic surgery. We anticipated the need for a large skin flap after our reconstruction. In addition, great care was taken to completely excise the needle biopsy tract from several days before the operation (Fig. 2). The spine from L1 to the coccyx was exposed, as well as both iliac wings. Pedicle screws were placed bilaterally from L1 through L4 in the standard fashion. Partial pediculectomies were performed at L5, preventing pedicle screw placement at that level. Posterolateral fusion with morcellized autograft from distant sites and allograft was performed from L1 through L5. Osteotomies of the left ilium and right sacroiliac joint were then carried out to mobilize the sacrum. The sacrum was dissected circumferentially. Dorsal sacral roots were ligated. The ventral membrane was identified. Laminectomies were carried out from L4 to S1. Again, care was made not to disrupt the tumor capsule. The thecal sac was ligated immediately caudal to the takeoff of the L5 nerve roots. The sacrum and the en bloc tumor were then passed off the field.

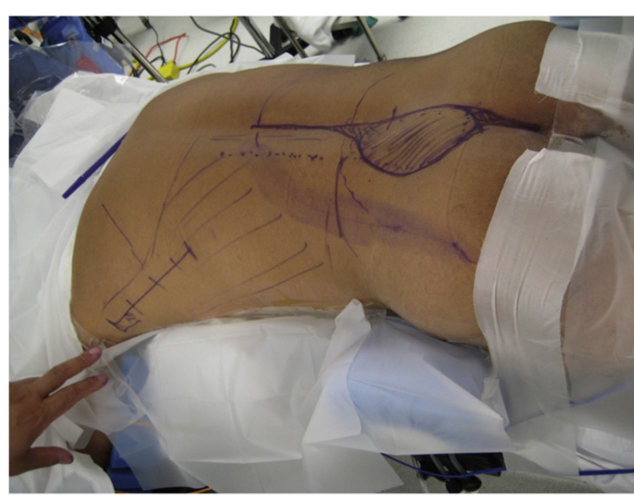

Fig. 2. Skin incision marked out for latissimus flap, biopsy needle tract excision, and en bloc sacral resection.

Reconstitution of the spinopelvic apparatus was then carried out. Bilateral iliac screws were placed and attached to each other with horizontally oriented cross-connecting rods. This process was repeated for a total of 4 iliac screws (ie, 2 per side) and 2 cross-connecting rods. Multiple stackable carbon fiber cages were placed in between the ilia. The cages were packed with local bone graft harvested from the right iliac crest, distant from the tumor margin. In this manner, the pelvic ring was reconstructed. The stackable cages were segmentally secured to the horizontal bar by lateral offset connectors that screw into the cages. This was done to prevent migration because these constructs are not axially loaded. The cage-bone interface was the right sacroiliac joint, and the bone resection surface was on the left.

The interiliac cross-connecting rods were secured to one another, with a total of 4 cross-link connectors. The vertically oriented pedicle screw rods were secured to the interiliac rods by way of an L-connector, thereby reestablishing the spinopelvic association (Fig. 3). The skin and soft tissue overlying the operative field was closed by way of right latissimus turnover flap, local tissue advancement, and skin graft. The procedure required 9 hours of operating time and was carried out in a single day. Estimated blood loss was 1500 mL, and the patient required 6 U of packed red blood cells.

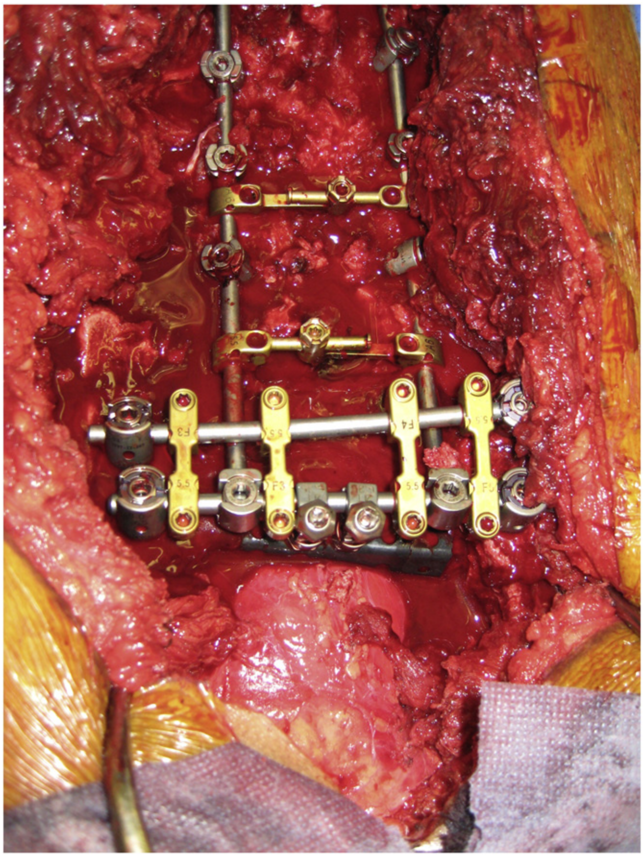

Fig. 3. Intraoperative photograph of the postsacrectomy construct. The carbon fiber cages are visible deep to the caudal-most transverse rod.

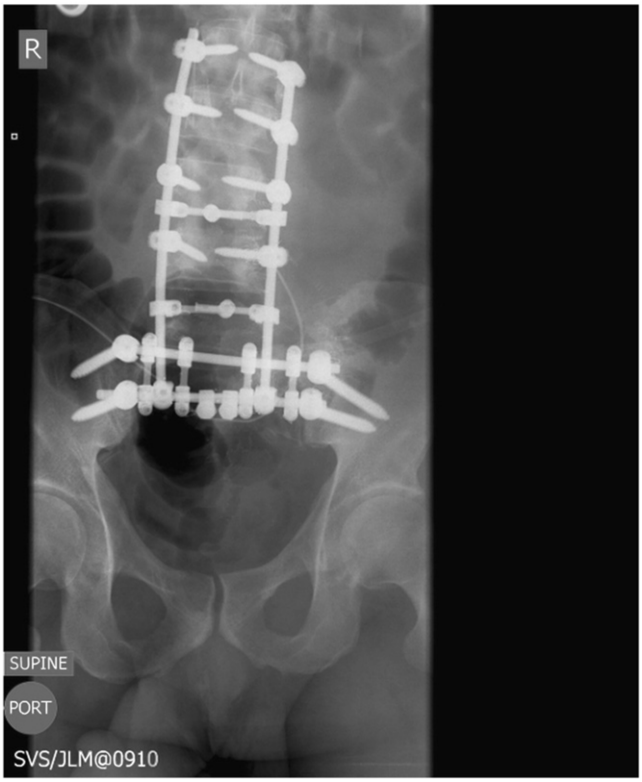

Fig. 4. Postoperative anteroposterior lumbosacral radiographs.

4. Postoperative course

Postoperatively, the patient had marked bilateral weakness in ankle plantar flexion (3/5). His postoperative course was complicated by a flap hematoma, requiring evacuation by the plastic surgeons. The hardware was noted to be in excellent position on initial postoperative x-rays (Fig. 4). He was transferred to inpatient rehabilitation 4 weeks after his initial surgery. His distal lower extremity weakness persisted despite aggressive physical therapy; however, he was able to ambulate with a walker for a distance of 200 ft at 6-month follow-up. He was able to manage his bowel movements with stool softeners and laxatives. He required self-catheterization to empty his bladder. At 6 months, his radiographs show early evidence of fusion and stable hardware without migration.

5. Discussion

The treatment of large sacral and pelvic tumors is challenging. The spinopelvic apparatus is responsible for transmitting force from the lower extremities to the axial skeleton, and as such, its integrity is essential for patients to remain ambulatory [12]. Furthermore, if there is no attempt to reconstitute the pelvic ring, intra-abdominal visceral and vascular structures can be compromised, leading to chronic abdominal and pelvic pain [7]. Common neoplastic lesions of the sacrum are metastatic tumors, myeloma, Ewing sarcoma, and lymphoma [5]. Tumors requiring an en bloc resection, where great care must be taken not to violate the tumor capsule, are metastatic tumors, giant cell tumors, chordoma, chondrosarcoma, and Ewing sarcoma [5,24].

In sacrectomies, the extent of sacral resection determines the integrity of the pelvic ring and, consequently, of the spinopelvic junction. Lumbosacral iliac stability is dependent on the posterior bone and the ligamentous structures of the sacrum and ilium [1]. The seminal biomechanical analysis of the relationship of the sacrum and the pelvic ring was carried out by Gunterberg et al [12]. Their analysis examined the relationship between compressive axial load and pelvic ring failure in cadaveric specimens when progressively removing caudal elements of the sacrum. Sacroiliac stability is not greatly affected if the sacroiliac joint is left intact [12,20]. When the sacrum is divided between the S1 and S2 vertebral bodies, the pelvic apparatus is weakened by 30%. When the sacrum caudal to the midpoint of the S1 body is removed, the ring weakens by 50%. In clinical studies, patients who retain at least 50% of the S1 body do not demonstrate instability and do not require instrumentation [14,20].

There are several spinopelvic reconstruction techniques that have been reported in the literature, including sacroiliac joint screw fixation [13], iliac-sacral screw fixation [8,15], posterior iliosacral plating and screw fixation [9,15], custom-made prosthesis [22,23], and vascularized free fibular flaps [6,17].

Our technique for reconstituting the pelvic ring after sacrectomy is a modification of the Galveston L-rod method initially described by Gokaslan et al. Dr Gokaslan uses fibular allograft between the 2 ilia. To address the issue of fibular migration, we wired the fibular strut to the horizontal bar. Our modification uses stackable carbon fiber cages, into which screws can be inserted at multiple locations. This allows for multiple points of fixation to the horizontal bar, or bars as is in the case presented here. We prefer to place 2 screws in each ilium to improve resistance to the rotational force of the spinopelvic axis and, in addition, to improve coupling between the horizontal bars and the interiliac construct; this technique also allows for gentle compression of the ilia against the cages that should provide an advantage in terms of fusion. Clearly, a biomechanical analysis and clinical review would need to be performed to evaluate these assumptions. Even without such data, this technique is a promising modification of an accepted pelvic reconstruction method that takes advantage of newly available materials to provide equivalent and possibly improved spinopelvic stability in the short term.

6. Conclusion

Cases where tumor removal requires total sacrectomy are challenging. A thorough understanding of the vascular, visceral, and bony anatomy as well as the biomechanical relationships of the components of the spinopelvic apparatus is essential. These cases are best approached in close consultation with vascular, colorectal, and plastic surgery colleagues for optimal patient outcomes. A variety of options exist for reconstituting the pelvic ring and reestablishing the continuity of the axial skeleton with the lower limbs, which is essential for ambulation. The appropriate technique will be dictated by the individual patient and their disease process.

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Commentary

This case report by Newman et al of a technique modification is to be admired for the multidisciplinary approach to a challenging and complicated disease process. Considerable resources and efforts went into trying to salvage the life and ambulatory function of one patient. The monetary costs were no doubt sizable as well as the "man hours" required. Permanent loss of bowel and bladder voluntary sphincter control as well as sexual function might not be acceptable to all patients. Of interest from a neurologic functional and anatomical standpoint is that sacrifice of all nerve roots distal to the L5 roots bilaterally resulted in only 4/5-ft plantar flexor weakness.

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