Neural function preservation and early mobilization after resection of metastatic sacral tumors and lumbosacropelvic junction reconstruction

Report of three cases

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The management of tumors that metastasize to the sacrum remains controversial. Typically, resection of such tumors and reconstruction of the lumbopelvic junction requires sacrifice of neural elements resulting in neurological dysfunction and prolonged periods of bed rest. This severely affects the quality of life in patients in whom there is frequently a limited life expectancy.

The authors describe three patients who underwent subtotal resection of metastatic sacral tumors. Postoperatively, good outcome was demonstrated in all patients.

The authors present a technique for debulking and reconstruction that provides immediate spinopelvic junction stability and allows for early mobilization. Quality of life is significantly improved compared with that resulting from either medical treatment or traditional surgery.

KEY WORDS • spinal cord neoplasm • spinal fusion • metastasis • reconstructive surgery • sacrum

M ETASTATIC tumors of the sacrum are exceedingly rare. The survival rate in such cases remains dismal despite gross-total resection. In most reports in the literature authors describe procedures that involve sacrificing neural structures below the L-5 nerve roots. This invariably results in lower-extremity weakness and the loss of bowel and bladder control. In such cases neural sacrifice is typically combined with the resection of the sacrum and a portion of the iliac bone, causing the skeleton to sustain unstable axial load transfer from the spinal column down to the pelvis. Reconstructive surgery is typically followed by a prolonged period (up to several months) of bed rest, which ultimately is a suboptimum result in patients in whom life expectancy is limited by metastatic disease.

In this report, we examine three patients who suffered from aggressive metastatic tumors of the sacrum that caused spinopelvic instability and neurological dysfunction. Tumors were subtotally resected and maximum efforts were made to preserve neural function. Spinopelvic junction reconstruction was performed in a manner that provided immediate stability and early mobilization.

Case Reports

Summary of Clinical Data

Diagnoses included metastatic fibrosarcoma from the chest wall (Case 1), metastatic adenocarcinoma of the lung (Case 2), and metastatic paraganglioma (Case 3). In each patient metastatic disease to other organs was minimal. The primary tumor burden was in the sacrum. In all patients extensive sacral destruction was present from the S-1 endplate to at least S-3. In all cases, the disease did not cross the sacroiliac joint into the ilium. Neurological dysfunction included lower-extremity weakness, radiculopathy, urinary incontinence, and saddle block anesthesia (Table 1).

Both computerized tomography and magnetic resonance imaging of the lumbar spine and pelvis revealed aggressive tumor growth and extensive osseous destruction in all patients (Fig. 1). In all cases the ilium was free of disease. Angiography was performed in all three patients, in two of whom (Cases 1 and 2) no extensive vascular infiltration of the tumor was shown and embolization was not required. In the third patient (Case 3) an extensive vascular supply fed the tumor, requiring multi-
Clinical Material and Methods

Surgical Technique

The patients in Cases 1 and 2 in whom an extensive vascular supply to the tumor was absent underwent decompression and reconstruction of both the anterior and posterior spinal columns via a posterior approach. The first steps were to expose the posterior elements, perform an L-5 laminectomy, and undome the sacrum. The tumor was identified and the thecal sac was dissected free of tumor that had broken through the sacrum’s posterior wall. The L5–S4 nerve roots were identified and carefully tracked into the tumor. We used both the Midas Rex drill (Medtronic; Fort Worth, TX) and CUSA ultrasound aspirator (Valleylab; Boulder, CO) to remove bone fragments and tumor from beneath and around the nerve roots. The thecal sac was retracted to gain exposure for the aspirator between the nerve roots. Each nerve root was carefully resected free of the tumor (Fig. 2). The resection was performed down to the anterior wall of the sacrum. The drill, aspirator, and curettes were used to remove the anterior wall of the sacrum down to the interpelvic fascia. The lateral aspect of the sacrum was removed in a fashion similar to the sacroiliac joint, which was fused. By tracking the nerves from the known thecal sac through the tumor, an extensive tumor debulking was achieved without sacrificing the neural structures. Intraoperative free-run electromyography and somatosensory evoked potential monitoring were used to ensure that retraction of the nerve roots did not cause injury.

The patient in Case 3 harbored a paraganglioma that was fed by an extensive vascular supply and required embolization. To improve vascular control, the initial decompressive surgery was performed via an anterior approach. This patient also harbored a tumor that extended into L-5, requiring an anterior corpectomy L-5 in addition to sacral resection. The decompressive procedure was performed in two stages because of the extensive vascular supply of the tumor. The initial anterior resection involved the region of the sacroiliac joints. This anterior decompressive portion was concluded after debulking the tumor and eradicating its vascular supply because the nerve roots could not be clearly identified in the abnormal tissue. The patient underwent a second-stage posterior procedure in which neural decompression was performed similarly to that in Cases 1 and 2.

The reconstructive portion of the procedure involved restoration of the axial support of the spine and load transfer from the lumbosacral junction to the pelvis (Fig. 3). This was accomplished by making a stab incision in the gluteal region at a level parallel to the midaxis of the

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**TABLE 1**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>Diagnosis</th>
<th>Preop Symptoms</th>
<th>Preop Strength</th>
<th>Postop Symptoms</th>
<th>Postop Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52</td>
<td>fibrosarcoma</td>
<td>low-back pain, l/s radiculopathy, urinary incontinence</td>
<td>5/5 motor, all groups</td>
<td>resolved radiculopathy, normal bladder function</td>
<td>5/5 motor all groups</td>
</tr>
<tr>
<td>2</td>
<td>52</td>
<td>metastatic lung</td>
<td>low-back pain, rt foot weakness</td>
<td>rt 3/5 plantar flexor</td>
<td>normal bladder function</td>
<td>rt 4/5 plantar flexor</td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td>paraganglioma</td>
<td>low-back pain, rt L-5 radiculopathy, urinary incontinence</td>
<td>bilat 4/5 dorsiflexor</td>
<td>normal bladder function</td>
<td>bilat 3/5 dorsiflexor</td>
</tr>
</tbody>
</table>

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**Fig. 1.** Case 1. A: Axial computerized tomography scan obtained at S-2 in the patient with fibrosarcoma metastasis to the sacrum. The majority of the sacrum is involved with tumor. B: A three-dimensional reformatted scan obtained in the lumbosacral region. Note the punched-out lesion at S-2.
sacrum. A K-wire was then placed through the ilium into
the region of the S-1 resection. A titanium mesh cage was
fashioned to extend from the L-5 inferior endplate, where
discectomy and fusion had already been performed to
S-2. Using the drill, a 0.25-in hole was made in the cage
at the level of the K-wire. The cage was then filled with a
combination of allograft and demineralized bone matrix
and seated on the L-5 inferior endplate. The K-wire was
then passed through the 0.25-in hole and out the con-
tralateral ilium and skin. A small reamer was passed over
the K-wire, and 0.25-in holes were made through the
ilium, first on the right and then on the left. Through the
0.25-in holes in the cage, a 0.25-in titanium rod was then
placed through the ilium on the right and out through the
left ilium (Fig. 4). The top-tightening eye-bolt connectors
were then affixed to the rod to prevent migration. In the
patient in Case 3, the anterior axial reconstruction was
performed by seating a fibula graft onto the L-4 vertebral
body anteriorly. This was held in place by using anterior
Cotrel–Dobouset horizon screws and rods.

In all cases, the posterior reconstruction was conduct-
ed by placing pedicle screws at L-4 and L-5. A modified
Galveston technique was used to connect the posterior
elements of the spine to the ilium. We used the Farsi ilial
bolt system (Sofamor-Danek, Memphis, TN) for fixation
to the ilium and connected this system to the 0.25-in rod
that had been affixed to the pedicle screws (Fig. 5).
Crosslinks were then placed (Fig. 6).

In this way, the reconstruction provided immediate ax-
ial support with load transfer from the spine to the pelvis,
and posterior tension band stability by reconnecting the
ilium to the posterior elements of the lumbar spine.

**Surgery-Related Results**

Table 1 provides a summary of the neurological findings
demonstrated 1 month postoperatively. Two of the three
patients experienced no new neurological deficits and in
fact their bladder function improved. In the one patient with
a motor weakness, bilateral L-5 motor deficits were ob-
served and required ankle/foot orthoses; bowel and bladder
function was intact with a low postvoid residual.

Nonneurological complications are summarized in Ta-
ble 2. The patient in Case 1 required reoperation when the
pelvic rod loosened once he started ambulating. The bar
was repositioned and a locking screw was placed at each end
of the bar.

Postoperative imaging revealed 80 to 90% tumor resec-
tion. Postoperative x-ray films also demonstrated stability
of the pelvis, spine, and spinopelvic junction in all cases.

Patients were mobilized upon transfer to the neurosurgi-
cal floor. Their level of activity was gradually increased—
first by having them sit up in bed at a 45° angle and subse-
tively by having them sit in a chair with legs extended
after application of a rigid external thoracolumbosacral
orthosis. The patient in Case 1 was ambulating without as-
suance on postoperative Day 14; the patient in Case 2 was
ambulating by postoperative Day 6; and the patient in Case
3 was ambulating with assistance by postoperative Day 7.

The patient in Case 1 continued to ambulate without
assistance and required no narcotic agents up until his
death 9 months postoperatively. The patient in Case 2 died
15 months postoperatively of liver and pulmonary metas-
tases. He received narcotic agents occasionally for pain
control and continued to ambulate until the time of his
medical deterioration. Fourteen months postoperatively
the patient in Case 3 is still alive, requires narcotic agents
occasionally for pain control, and continues to ambulate.

**Discussion**

In the treatment of metastatic sacral disease the surgery-
related goals include prevention of new neurological deficits, improvement when possible of existing neurological deficit, restoration of stability to the spinopelvic junction, early ambulation, and pain control. All of these factors dramatically improve the patient’s quality of life. The aim of surgery should remain decompression and maximum tumor debulking, which can often be accomplished simply via a posterior approach without sacrifice of the neural elements. When extensive vascular involvement has been identified, we recommend a combined anterior–posterior approach to obtain improved vascular control.

Some authors have advocated a radical resection of the tumor and sacrifice of the neural elements below the L-5 nerve root. Although this may be appropriate in cases of benign or potentially curable disease involving the sacrum, this course, we believe, is not appropriate in patients with metastatic cancer and a limited life expectancy. In these cases, the goal should be to preserve quality of life.

Similarly, immediate stabilization and early mobilization are also realistic goals in patients with metastatic disease and limited life expectancies. Two to 6 months of bed rest is not a reasonable expectation in most of these patients. As such, every effort should be made to achieve immediate spinal stability. Our technique combines those reported by several other authors into a comprehensive reconstructive procedure that provides immediate axial stability to the spine, as well as immediate transfer of the axial spinal load to the pelvic ring, allowing mobilization.

**Fig. 3.** Stepwise illustrations of the lumbosacral junction reconstruction. A: Posterior view of the lumbosacropelvic junction. The hatched area will be resected. B: The sacrectomy is completed. C: A K-wire is passed through the left ilium in the resected region of S-1. D: The K-wire is passed through the cage and the right ilium. E: A reamer is passed over the guide wire. F: A 0.25-in titanium rod is passed through the left ilium, cage, and the right ilium. G: Lumbar pedicle screws, Farsi ilial screws, and the side-tightening bolts at either end of ilial rod are placed. H: Pedicle screws are attached to the ilial screws by using rods. This is the final stage of lumbopelvic fixation.
using pedicle screws and a modified ilial post–assisted Galveston technique. In our opinion, this provides immediate stability to the spine and pelvic ring, as well as the spinopelvic junction, which allows for mobilization within 1 to 2 weeks of surgery in contrast to the typical early ambulation times of 3 months after total sacrectomy.13 Although we believe that this reconstruction procedure is

The need for such reconstruction has been carefully determined by authors such as Gunterberg.4,11 In cadaveric and biomechanical analyses investigators have found that sacral resection up to 1 cm below the sacral promentary caused a 50% reduction in pelvic strength.4 Shikata, et al.,10 have described using an iliac bar to L-5 to regain axial stability in the spinopelvic transfer of weight.

Other authors have described techniques for performing anterior and posterior reconstruction. One unique procedure combines pyramesh cage–induced axial support with spinal pelvic weight transfer through a transiliac bar, in which posterior segmental reconstruction is performed

Fig. 6. Color illustration of sacral resection involving tumor and lumbopelvic fixation.

Fig. 5. Case 1. Anteroposterior (a) and lateral radiographs (b) demonstrating the results of lumbosacral reconstruction. Note the transiliac rod through the cage.
Management of metastatic sacral tumors

TABLE 2
Summary of nonneurological events

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Postop Nonneurological Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>internal iliac vein thrombosis, reop for instrumentation revision</td>
</tr>
<tr>
<td>2</td>
<td>none</td>
</tr>
<tr>
<td>3</td>
<td>disseminated intravascular coagulopathy</td>
</tr>
</tbody>
</table>

appropriate in all patients undergoing extensive sacral resection, one involving subtotal tumor debulking and preservation of neural structures is most appropriate in patients with metastatic disease. In young patients in whom a gross-total resection provides the only chance for cure,9 we still recommend a traditional procedure of en bloc tumor resection and sacrifice of neural elements.

Conclusions

Treatment of metastatic tumors to the sacrum remains challenging and controversial in spinal surgery. In patients with a limited life expectancy, we describe a new surgery-related strategy in which sacral tumors are subtotally resected and neural function is preserved. We also present a novel reconstructive technique that provides immediate spinopelvic stability as well as allowing for early ambulation in all patients undergoing extensive sacral resection.

We believe that this combination provides the optimum quality of life for patients with metastatic disease to the sacrum.

References


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