Surgical treatment of primary sacral tumors: complications associated with sacrectomy

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Object. Sacral tumors are relatively rare, and experience related to resection of these tumors is therefore usually limited to a small number of patients. The purpose of this retrospective study was to review the authors’ experience with sacral neoplasms over the last 12 years.

Methods. Based on a review of records in 11 patients who underwent sacrectomy, and the various patient characteristics, presenting symptoms, histological findings for their tumors, as well as the type of surgical treatment used (including a whole spectrum of sacral amputations), and their outcome are reported.

Conclusions. Despite the potential for complications, sacrectomy can be performed successfully, and is an important procedure in the treatment of primary sacral tumors.

Key Words • sacral tumor • sacrectomy • surgical approach • complication

Primary sacral tumors, although rare, include benign neoplasms such as osteochondroma, giant cell tumors, and osteoid osteoma, as well as the more common malignant lesions such as chordoma, osteosarcoma, and myeloma. Because of their mild symptoms, sacral neoplasms are usually not diagnosed early in their disease course. These tumors are often large by the time they are diagnosed, and they then pose a technically challenging surgical problem. Excision of malignant or benign, aggressive sacral tumors with intralesional margins is rarely curative, because of the high likelihood of local recurrence. A radical surgical approach such as partial or total sacrectomy, with sacrifice of sacral roots, is often warranted to achieve total resection with wide margins. The risk of infection, loss of large amounts of blood, wound complications, and neurological dysfunction are problems associated with sacrectomy. Total sacrectomy also presents the challenge of spinal–pelvic fixation to achieve stabilization after complete dissociation of the spine and pelvis. In this report, we present a surgical series of patients with primary sacral tumors and discuss the challenges associated with sacrectomies.

CLINICAL MATERIAL AND METHODS

Patient Population

Between 1991 and 2003, 34 patients (20 female and 14 male patients) with primary sacral tumors were treated at the University of Ege, Izmir, Turkey. These patients’ mean age was 42 years ± 17 years (mean ± standard deviation, range 14–71 years). The number of operations per patient was 2.3 ± 2.1; sacrectomy was performed in 11 patients with malignant tumors. The patients’ records were retrospectively reviewed and data were collected on age, sex, histological characteristics of the primary tumor, neurological symptoms, and surgical approach (Tables 1 and 2). Preoperative evaluation included neurological examination, biopsy sampling, assessment of pain, CT scanning, abdominal ultrasonography, and 99mTc bone scanning. Medical treatment received before the surgical consultation was recorded.

Indications for sacrectomy included malignant or benign, aggressive tumors (Table 3). The histological composition of the tumors included chordoma in seven patients, chondrosarcoma in three, and osteosarcoma in...
one. All patients experienced significant sphincter disturbances. We excluded from surgery those patients who had previously undergone anterior operations, whereas patients who had previously undergone resection via a posterior approach, or who had received radiotherapy or chemotherapy, were candidates for sacrectomy. Either a partial (caudal to the S-1 level, two cases) or total sacrectomy (rostral to the S-1 level, nine cases) was performed (Table 4).

**Total Sacrectomy Procedure**

Our surgical team consisted of a spinal neurosurgeon, a surgical oncologist, and in some cases a plastic surgeon. Sacrectomy can be performed using either two sequential approaches,26 which we preferred, or by using a synchronous AP approach in the lateral (right) position 14 (Table 5).

The anterior approach consisted of making a U-shaped incision, preserving the rectus abdominis muscle. A retroperitoneal dissection of the lower lumbar and pelvic area was then performed. Both the iliac arteries and veins were dissected, and the internal iliac arteries were ligated. (This part of the operation was performed by a general surgeon [C.H.]). Next, the visceral and vascular structures of the pelvis were mobilized away from the tumor. After dissecting the rectum, sacral nerve roots entering the tumor were sacrificed, followed by an L5–S1 anterior discectomy and partial ventral sacroiliac osteotomies. A piece of sterile gauze was placed in the abdomen dorsal to the rectum to isolate the rectum from the lumbar vertebrae and sacrum, and the abdominal incision was closed.

The patient was turned to the prone position and a Y- or inverted C-shaped incision was made. If there had been a previous operation, a vertical midline cut was preferred, and the existing incision lines were resected. After dissecting and retracting the gluteal muscles, the sciatic notch was identified and posterior osteotomies were performed. An L-5 laminectomy was performed, and after identification of the dural sac and the L-5 and S-1 roots, the dura mater and sacral roots were ligated distal to the L-5 roots. After completion of the osteotomies, the tumor mass was completely removed. Closed suction drainage catheters were placed as needed. Myocutaneous flap closure was used in most cases.

The duration of surgery ranged between 6 and 22 hours (mean 13.4 ± 4.4 hours). The blood loss ranged between 2400 and 5250 ml (mean 4518 ± 1773 ml).

**Stabilization Procedure**

The stabilization procedure was performed in a second session in two cases, and at the same session in one. For lumboiliac stabilization, we first used a custom-made sys-
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Additional Therapies

Two patients each with osteosarcomas, underwent chemotherapy in addition to radiotherapy.

RESULTS

Patient Data

Table 1 summarizes the baseline characteristics of the patient population. The median duration of symptoms prior to surgery was 20 months (7 days–10 years). The most frequent clinical symptom was pain. More than 50% of our patients experienced some neurological symptoms, which consisted of monoparesis, cauda equina syndrome, and sphincter disturbance. Twenty patients harbored malignant tumors, and 14 had benign ones (Table 2).

Perioperative Data

The outcome data in our patients are provided in Tables 6 and 7. The median follow-up period in this series was 42 months (range 1 month–12 years). Twenty-seven patients were still alive at a mean of 4 years postsurgery. There were no deaths or significant morbidity in patients who underwent surgery other than sacrectomy. Seventeen patients had residual tumors after their surgery. Two of them, one harboring an osteosarcoma, and the other a giant cell tumor, declined sacrectomy. Other patients had benign tumors and underwent additional surgeries after tumor recurrence.

Perioperative Complications

Several complications occurred within 30 days of sacrectomy (Table 8). Three patients died in the early postoperative period because of these complications. One patient with a low-grade chondrosarcoma, who underwent a total sacrectomy and hemipelvectomy, died of cerebral infarction resulting from fat emboli. Two patients died of septic infections following rectal perforations 2 and 3 weeks, respectively, after the sacrectomy. Because there had been no detectable perforation of the rectum in these patients during the sacrectomy, we suspected that ischemia of the rectal wall could be the reason for these complications. Although an emergency colostomy was performed, and an irrigation–suction system was used, both patients died of sepsis. Three patients had unintentional motor deficits (foot drops) that were possibly caused by traction injury to the lumbosacral plexus or L-5 nerve root. Local infections and wound complications were observed in five patients, and treated with regular dressings, antibiotics, and in some cases, additional surgeries. One patient who had cerebrospinal fluid fistulas originating from a dural tear was treated using external lumbar drainage.

The mean length of follow up in the patients who underwent sacrectomy was $5.1 \pm 2.7$ years (range 1–8 years). Two patients died during the follow-up period (Table 9).

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ILLUSTRATIVE CASES

Case 1

**History.** This 18-year-old woman had suffered low-back pain and urinary incontinence for 2 years. Previously, she had undergone two partial tumor resections in other hospitals. Osteosarcoma was diagnosed in a tissue sample, and she underwent three cycles of chemotherapy (methotrexate, vincristine, doxorubicin, and cyclophosphamide) for palliation.

**Examination and Diagnostic Studies.** Physical examination demonstrated a neurogenic bladder, anal sphincter weakness, and perineal hypesthesia. Plain x-ray films (Fig. 1A) revealed an ossified mass covering almost the entire pelvis. Admission MR and CT studies (Fig. 1B and C) demonstrated an aggressive, destructive tumor that occupied most of the pelvis, sacrum, and L-5 VB, and part of both iliac wings. The CT scans revealed that the tumor was mostly an ossified mass. A 99mTc scan, a chest CT scan, and echographic examination of the abdomen demonstrated no systemic disease elsewhere. We planned to perform a high sacral amputation, a partial hemipelvectomy, and excision of the L-5 VB, along with excision of scar tissue from two previous incisions (Fig. 1D).

**First Operation.** In June 1996, a bilateral retroperitoneal ventral dissection was performed, and both internal iliac arteries were ligated. After turning the patient to the prone position, a posterior dissection was performed (Fig. 1E). To reconstruct the posterior skin defect, the plastic surgery team used a rectus abdominis myocutaneous flap

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TABLE 9

*Follow-up findings in 11 patients who underwent sacrectomy*

<table>
<thead>
<tr>
<th>Finding</th>
<th>No. of Patients</th>
</tr>
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<tbody>
<tr>
<td>early postop death (1st mo)</td>
<td>3</td>
</tr>
<tr>
<td>dead at follow up (13 mos &amp; 5 yrs survival)</td>
<td>2</td>
</tr>
<tr>
<td>alive w/ recurrence</td>
<td>1</td>
</tr>
<tr>
<td>alive w/ metastasis, w/o recurrence</td>
<td>2</td>
</tr>
<tr>
<td>alive w/o recurrence</td>
<td>3</td>
</tr>
<tr>
<td>(1–8 yrs; mean survival 4.8 ± 3.1 yrs)</td>
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Fig. 1. Case 1: sacral osteosarcoma. A: Plain pelvic x-ray film showing an ossified mass covering almost the entire pelvis. B and C: Sagittal MR imaging (B) and CT scan (C) studies demonstrating an aggressive, destructive tumor occupying most of the pelvis, sacrum, and L-5 VB and part of both iliac wings. D: Photograph showing that previous skin incisions were kept in excision margins. E: Intraoperative photograph obtained after total sacrectomy and excision of the L-5 VB: posterior view of the wound showing both iliac wings, lumbosacral plexus, and rectum. F: Photograph showing a rectus abdominis myocutaneous flap with vascular pedicle about to be prepared during anterior surgery. G: Intraoperative photograph showing this flap transposed back to the sacral region. H: Photograph showing healed abdominal wall flap in the sacral region. I: Intraoperative photograph obtained during the second surgery 3 months later, showing a posterior instrumentation and allograft application. J and K: Plain AP (J) and lateral (K) x-ray films obtained after instrumentation. At the 7-year follow-up review, the patient was able to walk with the aid of crutches.
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with vascular pedicle (Fig. 1F). A vascularized flap of the upper abdominal wall was transposed retroperitoneally to the sacral region of the patient, and the umbilicus was constructed anteriorly. The flap healed within 30 days of surgery (Fig. 1G and H). The duration of the surgery was 17 hours and total blood loss was 3400 ml (11 U blood was transfused).

Second Operation. The second surgery was performed 3 months later. For this procedure, pedicle screws were placed at the L-2 and L-3 levels. Two specially designed plate and rod constructs were used for lumboiliac stabilization. The rods were bent to fit into the lumbar pedicle screws and iliac wings. Navicular screws were used to fix the two plates to the iliac wings. Iliac crest grafts obtained in the patient’s father were used for fusion (Fig. 1I–K).

Outcome. At the 7-year follow-up review, the patient had no tumor recurrence at the site of sacrectomy, and she was able to walk with the aid of crutches. Nevertheless, she has three lung metastases, and resection of pulmonary nodules was performed in 2002.

Case 2

History and Examination. This 42-year-old man had a 3-year history of urinary urgency, and a 6-month history of constipation. Proctoscopic examination revealed a pelvic tumor obstructing the rectum; this diagnosis was confirmed on MR and CT studies (Fig. 2A–F). A biopsy sample demonstrated a low-grade chondrosarcoma.

Operation. We performed a combined ventral–dorsal surgery and lumbopelvic reconstruction in one session in May 2002. Via a ventral approach, we made a U-shaped incision (Fig. 2G), performed a retroperitoneal dissection, and ligated both of the internal iliac arteries and the median sacral artery. Then, from the dorsal approach, an inverse C-shaped incision was made (Fig. 2H), gluteal muscles and sciatic nerves were dissected, and an L-5 partial laminectomy was performed. After ligation of the sacral dura mater distal to the L-5 roots, an L5–S1 discectomy and posterior osteotomy were performed at the level of the sacroiliac articulations. Figure 2I and J shows the resected tumor.

Lumbopelvic stabilization was achieved in the same session by using a custom-made system (Fig. 2K). This system consisted of two threaded lateral bars connecting both iliac wings, and sagittal rods connected to transverse rods. Femoral allografts supported with autografts and de-mineralized bone matrix were placed ventral and dorsal to the iliac bars, and mesh was used to cover the rectum (Fig. 2L–N).

Outcome. The patient was free of disease at the 1-year follow-up review, and there was no evidence of tumor recurrence (Fig. 2O and P).

DISCUSSION

Radical resection may be the best available treatment for low-grade malignancies and aggressive, benign sacral tumors that are resistant to noninterventional therapies. Because they are technically difficult procedures, however, partial and total sacrectomies pose several complex challenges, and require the expertise of specialists from several fields.

Complications and Concerns

Protection of Vascular Structures. These structures can be protected using meticulous dissection techniques, aided by a vascular surgeon for handling of the ventral compressed vascular structures. Ligation of the median sacral artery, internal iliac arteries, and iliolumbar arteries is necessary to cut off the vascular supply to the sacrum and tumor.

Protection of Visceral Structures. Care must also be taken to protect the visceral structures, including the ureters, intestines, and rectum. If the rectum is adherent to the tumor, an elective colostomy may be needed.

Protection of the Roots and Plexus. Neurological deficits resulting from the sacrifice of sacral nerve roots are extensive and permanent. In total sacrectomies, most of the sacral roots invaded by the tumor are sacrificed, and this usually results in loss of bladder and sexual function and bowel control.10,11 In most cases, preservation of the lumbar roots is possible, and they allow the patient to be ambulatory. Sparing the L-5 root bilaterally may be adequate for plantar flexion of the foot.11

Excessive Bleeding. This may be a life-threatening problem in radical sacral surgery. Considerable blood loss (7–80 L in some series) has been reported.5,29 Different methods to overcome excessive bleeding have been proposed, including the application of polymethylmethacrylate,19,20 fluid nitrogen,15–18 phenol, hydrogen peroxidase, and hot water. Applying substances such as hemostatic gauze, fibrin glue, or an omentum flap onto the bed of the tumor are also possibilities for preventing blood loss, as is cryosurgery.7 Cell saver autotransfusion may be used following excessive blood loss, but it cannot be applied to malignant tumors.

Wound Complications and Risk of Infection. These potential complications pose another challenge.7,23,25,27 Some authors have proposed using a Vicryl net bag containing gentamicin beads to fill the defect, to prevent infection and herniation until the granulation tissue develops.39 To facilitate wound healing, various types of muscle flaps and incisions were made. In partial sacrectomy, or in the presence of previous incisions, we made a median longitudinal incision. In total sacrectomy, in which the resulting tissue defect was large, we made a downward-based, C-shaped incision with a median longitudinal extension at its apex. We used gluteal muscles as a flap inside the defect, and in one case a rectus abdominis myocutaneous pure island pedicle flap was used.3

Lumbosacral and Sacroiliac Stability. Spinal–pelvic stability is one of the most difficult challenges faced in total sacrectomy, partly because of the large loads carried by the lumbosacral junction, and the angular position of the sacrum. This region is a transition zone from the mobile spine to the rigid pelvis. Sacrectomy rostral to S-1 destabilizes the sacrum and the pelvic ring, and warrants fixation, whereas sacrectomy caudal to the sacroiliac joints (S-1) does not require fixation.29 Sacral and iliac screws are sufficient for patients with an intact sacrum and minimal spinal–pelvic instability.
from the dorsal view (J). K and L: Intraoperative photographs showing how lumbopelvic stabilization was achieved using a custom-made system during the same operative session (K). Femoral allograft supported with autografts and a mesh covering for the rectum were placed dorsal to the iliac bars (L). M and N: Photographs showing this custom-made system (TIPSAN Co., Izmir, Turkey), which consisted of two threaded, lateral bars connecting both iliac wings, and sagittal rods connected to transverse rods. O and P: Postoperative AP (O) and lateral (P) x-ray films obtained after instrumentation.

Fig. 2. Case 2: sacral chondrosarcoma. A–C: Sagittal (A) and coronal (B and C) MR images demonstrating the huge sacral and presacral mass. D–F: Axial CT scans (D and E) and three-dimensional reconstruction (F) depicting calcification inside the tumor. G and H: During the ventral approach, we made a U-shaped incision (G); then, from the dorsal approach, an inverse C-shaped incision was made (H). I and J: Photographs showing the excised tumor mass from above (I) and
Fixation Systems

Lumbar–iliac L-rod pelvic fixation, known as the Galveston technique, was the first system used for sacroiliac fixation, and was proposed by Allen and Ferguson\(^1\) for the treatment of scoliosis and pelvic obliquity. Use of the sublaminar wiring described by these authors requires intact laminae, however, and does not provide as much rigidity as screws. Shikata, et al.,\(^24\) described the first lumbar-iliac fixation system for sacrectomy in which a combination of Harrington rods and hooks, sacral bars, and massive bone grafts were used. Iliac bones were joined with the sacral bars, and L-5 was lowered 2 cm and shifted anteriorly. This technique does not provide much rotational stability around the horizontal axis of the spine;\(^6\) furthermore, the sacral bars joining the soft posterior iliac wings do not provide firm fixation.\(^12\)

Gokaslan, et al.,\(^9\) modified the procedures described earlier. They replaced the sublaminar wiring used in the Galveston technique, and the Harrington rods, with lumbar pedicle screws. Two L-shaped Galveston rods were used to connect the lumbar pedicles to the iliac wings, one transiliac threaded rod was used to reconstruct the pelvic ring, and a tibial strut allograft was placed between the ilia to augment the instrumentation. Jackson and Gokaslan\(^12\) also proposed rod insertion into the iliac wings. The modified Galveston technique described by Gokaslan, et al., provides more rigidity than the wiring technique, but has the disadvantage of requiring rod contouring, which can be time-consuming and difficult.\(^12\)

Custom-made systems have also been used successfully in lumbosacral reconstruction.\(^3,22,30\) Wuismann, et al., used a three-dimensional, real-sized model to design and test a sacral prosthesis.\(^30\) The prosthesis consisted of an L-shaped plate covering the L-5 corpus vertebrae and the surface of the L-5 endplate. An iliac wing flap covered and connected the remaining external anterior part of the iliac wing. To provide torsional stability, Althausen, et al., used iliac screws and bolts, a reconstruction plate, and cross connectors of varying lengths to connect this system to lumbar pedicle screws and rods.\(^3\) The reconstruction system used by Salehi, et al., also included a transverse iliac bar and iliac screws, but the iliac bar traversed a mesh cage resting on the lower end plate of the L-5 VB.\(^22\) This system allowed immediate spinal–pelvic stability and early ambulation in patients with metastatic tumors who underwent subtotal resection.

Our first stabilization system (used in Case 1) was semirigid, consisting of iliac plates fixed with navicular screws. Because a significant amount of contouring was necessary during surgery, we modified the design in the last two cases. In those patients we used two transverse bars connected to lumbar rods with special connecters, and lumbar pedicle screws similar to those used by Gokaslan, et al.\(^9\) This modified system does not require rod contouring, and it is more rigid than the previous system of iliac plates and screws.

CONCLUSIONS

Radical resection can prolong the overall survival time of patients with primary malignant or benign, aggressive neoplasms in the sacrum that are resistant to noninterven-}

References


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