Spinal–pelvic fixation in patients with lumbosacral neoplasms

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Object. Primary and metastatic neoplasms of the lumbosacral junction frequently pose a complex problem for the surgical management and stabilization of the spine because of the anatomical and biomechanical factors of this transition zone between spine and pelvis. The authors have used a modification of the Galveston technique, originally described by Allen and Ferguson in the treatment of scoliosis, to achieve rigid spinal–pelvic fixation in patients with lumbosacral neoplasms. The authors retrospectively reviewed their experience, with particular attention to method, pain relief, and neurological status.

Methods. From July 1994 through December 1998, 13 patients at the authors’ institution have required spinal–pelvic fixation secondary to instability caused by primary (eight cases) or metastatic (five cases) neoplasms. Previous treatment included spinal surgery in 10 (77%), radiation therapy in seven (54%), and/or chemotherapy in six (46%). Following tumor resection, fixation was achieved by intraoperative placement of contoured titanium rods bilaterally into the ilium. These rods were attached to the lumbar spine with pedicle screws and subsequently crosslinked. Arthrodesis was performed.

In the follow-up period of 3 to 50 months (average 20 months), nine (69%) of 13 patients were still alive. There were no cases of surgery-related death. Seven weeks postoperatively instrumentation failure occurred in one patient and was corrected by performing double L-rod spinal–pelvic fixation. Two patients experienced neurological dysfunction (ankle weakness and neurogenic bladder) that was thought to be related to tumor resection rather than the fixation procedure. Neurological status improved in all patients and remained unchanged in seven patients. Ambulatory status improved in 62% (eight patients), remained unchanged in 23% (three patients), and worsened in 15% (two patients). Spinal pain, as measured by a visual analog pain scale and determined by medication consumption was significantly reduced in 85% (11 cases).

Conclusions. In selected patients with primary or metastatic lumbosacral tumors, resection followed by modified Galveston L-rod spinal–pelvic fixation is an effective means of achieving stabilization that can provide significant pain relief and preserve ambulatory capacity.

KEY WORDS • spinal fixation • spine • metastasis • lumbosacral • tumor

SURGICAL resection followed by internal fixation to achieve stabilization is often indicated in the management of patients with primary or metastatic lumbosacral neoplasms. Primary sacral tumors are amenable to complete en bloc resection for possible cure. Palliation is the goal in cases of metastatic lumbosacral tumors. Palliative goals include restoration of neurological function or prevention of further neurological decline, as well as the alleviation of pain. The destructive process of the tumors and the removal of such tumors often necessitate a stabilization procedure.

Primary and metastatic neoplasms of the LSJ frequently pose a complex problem for surgical management and stabilization because of anatomical and biomechanical factors of this transition zone between spine and pelvis. The LSJ has been considered by some to be the most difficult portion of the spine at which to obtain a solid fusion, in part because of the large load carried and because of the angular position of the sacrum, which produces unique load-bearing characteristics. This region also represents a transition from the mobile spine to a relatively fixed pelvis that places additional stress at the LSJ. These inherent biomechanical factors of the LSJ combined with the destructive element of neoplastic processes and the treatment of such disease present a challenging problem in terms of spinal stabilization.

Various methods of sacral fixation exist. Use of a single pair of sacral pedicle screws is often adequate to achieve fixation in short segment cases in which minimal instability is demonstrated. More substantial fixation techniques...
Clinical Material and Methods

Patient Population

From July 1, 1994 to December 31, 1998, 802 spinal operations were performed in 621 patients by the surgeons of the neurosurgery service at The University of Texas M. D. Anderson Cancer Center. Thirteen of these patients required spinal–pelvic fixation for instability due to primary (eight cases) or metastatic (five cases) neoplasms. Previous treatment included spinal surgery in 77% (10) radiation therapy in 54% (seven), and/or chemotherapy in 46% (six) of patients.

Indications for surgery varied depending on the type of neoplasm. Primary sacral tumors are amenable to complete en bloc resection for possible cure. Palliation is the goal in cases of metastatic lumbosacral tumors. Palliative indications include restoration of neurological function or prevention of further neurological decline, as well as the alleviation of pain. All patients had an estimated life expectancy that exceeded 3 months.

The patients’ records were retrospectively reviewed, and data were collected on age, sex, and presence of primary and metastatic disease. Medical treatment (chemotherapy, radiotherapy, or both) and history of previous spinal surgery were reviewed (Table 1). Preoperative evaluation included neurological examination, assessment of pain level, radiography, magnetic resonance imaging, and computerized tomography scanning in selected cases. Neurological function was assessed, and each patient’s neurological status was scored by the method of Frankel.14 A VAS15 was administered to measure pain status. The effectiveness of medication and quantity of pain medication consumption were recorded. The average length of follow-up was 20 months (range 3–50 months). Telephone interviews were conducted with patients to obtain additional information.

Operative Technique

Following endotracheal intubation and induction of anesthesia, patients were positioned prone on gel bolsters with great care to pad all pressure points adequately. Somatosensory evoked potential monitoring was used intraoperatively to assess the physiological integrity of the spinal cord in selected cases. The dorsolumbar spine and sacrum were exposed via a midline incision in most cases. A lumbar–iliac pelvic fixation was performed in patients who underwent total sacrectomy. En

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**TABLE 1**

Demographic and clinical data obtained in 13 patients undergoing spinal–pelvic fixation

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<th>range</th>
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<td>unclassified spindle cell sarcoma</td>
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<table>
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<td>range</td>
<td>3–50</td>
<td>mean</td>
<td>20</td>
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Spinal–pelvic fixation for lumbosacral instability

![Image](image-url)

FIG. 1. Artist’s illustration depicting the posterior exposure of the sacrum, medial ilium, and lumbar spine. The lumbosacral fascia/muscular flap is lifted off of the sacrum and retracted cephalad and laterally. Inset: The dashed line represents the posterior incision.

Bloc resection was performed for primary tumors of the sacrum (Fig. 2). Metastatic tumors were generally removed in a piecemeal fashion by using routine neurosurgical techniques. In situations in which the tumor was too solid for suction and too soft for high-speed drilling, we used an ultrasonic aspirator (Cavitron Ultrasonic Aspirator; ValleyLab, Inc., Boulder, CO). After the tumor was resected and the neural elements were completely decompressed, attention was turned to segmental fixation. In those patients in whom total sacrectomy was performed, the procedure was undertaken in two stages: anterior mobilization followed by a posterior resection and fixation at a later date.

The stabilization procedure used is a modification of Galveston technique of pelvic fixation.1-4 Instead of using lumbar sublaminar wiring, we use pedicle screw fixation segmentally to attach the rods to the lumbar spine. This thought to provide more security than the wiring technique, allowing a shorter fixation length and increased rigidity.1,4,11,13,17,19,28 Additionally, in many of our patients laminec- tomy was required for tumor removal, which precludes the use of sublaminar wiring. Rigid crosslinks were placed between the rods to provide increased torsional stability. Transiliac threaded rods were used to reconstruct the pelvic ring in cases in which total sacrectomy was performed, as described previously.15

Initially, screws (Universal Spinal System; Synthes Spine, Paoli, PA) are placed bilaterally in the lumbar pedicles in a standard fashion.1,11,21,26,30 Intraoperative radiography is used to confirm correct positioning. Using a high-speed burr drill, a 6-mm hole is made in the cortex of the medial posterior iliac crest at approximately the S2–3 level. This allows one to tap a 6-mm titanium pilot rod into the cancellous portion of the ilium to create a path for the contoured rod (Fig. 3 left). This temporary rod is directed 1.5 cm above the sciatic notch and between the two cortices of the ilium, and it is tapped into place with a mallet to a depth of 6 to 9 cm. This pilot rod is then removed, and a malleable template rod (wire) is inserted, subsequently contoured, and removed. A 6-mm titanium rod is contoured to match the template rod (wire) by using tube benders and a table vice (Fig. 3 center) and is subsequently tapped into the ilium. The rod is attached to the lumbar pedicle screws. Crosslinks are then placed between the rods (Fig. 3 right). In cases requiring total sacrectomy, a threaded rod is placed through lateral to medial ilium, through tibia or femoral allograft, and then through the opposite medi- al to lateral ilium to reconstruct the pelvic ring. Locking collars are placed on the transiliac rod to prevent lateral migration of the rod. A combination of autograft, allograft, and de-mineralized bone matrix is placed over selectively decorti-cated bone to promote arthrodesis. Closed suction drainage catheters are placed as needed. Rotational or free myocuta-neous flap closure was necessary in five patients (38%) due to the presence of a large soft-tissue defect caused during tumor resection.

Postoperative Care

Most patients were observed in the surgical intensive care unit overnight and were transferred to the neurosurgical ward the next day. Those patients in whom surgery took less time and in whom there was minimal blood loss were observed in the recovery room and were then transferred to the neurosurgical ward. An external TLSO was used in four cases (Cases 1–3 and 5; Table 2). Our first two patients to undergo total sacrectomy (Cases 1 and 2) were placed in cases (Cases 1–3 and 5; Table 2). Our first two patients to undergo total sacrectomy (Cases 1 and 2) were placed in external orthosis; in patients treated later in the series who underwent total sacrectomy an external orthosis was not used. The patient in Case 3 was temporarily given a TLSO by her rehabilitation doctor to assist with pain in the early postoperative period. In the patient in Case 5 limited iliac bone for fixation was observed after tumor resection and an external TLSO was provided to assist fusion. Inpatient rehabilita-tion was provided as needed. Early mobilization was encouraged for all patients except for those in whom total sacrectomy was performed. For these patients bedrest was ordered for 6 to 8 weeks, and they performed nonweight-bearing exercises and subsequently underwent progressive inclination on a tilt table, prior to working on the parallel bars and eventual ambulation.

Results

Operative and Perioperative Data

Thirteen patients with lumbosacral neoplastic disease underwent resection and spinal–pelvic fixation in which arthrodesis was performed. In all 13 patients spinal instability secondary to direct tumor invasion and/or iatrogenic instability was demonstrated after surgery to resect the...
tumor. Five patients required a total sacrectomy (and a staged, anterior then posterior approach) because significant anterior extension of tumor and/or tumor extension rostral to the S1–2 level. The median operative time was 8 hours and 25 minutes (range 5:46–22:35 hours). Increased operative time occurred in patients requiring total sacrectomy because of its associated extensive tumor resection and rotational or free myocutaneous flap closure. Intraoperative estimated blood loss (median estimated blood loss 2450 ml; range 600–16,500 ml) was also expected to be higher in cases of total sacrectomy.

Patients were mobilized as soon as possible except for those who underwent total sacrectomy. Those in whom sacrectomy was not performed were ambulatory with or without assistive devices by a median of 2.5 days postoperatively (range 1–11 days), as compared with a median time of 60 days postoperatively (range 42–90 days) in those who underwent total sacrectomy. The median LOS, including the time spent in the intensive care unit, acute care and in certain cases inpatient rehabilitation, was 9 days for patients in whom sacrectomy was not performed compared with 83 days for those in whom it was. In the patients in whom total sacrectomy was performed, LOS was considerably lengthened because of the more extensive surgery and its associated increased intensive care unit and acute care stays, as well as a 54-day average stay in inpatient rehabilitation.

The clinical details and results obtained in the 13 patients with lumbosacral tumors who underwent spinal–pelvic fixation and arthrodesis are summarized in Table 2. Neurological outcome, pain status, ambulatory status, and complications are reported hereafter in additional detail.

**Neurological Outcome**

Preoperatively, neurological compromise was revealed in all 13 patients. Neurological status improved in four patients, three of whom improved one Frankel grade. Two patients experienced neurological dysfunction following surgery (ankle weakness and neurogenic bladder, respec-
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FIG. 3. Artist’s illustrations. Upper Left: A 6-mm titanium pilot rod is tapped into the cancellous portion of the ilium to create a path for the contoured rod. This temporary rod is directed 1.5 cm above the sciatic notch and between the two cortices of the ilium. It is tapped into place with a mallet to a depth of 6 to 9 cm. Upper Right: A 6-mm titanium rod is then contoured to match the template rod (wire) by using tube benders and a table vice. The final shape of spinal-pelvic rod matches template rod (A); tube benders are used to create the sacroiliac bend of approximately 60° (B); and the table vice is used to stabilize the sacral and iliac segments of the rod while an approximately 110° bend is created between the lumbar and sacral segments (C). Lower Left: Illustration of the spinal–pelvic fixation.
<table>
<thead>
<tr>
<th>Case No.</th>
<th>Diagnosis</th>
<th>Procedure</th>
<th>Type of Closure</th>
<th>Pain Reduction</th>
<th>Ambulatory Status</th>
<th>Follow Up (mos)</th>
<th>Fusion</th>
<th>Postop Complications*</th>
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<td>free rectus</td>
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<td>bedridden</td>
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<td>severe unilat plantar &amp; dorsiflexion weakness</td>
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<td>independent</td>
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<td>temporary</td>
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<td>walker</td>
<td>15 (died)</td>
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<td>independent</td>
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<td>31</td>
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<td>small intestinal perforation, sepsis, coagulopathy, <em>Clostridium difficile</em> colitis</td>
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<td>fused unilat</td>
<td><em>Clostridium difficile</em> colitis</td>
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<td>yes</td>
<td>independent</td>
<td>cane</td>
<td>8</td>
<td>partial</td>
<td>urinary tract infection</td>
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</table>

* Complications that occurred within 30 days postoperatively are listed. Abbreviation: met = metastasis.
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Pain Status

All patients in this series presented with lumbosacral pain. Eight patients (62%) rated their preoperative pain as severe, five (38%) as moderate, and two (15%) as mild based on a VAS. Postoperatively, 11 (85%) of patients experienced significant pain reduction. Of the two patients in whom significant pain relief was not obtained, one patient experienced only slight reduction in pain, and the other experienced significant relief for only 6 months prior to recurrence of similar severe pain. He eventually required a myelotomy. The preoperative median VAS was 7. This median VAS pain score decreased to 4 at 1-month, 3 at 3-months, 2.5 at 6-months, 2 at 1-year, and 2 at last follow-up examination (Fig. 4). The reduction in levels of pain at these five follow-up examinations was found to be statistically significant (exact Wilcoxon's signed rank sum test). The quantity of total pain medication consumption decreased in 10 of 13 patients postoperatively when compared with preoperative consumption. Pain relief was found to be immediate and long lasting.

Ambulatory Status

Ambulatory status (classified as bedridden, wheelchair bound, dependent on a walker or cane, and independent), which is associated with neurological function, spinal–pelvic stability, and pain control improved one or more classification levels in eight patients (62%), remained the same in three patients (23%), and worsened in two patients (15%). One of the patients with worsened ambulatory status is currently using a cane and is likely to be independent in the near future. Five patients who were bedridden preoperatively secondary to pain and lower-extremity weakness became ambulatory. Individual patient ambulatory status is listed in Table 2.

Perioperative Complications

All adverse events that occurred within 30 days of surgery were considered complications. Complications that required additional surgery, caused an increase in LOS, or those that were potentially life threatening were considered major complications. Complications that did not significantly change the overall course of events and that did not increase the LOS were considered minor complications.

Five minor complications occurred in four patients. One patient developed a generalized seizure on postoperative Day 2, which resolved without treatment and did not require anticonvulsant medication. This complication was thought to be secondary to an electrolyte disturbance. Three patients developed urinary tract infections, which was not surprising considering the frequency of neurogenic bladders in our patient population. Another patient developed Clostridium difficile-associated colitis.

Five major complications occurred in five patients. The patient in Case 1 experienced unilateral ankle plantarflex-
ion and dorsiflexion weakness, which was thought to be secondary to manipulation of the L-5 and S-1 nerve roots during resection of recurrent tumor rather than to the fixation process. This weakness has persisted, with minimal improvement observed postoperatively. The patient in Case 4 suffered an initially unrecognized intestinal perforation during the harvesting and pull through of a rectus myocutaneous flap closure. This led to sepsis, and the patient was returned to the operating room for repair of the injury. The hardware was not disturbed and was left in place without complication. The patient in Case 8 developed a neurogenic bladder that required long-term intermittent catheterization following resection of a recurrent spindle cell sarcoma. In the patient in Case 10 development of a wound infection and meningitis necessitated a return to the operating room for debridement and reclosure of the wound. No cerebrospinal fluid leak or dural defect was identified on exploration. The patient was given intravenous antibiotic medications in the hospital for 2 weeks and at home for 4 weeks. His infection resolved without sequelae, and his pain and neurological status improved. The patient in Case 11 was readmitted to the hospital 2 weeks postdischarge with pneumonia, which required a 6-day hospitalization and intravenous antibiotic medications.

There was one hardware-related complication. This 43-year-old patient with history of testicular cancer that metastasized to the lumbar spine and who had undergone three previous operations in which fixation and fusion of L-1 to the sacrum were attempted, was referred to our service with severe low-back pain. He was found to have LSJ instability with loss of posterior sacral hook fixation. We used the modified Galveston technique in which L-rod fixation was performed; however, both rods were subsequently fractured (Fig. 5 left) at the lumbosacral curve 50 days postoperatively. This was repaired using a double spinal–pelvic rod technique, in which two linked rods were placed into the ilium bilaterally. These dual linked rods were attached to lumbar pedicle screws and subsequently crosslinked (Fig. 5 right). Postoperatively his pain, neurological function, and ambulatory capacity improved; however, unfortunately he died 7 months later of a cocaine overdose.

Discussion

Primary and metastatic neoplasms of the LSJ frequently pose a complex problem for surgical management and stabilization because of anatomy and biomechanical factors of this transition zone between spine and pelvis. In this report we describe a safe and effective technique in which rigid internal fixation is used to stabilize the spinal–pelvic junction in patients with lumbosacral neoplasms, as well as the results of such treatment.

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Surgical resection is often considered the best treatment in cases of primary malignant tumors of the sacrum. These tumors are often amenable to complete surgical resection and cure. Palliation is the goal when metastatic tumors of the LSJ are involved. Palliative goals include restoration of neurological function or prevention of further neurological decline, as well as the alleviation of pain. Pain is the chief complaint of many patients with metastatic spinal disease. In general there are three types of pain associated with neoplastic spinal involvement: local, radicular, and axial spinal pain. Local pain is usually constant and not affected by movement or recumbency, and it is thought to be secondary to peristeal stretching of the spinal structure and by local tumor mass effect. Local pain as well as radicular pain can be relieved by resecting the tumor and decompressing the neural elements. Radiation is frequently effective for this type of pain, particularly if the tumor is radiosensitive. Axial spinal pain is a mechanical pain, which is exacerbated by movement and relieved with recumbency, that is associated with a structural abnormality in the spinal column. Spinal stabilization is very effective in relieving this type of pain but radiation therapy is not.

Spinal–pelvic stabilization is often needed in the management of patients with lumbosacral tumors. Various methods of lumbosacral fixation exist. These methods can be classified into three major categories: those requiring sublaminar devices, sacral screw fixation, or iliac rod or screw fixation.

Sublaminar devices such as hooks, wires, or cables may provide a dorsal tension band across the LSJ that can resist flexion. These devices do not provide substantial torsional stability or resistance to extension and a fusion rate similar to that achieved in cases in which fusion of the LSJ is performed without placement of instrumentation has been found. Because sacral laminae are often thin and/or are frequently removed in the process of lumbosacral tumor resection, the use of sublaminar devices may be precluded.

The use of sacral pedicle screws provides significantly increased rigidity as compared with sublaminar devices. When attached to rods and crosslinked, medially directed screws create a triangulation effect, which greatly increases screw pullout resistance and increases torsional stability. Although lumbosacral pseudarthrosis may be a frequent problem in cases of long, multilevel fixation to the sacrum, sacral screw fixation appears to be sufficient in cases in which the fixation length is short (one or two levels) and there is minimal instability. In patients harboring neoplasms of the LSJ significant instability secondary to the destructive process of the tumor is often observed. In addition, the sacral pedicles, body, or ala sacralis may be involved with the tumor, thereby precluding the use of sacral screws. In these cases spinal–pelvic fixation with the modified Galveston technique has proven useful.

The modification refers to the replacement of lumbar sublaminar wiring, as initially described by Allen and Ferguson, with pedicle screw fixation to attach the rods to the lumbar spine segmentally. This is thought to be more secure than the wiring technique, allowing a shorter fixation length and increased rigidity. Additionally, because many of our patients underwent laminectomy for tumor removal, sublaminar wiring cannot be used. In the modified technique the rods are contoured and then placed into the ilium as described and are optimally directed 8 to 9 cm in depth 1.5 cm above the sacral notch. In biomechanical testing of 10 different lumbosacral fixation techniques in a cadaveric calf model, McCord, et al., have found that rod or screw attachment to the ilium withstanded the greatest load before ultimately failing. An enhanced degree of fixation was found if purchase anterior to the lumbosacral pivot point was achieved. The iliac rod segment in the modified Galveston technique extends anterior to the lumbosacral pivot point and provides a longer lever arm within the ilium to counteract forces exerted by the lumbar spine. This fixation technique appears to provide the strongest lumbosacral fixation and is especially useful when the LSJ is compromised by tumor. Iliolumbar fixation may be necessary in cases of sacral tumors/resections or in cases of sacral agenesis.

In our series solid bone fusion was achieved in four (31%) and partial or unilateral fusion in three (23%) of patients. In five patients (38%) no convincing evidence of fusion on radiographic studies was demonstrated. Because three of these five patients have improved clinically, satisfactory fibrous union is suggested. Fusion may not have occurred because of the neoplastic disease process and its associated catabolism. In addition, a high percentage of these patients received radiation therapy (seven patients; 54%) and/or chemotherapy (six patients; 46%). All of these factors would probably decrease the fusion rate. The follow-up periods and/or survival rates were also relatively short in three of our patients.

A hardware-related complication occurred in only one patient (Case 7). The rods fractured bilaterally at the transition between the lumbar and sacral segments. This was corrected with double iliolumbar rod fixation. Metal fatigue in this area of acute angle may be responsible for the rod fracture. There have been no other instrumentation-related complications.

Potential drawbacks to this fixation technique include the relative difficulty of rod contouring and the fixation across the sacroiliac joint. The three-dimensional rod contouring technique has been well described by Allen and Ferguson in a pictorial. We recommend practicing the rod contouring and -placement techniques in a cadaveric spine prior to actual practice in the operating room. Preformed rods or iliac screws (Isola iliac screws; Acromed, Cleveland, Ohio) can be obtained, which may decrease intraoperative time and fiddle-factor, although we have not used either of these. Additionally, fixation across the sacroiliac joint has not been a problem in our series or others. The authors of cadaveric studies in adults have shown that autofusion of this joint occurs in 75% of specimens.

We have found the surgical treatment of both metastatic and primary neoplasms of the LSJ, followed by the appropriate stabilization procedure by using the modified Galveston technique, to be effective in relieving pain, restoring or preserving neurological function, and restoring ambulatory capacity. Spine-related pain, as reflected by the VAS score and medication consumption, was significantly reduced in 85% of our patients. Neurological status improved in four patients and remained unchanged in seven patients. Ambulatory status improved in 62% (eight patients), remained the same in 25% (three patients), and worsened in...

Conclusions

Surgical resection followed by subsequent stabilization in which internal fixation is used is often indicated in the management of patients with primary or metastatic lumbosacral neoplasms. Primary sacral tumors are amenable to complete en bloc resection for possible cure. Palliation is the goal in cases of metastatic lumbosacral tumors. In selected patients with lumbosacral neoplasms, tumor resection followed by modified Galveston spine–pelvis fixation is an effective means of stabilization that can provide significant pain relief, restore neurological function or prevent further neurological decline, and preserve ambulatory capacity.

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Disclosure

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