Sacral involvement by metastatic disease can occur via a number of routes. Invasion of the sacrum can occur by direct extension and is typically observed in recurrent rectal cancers. Intradural tumors can cause drop metastases within the thecal sac, which then grow into the sacrum. A third mode of metastatic spread to the sacrum is via hematogenous seeding. Hematogenous metastases to the sacrum can be a source of debilitating symptoms, and palliation may be critical for improving the quality of life of these patients. Most metastatic disease to the sacrum is treated nonoperatively with radiation, chemotherapy, or both. However, there are circumstances when these therapies fail and surgical intervention is warranted. Whether surgery can be of benefit for these patients is not clearly defined. In this study, we present the results of a series of patients undergoing surgery for metastatic disease to the sacrum to determine indications and to provide outcome data.

Methods

All patients undergoing surgery at The University of Texas M. D. Anderson Cancer Center between 1993 and 2005 for hematogenous metastatic disease to the sacrum were identified. The prospectively compiled Brain and Spine Database in the Department of Neurosurgery was reviewed retrospectively. Data on patient characteristics, surgical techniques used, pain and neurological function, complications, and survival were collected for analysis. The indications for surgery included intractable pain,
neurological deficit, or disease refractory to nonsurgical treatment modalities. We evaluated the palliative benefits of surgery with respect to pain and neurological function as primary objectives. Survival was evaluated as a secondary objective. The details of surgery, including the extent of resection and use of stabilization, were recorded.

**Outcome Measures**

Preoperative and postoperative pain was quantified by the numerical pain score system and by morphine equivalent doses. We documented numerical pain scores and morphine equivalents preoperatively and at 90 days, 6 months, and 1 year postoperatively. Motor function was characterized using the modified Frankel scoring system.

**Statistical Analysis**

The chi-square test, Fisher exact test, or Wilcoxon-signed rank test and repeated-measures analysis were used to compare categorical variables as appropriate. Nonparametric tests were used for paired and unpaired ordinal variables. The Kaplan-Meier method of estimating survival was applied. The log-rank test was used to test for significant differences between various survival curves. A p value < 0.05 was considered statistically significant.

**Results**

We identified 25 consecutive patients (21 men, 4 women; median age 57 years; range 25–71 years) who met the study criteria. The median length of follow-up for the cohort was 12 months (range 6–20 months). Twenty-four (96%) of the patients described pain at the site of the metastatic disease. The remaining signs and symptoms associated with sacral metastatic disease are detailed in Table 1. The median duration of symptoms prior to the first operation was 3 months (range 1–24 months). The primary diagnoses for the metastatic lesions are listed in Table 2. The most frequent were renal cell carcinoma (in 15 cases) and prostate carcinoma (in 3 cases). At the time of presentation, the sacrum was the sole site of disease in 12 patients, whereas 13 had evidence of disease in one or more other sites (skeleton other than spine in 8 cases; lung in 7; adrenal gland in 2; lymph nodes in 2; and liver and mediastinum in 1 case each). Of note, 6 patients also had metastases to the mobile spine. Nine patients had no prior treatment. However in 16 cases, surgery was performed after failure of one or more other measures (radiation therapy in 11 cases; chemotherapy in 9; previous surgery in 2; and hormonal therapy, immunotherapy, and radioactive isotope therapy in 1 case each). Twenty-two patients (88%) had evidence of epidural disease, and in 4 (16%) the sacropelvic joints and ilium were affected by tumor. Twelve (48%) underwent preoperative embolization. In 24 patients (96%), the primary indication for surgery was pain relief. This group included 3 patients (12%) who suffered from symptomatic mechanical instability, defined as severe pain present when upright or during motion, that disappeared with recumbency. All procedures were performed in a single stage with the patient in the prone position. Instrumentation (modified Galveston technique) and fusion were used in 12 patients (48%) (Fig. 1). Instrumentation was used in patients with preexisting instability as well as in those in with resection-related instability. Tumor removal was performed in 23 cases (92%). Gross-total was achieved in 12 (48%) cases, and subtotal resection in 11 (44%). In 1 patient with breast cancer, the goal of surgery was to correct instability from a pathological S-1 fracture, because the tumor was adequately treated with radiotherapy administered after surgery. In a patient with metastatic nasopharyngeal carcinoma, the goal of surgery was tissue diagnosis by open biopsy after multiple percutaneous biopsies were nondiagnostic. Radiotherapy was then administered as the primary treatment to the lesion.

We categorized tumor location within the sacrum by the uppermost level of involvement and subdivided it into upper (lumbosacral junction and S-1), middle (S2–3), and lower (S4–coccyx). The tumors were in the upper sacrum in 22 (88%) of 25 cases, in the middle sacrum in 2 cases (8%), and in the lower sacrum in 1 case (4%) (Table 3). Nerve roots were resected in 3 cases (12%) to facilitate tumor removal (bilateral S-5 roots in 1 case; unilateral S-2 root in 1 case; unilateral S-1 root in 1 case). The majority of tumor resections (20) were performed piecemeal. Only 3 resections were done in an en bloc fashion (with marginal margins). Complications occurred in 10 cases (40%) (Table 4). The 30-day surgical mortality rate was zero. Of note, patients who underwent surgery after prior therapy (16 patients) had a significantly increased risk of postoperative complications (62%) compared with patients undergoing sacral surgery without prior therapy (9 patients) who had no postoperative complications (p = 0.003; Fisher exact test). Ten patients were discharged to inpatient rehabilitation, 1 patient was transferred to hospice care, and the remaining 14 patients were discharged home. The median hospital stay was 8 days (range 3–29 days).

The median preoperative numerical pain score was 8 (range 2 to 10), and the median preoperative daily morphine equivalent doses were 32.5 mg (range 2.5–970 mg). At 90 days, 6 months, and 1 year postoperatively, there were 21, 17, and 9 patients, respectively, available for analysis of postoperative palliative effect. The numerical pain scores at 90 days, 6 months, and 1 year after surgery were

| Table 1: Signs and symptoms associated with metastatic sacral tumors in 25 patients* |
|---------------------------------|-----------------|
| Sign or Symptom                          | No. of Patients |
| sacral pain                                        | 24 |
| other back pain                                | 13 |
| hip pain                                        | 5  |
| buttock pain                                   | 3  |
| leg pain                                        | 18 |
| neurogenic bladder dysfunction                 | 6  |
| neurogenic bowel dysfunction                   | 5  |
| numbness                                       | 4  |
| weakness                                       | 2  |

* Some patients presented with more than 1 sign or symptom
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3 (range 0–7), 2 (range 0–8), and 3 (range 0–8), respectively. The daily morphine equivalent doses at 90 days, 6 months, and 1 year after surgery were 5 mg (range 0–200 mg), 20 mg (range 0–450 mg), and 8 mg (range 0–575 mg), respectively. The postoperative numerical pain scores were significantly different from the preoperative scores at 90 days, 6 months, and 1 year (p < 0.01, Wilcoxon signed rank test and repeated-measures analysis). The morphine equivalent doses required for pain relief were not significantly different at these time points (p > 0.2).

Comparison of preoperative and best postoperative ambulatory function showed no change in 14 cases, improvement in 8, and worsening in 3 (due to overall decline from disease progression). The difference in postoperative and preoperative grades was not statistically significant (p = 0.19, Wilcoxon-signed rank test). Among the 22 patients who maintained or improved their ambulatory function, 3 were transiently worse at the time of discharge following surgery. Bladder function improved on follow-up in 1 of the 6 patients who presented with bladder dysfunction. Bowel function improved in 1 of 5 patients who presented with bowel dysfunction.

The median overall survival for the entire cohort (Fig. 2) was 11.0 months (95% CI 5.4–16.6 months). The median time to sacral disease progression for the entire cohort was 14 months (95% CI 0.0–29.3 months). All but 3 patients had died of their disease at last follow-up. Sacral progression occurred in 10 patients (40%), and distant progression occurred in 18 (72%) patients. In the 23 cases in which tumor resection was performed, there was no statistically significant difference in time to sacral disease progression between cases in which the resection was gross-total resection (24.0 months, 95% CI 0.0–48.7) and those in which it was subtotal (12.0 months, 95% CI 5.5–18.5), although a trend was observed favoring gross-total resection (Fig. 3) (p = 0.07, log-rank test).

The median overall survival of patients with the sacrum as the sole site of metastatic disease was 17 months (95% CI 8.4–25.6 months), whereas the median overall survival of patients with multiple sites of metastasis was 4 months (95% CI 0.0–8.1 months; p = 0.53, log-rank test; Fig. 4). Median progression-free survival for patients with single-site metastasis was 4 months (95% CI 0.0–8.5 months), compared with 3 months (95% CI 0.0–10.0 months) for those with multiple metastatic sites (p = 0.76). Of 12 patients with metastatic disease in the sacrum only, 8 had local recurrence. In 13 patients with multiple sites of metastasis, only 2 had local sacral recurrence. Among the 23 patients who had resection of their sacral disease, the overall median survival did not differ significantly between those treated with surgery immediately and those being treated for salvage of sacral disease (17.0 months,
Since cancers that have hematogenously spread to the sacrum cannot be cured, treatment efforts are focused at palliation. Treatment is indicated if symptoms significantly impair quality of life. The most common symptom is pain (reported by 24 of 25 patients in this series), which may be local, mechanical, and/or radicular. The second most common manifestation is neurological deficit, including motor and sphincter dysfunction. Surgery is usually offered once standard nonsurgical modalities, including radiation therapy, chemotherapy, hormonal therapy, or radioisotope therapy, have have failed. This underscores our study’s limitations, which include its retrospective nature, limited sample size, and the surgical bias. Nevertheless, this is an underreported population in the neurosurgical literature. Here, we show that resective surgery in carefully selected patients with sacral metastases can result in palliative benefit (with respect to pain control and neurological function).

Some patients in the present series had pain as a result of overt mechanical instability, which cannot be treated adequately by nonsurgical measures because a significant component of the pain derives from structural failure of the lumbosacropelvic junction. In such cases, surgical stabilization with a modified Galveston technique offers improved symptom control and can restore ambulatory function. Although only 3 patients in our series presented with this condition, significant pain relief was achieved postoperatively in these cases. Ambulatory function stayed the same or improved in the majority of patients (88%). This effect was achieved immediately after surgery in all but 3 patients, who rapidly regained preoperative ambulatory function within weeks after discharge. Permanent worsening of ambulatory function occurred postoperatively in only 3 cases, and this was due to generalized decline from tumor progression rather than surgical complications. In general, bowel and bladder dysfunction, when present, did not change significantly with surgery, as only one patient with bowel dysfunction and one with bladder dysfunction showed improvement. This experience seems contrary to other reports in which sacral surgery for metastatic disease normalized bladder dysfunction. However, in our series, all patients with bladder or bowel dysfunction had symptoms of at least 48 hours’ duration at surgical intervention. Given a median overall survival of 11.0 months, the importance of effective and durable symptom palliation must be stressed.

Tumor types such as non–small cell lung cancer, gastrointestinal cancers, renal cell carcinoma, and melanoma are known to respond poorly to primary nonoperative treatment modalities. Even when surgical modalities are applied to treat spinal metastases, patients with metastatic disease from these histological tumor types continue to have poor survival. Because of this poor prognosis, aggressive spinal and sacral resections should only be considered in a select subset of these patients. Indications for an operative intervention may apply in cases of overt mechanical instability and in patients with very limited metastatic disease to restore ambulation or to reduce intractable pain. One example was a patient with metastatic colon cancer to the sacrum who had no other sites of disease but was suffering from a painful pathological fracture of the upper

### TABLE 3: Sacral level affected by metastatic tumor

<table>
<thead>
<tr>
<th>Sacral Level</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>upper sacrum (lumbosacral junction &amp; S-1)</td>
<td>22</td>
</tr>
<tr>
<td>middle sacrum (S2–3)</td>
<td>2</td>
</tr>
<tr>
<td>lower sacrum (S4–coccyx)</td>
<td>1</td>
</tr>
</tbody>
</table>

95% CI 0.0–44.3 months vs 9.0 months, 95% CI 7.7–10.3 months, respectively). This difference was not significant (p = 0.21).

### TABLE 4: Medical and surgical complications associated with resection of sacral metastases

<table>
<thead>
<tr>
<th>Complication</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSF leak</td>
<td>4</td>
</tr>
<tr>
<td>wound infection</td>
<td>2</td>
</tr>
<tr>
<td>deep venous thrombosis</td>
<td>2</td>
</tr>
<tr>
<td>urinary tract infection</td>
<td>1</td>
</tr>
<tr>
<td>pneumonia</td>
<td>1</td>
</tr>
<tr>
<td>cholecystitis</td>
<td>1</td>
</tr>
<tr>
<td>line infection</td>
<td>1</td>
</tr>
<tr>
<td>transient urinary retention</td>
<td>1</td>
</tr>
<tr>
<td>foot drop†</td>
<td>1</td>
</tr>
<tr>
<td>internal bleeding</td>
<td>1</td>
</tr>
<tr>
<td>pseudoaneurysm of the groin†</td>
<td>1</td>
</tr>
<tr>
<td>wound seroma</td>
<td>1</td>
</tr>
</tbody>
</table>

* Some patients had more than 1 complication.
† Complications related to preoperative embolization.

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**Fig. 2.** Graph depicting overall survival after surgery for hematogenously disseminated metastases to the sacrum in 12 patients. The estimate of median overall survival using the Kaplan-Meier method was 11.0 months (95% CI 5.4–16.6 months).
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Fig. 3. Kaplan-Meier plots of sacral progression as a function of the type of resection. Among patients undergoing resection of their sacral tumor (n = 23), gross-total resection (GTR) was associated with improved local control as demonstrated in the longer median time to sacral progression (TTSP) of 24 months (95% CI 0.0–48.7 months) versus 12.0 months (95% CI 5.5–18.5 months) in those who underwent subtotal resection (STR). This difference was not significant, although a trend was noticed favoring gross-total resection (p = 0.07, log-rank test).

Fig. 4. Graph depicting overall survival in patients with single-site versus multiple-site metastases. In cases in which the sacral metastasis was the sole site of metastatic disease, the median overall survival (17.0 months [95% CI 8.37–25.63 months]) was greater than in cases in which there were multiple sites of metastasis (4.0 months [95% CI 0.0–8.07 months]). This difference was not statistically significant, however (p = 0.53).

sacrum. Not surprisingly, preoperative chemotherapy and radiation had failed to control this patient’s symptoms. Following sacropelvic fixation and tumor resection there was marked improvement in the instability-related symptoms. The patient died of systemic progression 22 months after the index procedure (the sacral surgery). A less successful example was a patient with metastatic melanoma to the sacrum with minimal disease burden elsewhere. The sacral tumor was causing pain and was unresponsive to chemotherapy and radiation. Unfortunately, pain was not significantly improved postoperatively, and the patient died 2 months later from rapidly progressive systemic disease.

Other commonly encountered primary tumors that metastasize to the sacrum include breast and prostate cancers.8,35 These tumors are generally quite responsive to nonsurgical therapies.2,4,6,12,13,19,31,39 Indeed, the overall number of patients treated surgically for sacral metastases in our series was small relative to the high prevalence of these cancers and their frequent metastasis to the sacrum.35 In fact, the only patient treated surgically for metastatic breast cancer to the sacrum in our series did not undergo tumor resection, but had surgery for symptomatic instability from a pathological sacral fracture. The metastatic lesion was then treated with radiotherapy. This patient was alive with disease at last follow-up 86 months after the index operation.

If nonsurgical measures fail, however, and the patient is suffering from symptomatic sacral disease, surgery can be a reasonable therapeutic option. This was the case in the 3 patients in our series who were suffering from symptomatic metastatic prostate cancer to the sacrum. In these instances, the tumor was hormone insensitive, and prior nonsurgical local and systemic therapies (radiotherapy and chemotherapy) had failed to halt sacral progression and symptoms. Surgery was successful in providing palliation for these patients, and their survival after surgery ranged from 11 to 61 months. Although all patients must be considered on a case by case basis, it is worth noting that patients with metastatic breast or prostate cancer in the spine still can have a significant duration of survival after surgery.37,38,40

When reviewing the histological categories in our series, we found a clear trend toward surgery for tumors that do not respond well to nonoperative measures but have a favorable overall duration of survival. Renal cell cancer is the most obvious example of this, and it was by far the most common metastatic sacral tumor in our series (accounting for 60% of cases). In addition to the influence of tumor histological type on the decision to proceed with surgical intervention, the patient’s overall disease burden may also be an important factor. Although our data did not reach statistical significance, there was an apparent difference in median survival between patients with single-site metastatic disease (17 months) and multiple-site metastases (4 months). This difference further manifested itself in the rate of symptomatic local recurrence (75% in patients with single-site metastasis versus 15% in those with multiple-site metastases). Patients who live longer have a higher likelihood of symptomatic recurrence. Thus, local efforts should probably be maximized in patients with single-site or very limited systemic disease to optimize local control. New advances in focused radiation therapy may play an important role in this effort.3,5,7

The majority of the sacral metastases involve S1–3, making en bloc resection too morbid a procedure to undertake for palliation. Aggressive intralesional resection has typically been applied.23,28,29 In rare instances, where the distal sacrum is involved, an en bloc resection with preservation of the S1–3 nerve roots may be considered and performed to achieve optimal local control with a low
risk of neurological deficit. When en bloc resection could be performed in the 3 cases in our series, no sacral recurrence was seen. This is consistent with the results of 2 additional cases reported in the literature. In our experience, cases in which en bloc resection was feasible and could be performed without causing significant morbidity were those in which the tumor was either below the S-4 roots, involved the S-2 nerve root unilaterally in the foramen, or involved the ilium unilaterally with slight extension toward part of the sacral ala. The majority of patients in our series (80%) underwent intralesional resection of the tumor. We observed a strong trend toward improved local control (although the finding was not statistically significant) if a gross-total rather than subtotal resection could be achieved. This may be particularly important for patients with tumors that are resistant to adjuvant therapies or have already been heavily treated with nonoperative modalities.

Commonly, after resection with or without fixation, the surgeon is left with a potentially significant dead space, and the sacral paraspinal muscles may be devascularized. Soft tissue coverage in this territory is often challenging. A number of the complications observed in the present series were directly related to wound healing. Therefore, we frequently rely on plastic surgical expertise to assist with soft tissue coverage after sacral tumor surgeries. Mobilization of healthy tissue into the surgical defect is of particular importance when the sacral metastasis has been treated previously and surgery is performed as a salvage modality. As demonstrated in our series, all postoperative complications occurred in patients who had received prior treatment for their sacral disease. Although prior treatment was strongly associated with postsurgical complications, it should be emphasized that failure of these treatments (resulting in progressive pain, neurological dysfunction, or tumor progression) was frequently an indication for surgery. Ultimately, 14 (88%) of the 16 patients who experienced a postoperative complication were discharged home.

Conclusions

Surgery of the sacrum for hematogenously disseminated metastatic disease offers effective and durable symptom palliation in the majority of patients, even when standard nonoperative measures have failed. Symptom palliation can be achieved with acceptable risk, although the complication rate is higher in patients who have received prior treatment. The majority of metastases removed were from kidney cancer, which is known to be relatively radio- and chemoresistant, but is still associated with longer survival than more aggressive primary cancers. Patients with common cancers such as breast and prostate cancer are rarely treated surgically for metastatic disease to the sacrum due to the relative efficacy of nonoperative measures. Clearly, each case must be evaluated on the basis of the individual patient's specific situation. If surgery is undertaken, a gross-total resection may offer better local control than a subtotal resection. Given an overall median survival of nearly 1 year and the high rate of successful symptom palliation, surgery clearly has a role in the management of sacral metastatic disease.

Disclosure

Dr. Nader reports a consultant relationship with Alliance Partners LLC. Dr. Gokaslan reports stock ownership in US Spine and Spinal Kinetics and clinical or research support from DePuy Spine, Medtronic, and AO North America. Dr. Rhines reports a consultant relationship with Medtronic and Stryker.

Author contributions to the study and manuscript preparation include the following. Conception and design: Rhines, Feiz-Erfan, Rao. Acquisition of data: Feiz-Erfan, Fox, Nader, Chakrabarti, Mendel, Gokaslan, Rao. Analysis and interpretation of data: Rhines, Rao. Drafting the article: Rhines, Feiz-Erfan, Rao. Critically revising the article: Rhines, Fox, Nader, Chakrabarti, Mendel, Gokaslan, Rao. Reviewed submitted version of manuscript: Rhines, Feiz-Erfan, Suki, Rao. Approved the final version of the manuscript on behalf of all authors: Rhines. Statistical analysis: Suki, Rao.

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