Thoracolumbar spine metastasis occurs in 4%–15% of patients with solid tumors, and the prevalence of this pathology has increased during the past 2 decades as anticancer therapies become more effective. The most common primary sites for thoracolumbar spine metastasis are the breast, lung, and prostate. Due to the short life expectancy of most of these afflicted patients, treatment regimens for this disease are most often palliative rather than curative, with the rare exception of solitary metastatic lesions. Despite the high prevalence of spinal metastases, treatment remains controversial. The ideal management of this disease is multidisciplinary and involves numerous medical specialties such as medical oncology, radiation oncology, interventional radiology, pain specialists, and neurosurgery. Treatment strategies involve a combination of radiotherapy, pharmacotherapy, and even surgery for candidate patients. Because most metastatic lesions localize to the anterior spinal column, optimal surgical treatment of such patients requires spinal stabilization in addition to spinal cord or nerve root decompression. Although aggressive surgeries have resulted in improved outcomes for patients with metastatic spine disease, these surgeries are associated with high morbidity and complication rates, especially in patients with numerous neoplasm-associated comorbidities. One of the main disadvantages of these procedures is directly related to the morbidity of the approach. This approach requires a long midline incision and a large muscle disinsertion, which is associated with elevated blood loss, postoperative pain, infections, and lengthy hospital stays. Stabilization and decompression can also be performed using expandable working tubes and percutaneous pedicle screws. These surgical tools, introduced for degenerative spine diseases, were recently used for the treatment of metastatic lesions to reduce perioperative morbidity. Even as minimally invasive techniques gain in popularity, their effectiveness for the treatment of spinal metastasis has yet to be established. The purpose of this paper is to report on our experience in using minimally invasive decompression and stabilization for the management of thoracolumbar spine metastasis.
invasive decompression and stabilization for symptomatic metastasis of the thoracolumbar spine, and to detail the clinical efficiency and perioperative morbidity of this procedure.

Methods

Patient Population

Between January and June 2011, 10 patients underwent stabilization and decompression for symptomatic metastasis of the thoracolumbar spine using a minimally invasive approach. The main demographic data are summarized in Table 1. There were 7 men and 3 women, with a mean age of 64 years (range 47–79 years), and a mean Karnofsky Performance Scale score of 57 (range 40–70). All patients had a previously diagnosed neoplasm, and none had a history of receiving radiation therapy to the spine. All patients were believed to have a limited life expectancy due to the advanced nature of the disease, and their general condition made them ineligible for an invasive surgical procedure. All patients suffered from spinal pain and presented with symptoms of progressive radicular or spinal cord compression (Table 1). Before surgery, patients were examined using anteroposterior and lateral radiographs, CT scans with sagittal reconstructions, and MRI of the entire spine. The CT scan revealed the spinal instability, but sagittal alignment was preserved in all cases. Because there was no significant kyphotic deformity in any patient, none required reconstruction of the anterior column. Magnetic resonance imaging confirmed the compression of neural elements, which was always focused on 1 level (Fig. 1). In all cases, the treatment strategy was defined at a multidisciplinary medical staff meeting.

Surgical Technique

The patient was positioned prone on a radiolucent table, allowing anteroposterior and lateral fluoroscopic control. Prior to draping the patient, the midline and the projection of the pedicles were identified and marked on the skin. The K-wires were inserted in the adjacent vertebrae (Fig. 1C) using the technique of percutaneous screw placement (2 levels above and 2 levels below). This step was performed prior to any decompression to allow rapid screw and rod placement under lateral fluoroscopic control in case of massive bleeding in the decompression site. At the metastatic level, a 3–4 cm incision was made 2- or 3-cm lateral to the previous landmarks. The thoracolumbar fascia was exposed and its incision allowed gentle dissection between the muscles, parallel to their fibers, according to the Wiltse muscle-splitting approach. The Wiltse approach allowed direct access to the lateral junction between the articular and transverse processes. The space between the muscles was maintained and enlarged with the introduction of an expandable tube (22-mm in diameter), which was fixed and expanded as necessary to visualize the modified anatomy. Dorsal decompression was accomplished and partial transpedicular vertebrectomy was performed for ventral decompression (Fig. 2). We decompressed the neural structures by creating a safety zone of a few millimeters around the spinal cord and the nerve roots. At the end of the procedure, screws and rods were inserted (CD Horizon Longitude; Medtronic). A drain was put in place in the resection site for 48 hours. All patients underwent radiotherapy postoperatively.

Outcome Assessment

Data on operative time, blood loss, length of hospital stay, and complications were collected during hospitalization. Pain and neurological deficit were measured using the VAS and Frankel grade, respectively (Table 2), preoperatively and before discharge. Radiological follow-up studies were performed postoperatively, at 3, 6, and 9 months, and at 1 year using sagittal reconstructions of chest and abdominal CT scans required for the monitoring of the disease course.

Results

Operative Data

Mean operative time was 170 minutes and mean

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Type of Cancer</th>
<th>KPS Score</th>
<th>Spinal Level</th>
<th>Frankel Grade</th>
<th>VAS Score</th>
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<tbody>
<tr>
<td>1</td>
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<td>E</td>
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<td>T-7</td>
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<td>D</td>
</tr>
<tr>
<td>3</td>
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<td>L-1</td>
<td>B</td>
<td>E</td>
</tr>
<tr>
<td>4</td>
<td>62, F</td>
<td>breast</td>
<td>40</td>
<td>T-6</td>
<td>B</td>
<td>E</td>
</tr>
<tr>
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<td>L-1</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
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<tr>
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<td>60</td>
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<td>C</td>
<td>D</td>
</tr>
<tr>
<td>9</td>
<td>64, F</td>
<td>breast</td>
<td>70</td>
<td>T-7</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>10</td>
<td>74, M</td>
<td>prostate</td>
<td>60</td>
<td>T-10</td>
<td>D</td>
<td>E</td>
</tr>
</tbody>
</table>

* KPS = Karnofsky Performance Scale.
Management of thoracolumbar spine metastasis

Fig. 1. Case 2. Axial (A) and sagittal (B) T2-weighted MRI depicts spinal cord compression due to a metastasis at T-7. The operative photograph (C) shows insertion of the wires on the right side. Lateral fluoroscopy (D) shows the spine after bilateral pedicle screw insertion and the introduction of the rods.

estimated blood loss was 400 ml. No patient required a blood transfusion during or after the procedure. The mean hospital length of stay was 6 days. Seven patients were discharged home and 3 patients were transferred to the oncological care unit. The mean follow-up period was 10.1 months (range 5–13 months) and no patient was lost to follow-up.

Complications

No complications were reported during the procedure. One patient developed a urinary tract infection, which was treated with antibiotic therapy without any complication. All patients underwent both radiography and CT scans to assess the absence of procedure-related complications, and no screw misplacement was reported. During the study period, no instrumentation failure was reported.

During the follow-up period, 4 patients died (at 2, 4, 4, and 6 months after surgery). The deaths were all related to disease progression. No deaths were believed to be possibly related to the surgical procedure. No complications related to the procedure were reported during the follow-up period.

Neurological Course

No patient’s neurological condition worsened postoperatively. Eight patients (80%) improved at least 1 Frankel grade. Two patients were able to walk independently during hospitalization despite having a significant gait deficit before surgery. Two patients were neurologically stable after the operation (Cases 5 and 7; Table 1). No patient experienced local recurrence or spinal cord compression at the treated level during the follow-up period.

Pain Alleviation

Pain was improved in all patients. Mean VAS score decreased from 5.5 (range 2–9) to 2 (range 0–5).

Discussion

The first step in the management of thoracolumbar spine metastasis is to clearly define the main goal of a potential surgery. The Tokuhashi score has proved useful for identifying patients who should benefit from curative care. However, most patients are candidates for palliative treatment, which aims to preserve neurological function and quality of life. Palliative management of symptomatic metastasis of the thoracolumbar spine has evolved considerably during the last few decades. Spinal cord decompression was commonly performed via a posterior laminectomy, because it was believed that this would relieve the pressure on the spinal cord, improving the neurological deficit. However, the majority of lesions affect the anterior column, and thus when combined with destabilization of the posterior column via a laminectomy, resulted in rapid spinal cord vascular insufficiency and radicular compression due to the loss of spinal column integrity. Unfortunately, the advances in surgical technique that improved surgical outcomes in patients with metastatic lesions required more aggressive methods, such as circumferential decompression or combined approaches (anterior and posterior) that were not suitable

TABLE 2: Frankel grade classification

<table>
<thead>
<tr>
<th>Grade</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>complete paralysis</td>
</tr>
<tr>
<td>B</td>
<td>incomplete paralysis, preserved sensation only</td>
</tr>
<tr>
<td>C</td>
<td>incomplete paralysis, preserved motor nonfunctional</td>
</tr>
<tr>
<td>D</td>
<td>incomplete paralysis, preserved motor functional</td>
</tr>
<tr>
<td>E</td>
<td>normal motor &amp; sensory function</td>
</tr>
</tbody>
</table>
for patients with shorter life expectancies, numerous comorbidities, or contraindications such as ongoing chemotherapy. In addition, these techniques are associated with a substantial morbidity rate, which can affect patient quality of life and delay the initiation of adjuvant therapy. Minimally invasive surgery was introduced for this condition to overcome these drawbacks while preserving the demonstrated effectiveness of surgical treatment.

**Clinical Efficiency**

Although preliminary results of minimally invasive treatment of spinal metastasis are encouraging, its safety and effectiveness have not yet been demonstrated. In a recent review of the literature, Molina et al. found only 11 publications that addressed minimally invasive surgery in the treatment of metastatic spine disease. Most of these publications were case reports or limited retrospective case series that reported the efficiency of video-assisted or minimally invasive anterior approaches. Deutsch et al. reported on a series of 8 patients who underwent minimally invasive transpedicular partial vertebrectomy for metastasis of the thoracic spine, and significant neurological improvement was reported for 5 patients. Pain was also improved in 5 patients in this study and not modified for the others. In this case series, the tumor was located in the anterior column. When the anterior column is affected, stability is often compromised. However, no stabilization was achieved in this series. As we point out, stabilization is recommended in these cases. The absence of a wide iatrogenic destabilization justified the use of this treatment strategy, but it has been established that stabilization reduces pain and improves quality of life for such patients. In our series, pain was systematically improved, which was likely due to the percutaneous stabilization that was performed. However, the use of analgesics was not analyzed in this study, which limits the conclusions.

**Morbidity and Complications**

As previously stated, surgery for metastatic disease is generally associated with a high morbidity rate, due to the commonly poor general condition of these patients. These patients may be subjected to immunosuppression from disease or treatments, and may have poor nutritional status and medical comorbidities. The limitation of morbidity has become a serious concern, not only for surgeons but also for patients. Many operative variables such as operative time, estimated blood loss, hospital stay, and complication rate are clearly considered markers of safety in spine surgery. Prolonged operative time is associated with a more important risk of complications (infections). Elevated blood loss leads to increased perioperative morbidity (such as infection) and death. Moreover, blood transfusion is associated with a higher risk of systemic infection, gastrointestinal complaints, and hemolytic reactions. Longer hospital stays are indicative of increased patient morbidity. In the review of Molina et al., decreased complication rates, blood loss, and length of hospital stay are believed to be among the benefits of minimally invasive approaches. These benefits were confirmed by our results when compared with gathered data outcomes for standard surgery. Criticism often made of minimally invasive surgery is the excessive increase in operative time. Data reported by Deutsch et al. and Schwab et al. contradict this notion and suggest that minimally invasive surgery compares favorably to open standard procedures with trained surgical teams. Our experience confirms these data.

Although life expectancy and follow-up duration were not long enough to analyze arthrodesis in this study, no case of instrumentation failure was reported. This complication may severely compromise the functional prognosis of the patient. It may be due to a failure of the anterior column or an extension of the tumor into adjacent vertebral segments, which can alter the anchorage of the screws. To avoid this complication, we advocate the systematic use of a long instrumentation (2 levels above and 2 levels below).

**Adjuvant Therapies**

In our experience, the most important benefit to the use of minimally invasive approaches is a more rapid initiation of postoperative adjuvant therapies. A standard open decompression and stabilization necessitates wide exposure, which induces large dead space and tissue necrosis. To guard against wound dehiscence and infection given this large exposure, we are hesitant to allow initiation of adjuvant radiotherapy or chemotherapy before 4–5 weeks after the surgery. After minimally invasive approaches we often ask for a rapid initiation of postoperative stereotactic radiotherapy, due to the low risk of wound dehiscence. At our institution, adjuvant therapies can be initiated 10–12 days after the procedure. During minimally invasive decompression, we cannot achieve gross-total resection of the lesion. In this procedure, our goal is to achieve a zone of decompression around the neural structures to allow spinal cord and nerve root release. Local tumor control is provided by the rapid initiation of postoperative stereotactic radiotherapy. To avoid the risk of early recurrence of the compression, the initiation of this treatment should not be delayed, and this requires perfect coordination with the radiation therapist.

It is necessary to note that this procedure has some limitations. First, this palliative strategy applies only to patients with limited life expectancy who would be less likely to be eligible for more invasive surgery. Anterior compression should be limited to 1 level because it is technically more difficult to achieve multilevel decompression using this approach. It is also necessary to ensure the absence of kyphotic deformity requiring anterior column reconstruction. Moreover, it is necessary to ensure that the patient will benefit from postoperative radiotherapy (that is, having not undergone previous radiation therapy). Tumor resection is limited with this approach. Our goal is to decompress the neural structures by creating a safety zone of a few millimeters around the spinal cord. Without the rapid initiation of postoperative radiotherapy, the patient may experience early recurrence of compression.

With respect to these precautions, our experience is encouraging, with low morbidity and good clinical outcomes with this approach. Further experience with a lon-
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greater follow-up period is mandatory to refine indications of minimally invasive techniques applied to the treatment of symptomatic metastasis of the thoracolumbar spine. To date, open surgery for decompression and stabilization remains the standard of care to which minimally invasive procedures must be compared.

Conclusions
Minimally invasive stabilization and decompression is a valuable therapeutic option in patients presenting with symptomatic metastasis of the thoracolumbar spine. This technique is likely to improve pain and decrease neurological deficit, with an overall morbidity rate that is lower than that using the conventional technique. Future investigations should be conducted to compare minimally invasive and standard surgery for this disease.

Disclosure
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Zairi. Acquisition of data: Zairi, Arikak, Marinho. Drafting the article: Zairi, Arikak. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Zairi. Study supervision: Allaoui, Assaker.

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