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Spinal Tumors: Viewpoint—Surgery

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Introduction

The majority of spine tumors encountered by clinicians are metastatic, accounting for approximately 70 % of all spine tumors [1]. Each year, an estimated 18,000 patients will be diagnosed with metastatic spine disease [2, 3]. Metastatic lesions most frequently originate from primary tumors in the breast, lung, and prostate. Less frequently encountered neoplasms of the spine and spinal cord include primary lesions such as meningiomas, schwannomas, osseous tumors of the spine, ependymomas, and gliomas. At the time of death, approximately 70–90 % of all terminal cancer patients have evidence of metastatic disease on postmortem examination [4–6], with the spinal column being the most common site for bony metastases [7]. Furthermore, it is likely that the observed incidence of metastatic spine disease will continue to increase over the next several decades, as diagnostic capabilities improve [8, 9].

In the current era, a number of treatment modalities are available for treating spinal tumors, including medical therapy, chemotherapy, surgery, radiation therapy, and radiosurgery. Quite frequently, combinations of these therapies are utilized to maximize clinical benefits and outcomes. Despite the benefit of minimal invasiveness inherent to radiation therapy or radiosurgery, there are numerous situations in which surgery remains the optimal treatment for patients with spinal tumors [10–14]. Although surgery has not been widely accepted as a primary treatment for metastatic spine disease in the past, a shift in this ideology is currently underway, with many physicians advocating more aggressive surgical resection of metastatic spine lesions [3, 11, 15]. Recent series have demonstrated that surgery can increase the overall quality of life by reducing pain and maintaining neurologic function as well as prolong survival in particular patients with metastatic spine disease [10, 12, 15–17]. Careful patient selection is the key to maximizing the potential benefits of surgical intervention. This chapter will describe the current role of surgery in the treatment of spinal tumors and the specific factors that make surgery the preferred treatment in a given situation.

Tumor Location

Tumors of the spine are frequently characterized according to their location with respect to the spinal canal, meninges, and spinal cord. The overwhelming majority (95 %) of spine metastases are extradural, while the remaining are intradural extramedullary (4 %) and intramedullary (0.5 %) [18]. Furthermore, metastases are most commonly found in the posterior half of the vertebral body, usually at the junction of the vertebral body and pedicles due to the increased blood supply to this area [19, 20]. They are infrequently confined to the posterior spinal elements (i.e., lamina and spinous process). The thoracic spine, with its numerous segments and a narrower canal diameter relative to the spinal cord [21], is the most common spinal region to present with neural compression secondary to spinal metastases (70 % of patients), followed by the lumbar spine (20 %) and cervical spine (10 %) [10, 22, 23]. The thoracolumbar junction and the T4 vertebral body, in particular, are the most common spinal levels to present with metastases [22, 23]. Unfortunately spinal metastases are located in multiple, noncontiguous levels in 10–38 % of cases at the time of presentation [24–26].

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Multiple surgical staging systems have been devised in the past to assist in surgical planning based on anatomical criteria. The surgical considerations based on spinal level and relationship to the spinal cord will be discussed later in this chapter.

Deciding on a Treatment Modality

Following a diagnosis of metastatic spine disease, a decision of surgery, radiation, medical treatment, and/or palliative care must be made. The patient's expected survival time is a crucial factor to consider in cancer patients, as many may be terminal patients in which surgery may not provide an overall quality of life benefit. As with any type of surgery, the age, performance status, and comorbidities of the patient must be taken into account when considering operative management for metastatic spine disease. Comorbidities such as coagulopathy, anemia, malnutrition, liver disease, and renal disease are frequently encountered in cancer patients and may complicate the surgery or postoperative course. The primary tumor type should be also factored into this decision, as some primary tumors (such as renal and thyroid cancer) may require preoperative embolization [8].

Radiation therapy was considered the mainstay of treatment for metastatic spinal disease for several years, and surgery was considered to add little value or even deemed detrimental for these patients [27, 28]. This was primarily because posterior laminectomy (the primary surgical option used by neurosurgeons to treat cord compression) did not address the compression (which is usually anterior to the spinal cord) directly and often led to increased spinal instability by removing the stable/intact posterior elements in the presence of an already diseased/weak anterior column. Therefore multiple older studies in the past failed to demonstrate a functional or survival benefit in patients undergoing surgery and irradiation as compared with radiation therapy alone [16, 24, 29, 30]. Over the past decade, however, surgical decompression of the spinal canal has regained favor because of more contemporary series utilizing modern circumferential surgical approaches for decompression and stabilization. Many series have demonstrated greater than 90 % maintenance in ambulatory status and pain improvement following decompression [13, 17, 31, 32].

Perhaps the most convincing evidence came from a recent study by Patchell et al. This prospective, multi-institutional study randomized patients with metastatic spinal cord compression to surgical decompression plus radiotherapy or radiotherapy alone. In the surgical decompression group, 42 out of 50 (84 %) of patients were able to walk following surgery, compared with 29 of 51 patients (57 %) in the radiotherapy group ($p = 0.01$). The number of nonambulatory patients who specifically regained the ability to walk following surgery was also significantly higher in the surgery group (62 % versus 19 %, $p = 0.01$). Finally, patients treated with surgery retained the ability to walk for much longer than did patients in the radiotherapy group (mean 122 versus 13 days, $p = 0.001$). The study was terminated prematurely secondary to an overwhelmingly beneficial outcome observed in the surgical group at interim analysis [33].

Furthermore, a recent meta-analysis by Klimo and colleagues, reviewing 24 surgical series (999 patients) and 4 large irradiation series (543 patients), demonstrated ambulatory success rates in 85 % of surgical patients compared with 64 % of radiation patients. Surgical patients in this study were 1.3 times as likely to remain ambulatory after surgery and twice as likely to regain ambulation when lost preoperatively (rescue procedure) [34]. Thus, in general, results from recent series of patients undergoing surgical intervention for metastatic spinal disease have been promising. Several series have also reported that greater than 90 % of patients have benefited from surgery in terms of pain relief as well as maintaining ambulatory status [11, 13, 15]. Furthermore, survival benefits have been reported with extensive resections in patients with solitary bone lesions or oligometastatic disease, with some 5-year survival rates being greater than 15 % [15, 35]. Despite recent data supporting surgical decompression as a primary treatment for spinal metastases, radiation therapy remains a primary treatment option, particularly for radiosensitive tumors such as breast, lymphoma, multiple myeloma, small cell lung cancer, seminoma, neuroblastoma, and Ewing sarcoma. In addition, limited anticipated patient survival time, inability to tolerate a surgical procedure, greater than 24–48 h of total neurological deficit, or multilevel/diffuse spinal involvement remain factors favoring radiation therapy [36].

Guidelines for Surgical Decision Making

In the past, various scoring systems have been developed to guide physicians in evaluating the surgical potential of a given patient based on multiple patient and tumor criteria (see Table 45.1) [37–40]. The complexity of these algorithms is indicative of how many factors must be taken into consideration for a given scenario. Such frameworks for decision making offer useful guidelines to assist physicians with surgical decision making, but cannot encompass the entire spectrum of individual factors that must be considered for each patient situation.

Goals of Therapy

In deciding on the optimal treatment for a patient, the goal of therapy remains a key factor. Goals for surgery in patients

Table 45.1 Classification algorithms in surgical decision making for spinal metastases

Study	Criteria	Recommendations
Harrington et al. (1986) [37]	Five categories:	Based on category:
	1. No neurologic dysfunction	(1) and (2): nonoperative management
	2. Involvement of bone without collapse or instability	(3): left to judgment of surgeon
	3. Neurologic dysfunction without bony destruction	(4) and (5): surgery indicated
	4. Vertebral collapse with secondary mechanical pain	
	5. Vertebral collapse or instability with major neurological deficits	
Tokuhashi et al. (1990) [38]	0–2 points for each of the following categories:	Based on total points (0–12):
	1. Primary tumor type	≤5: nonoperative management
	2. Neurological grade of the lesion	6–8: left to judgment of surgeon
	3. Physical condition of the patient	≥9: surgery indicated
	4. Number of lesions	
	5. Presence of visceral lesions	
	6. Spinal sites	
Tomita et al. (2001) [39]	Based on three categories:	Based on total points (2–10):
	1. Grade of malignancy:	≤3: wide/marginal excision (long-term local control)
	– Slow growth, 1 point	4–5: marginal/intralesional excision (middle-term control)
	– Moderate growth, 2 points	6–7: surgery for short term palliation
	– Rapid growth, 4 points	≥8: nonoperative supportive care
	2. Visceral metastases	
	– No metastasis, 0 points	
	– Treatable, 2 points	
	– Untreatable, 4 points	
	3. Bone metastases	
	– Solitary/isolated, 1 point	
	– Multiple, 2 points	
Fourney et al. (2005) [40]	"MAPS" assessment:	Considerations by category:
	1. Method of resection	1. En bloc spondylectomy, piecemeal excision, palliative decompression
	2. Anatomy of spinal disease	2. Tumor level, location, staging
	3. Patient fitness level	3. Comorbidities, irradiation, patient age
	4. Stabilization	4. Anterior, posterior, combined

with spinal tumors include: (1) neural decompression, (2) biomechanical stabilization, (3) curative resection, (4) control of intractable pain, and (5) diagnosis.

Neural Decompression

The most important indication for surgery remains neural decompression. Ambulatory status is a key prognostic marker for terminal patients with spinal disease [26]. Nonambulatory cancer patients have a mean survival time of only 45 days, due to multiple causes [13]. Maintaining neurologic function in patients with spinal metastases may therefore prolong survival time in addition to improving quality of life.

Patients with rapidly progressive or far-advanced paraplegia, especially for less than 24–48 h, require emergent surgical intervention [8]. In patients with complete spinal cord dysfunction for greater than 24 h or those with bowel/bladder dysfunction, however, surgery offers less hope for improvement and radiotherapy is usually the mainstay of treatment [36]. Patients with progressive neurologic deterioration that is refractory to radiation therapy should also be considered for surgical decompression [36]. Cord compression caused by bone or disk fragments in the spinal canal that may result from pathological fractures should also undergo primary surgical decompression instead of radiation therapy [41]. Recent prospective randomized trials of surgical decompression plus radiotherapy versus radiotherapy alone showed a quality of life benefit in the surgical arm that was statistically significant as well as a trend towards an increase in survival benefit in the surgical arm [42, 43]. These data represent high quality evidence favoring surgical decompression over traditional conservative radiotherapy in patients with spinal metastatic disease.

Stabilization

Maintaining spinal stability is another indication for surgical intervention in patients with metastatic spinal disease. Stability has been defined by Panjabi et al. as allowing the degree of motion that prevents pain, neurological deficit, and abnormal spinal angulation [44]. Spinal instability in patients with metastases can result from related pathologic fractures, surgical intervention, or diffuse changes in bone density and strength. Instability has been correlated with the following findings in patients with spine tumors: two-column injury, vertebral body collapse greater than 50 %, kyphosis greater than 20–30°, or involvement of the same column in greater than two levels [40, 45, 46]. Following most cases of surgical decompression, especially in cancer patients, instrumentation is required to provide stability. In non-terminal patients, postoperative stability is ideally achieved via a solid bone fusion following resection. In cancer patients, however, a bony fusion may not be a realistic goal due to multiple potentially complicating factors. Solid bony fusion may be prevented by shorter patient survival times, anemia, malnutrition, or frequent requirements for further chemotherapy, steroids, and radiation therapy. Although the ability to study spinal fusion in cancer patients has been compromised by decreased follow-up times, one study studying fusion rates in 25 patients undergoing anterior decompression and interbody fusion with bone struts followed by irradiation reported a relatively low pseudoarthrosis rate of 16 % at 1 year following surgery [47].

Several options are currently available for spinal instrumentation in cancer patients. Rigid spinal fixation systems are often used to provide spinal stability [13, 48]. With anterior approaches, constructs are often created to replace the resected vertebral body. Cortical endplate bone integrity must be preserved in order to stabilize anteriorly, however, and loss of integrity may necessitate a posterior fusion or even a combined anterior–posterior approach in cases of significant instability [8]. In posterior approaches, 2–3 levels of construct are generally used above and below the deficit [13, 48]. Polymethylmethacrylate (PMMA) is frequently used for reconstruction in conjunction with mechanical instrumentation if the estimated patient survival time is estimated to be less than 6 months. PMMA may be inserted inside of a titanium cage or chest tube and can provide immediate stability [48, 49]. It has been shown to be a safe option for patients requiring subsequent radiation therapy [50] and is an inexpensive, relatively easy to use, and safe alternative to bony fusion [51].

Curative Resection and Local Control

While a curative surgical resection of spinal metastases was not considered a reasonable goal in patients with metastatic spinal disease for many years, recent series have demonstrated that survival times can be significantly prolonged in particular patients who have undergone surgical intervention [15, 52]. In fact, surgery is the only treatment that has demonstrated a potential for cure of spinal metastases, as opposed to local control of tumor available with radiation therapy [35].

Procedures such as en bloc spondylectomy and vertebrectomy have become key developments in the ability to aggressively treat and even potentially cure localized metastatic spinal disease. Patients with bony metastases as opposed to visceral metastases, and those who present following a long disease-free interval, are considered to have a low tumor burden and may be optimal candidates for curative resection [15, 35, 39, 52, 53]. Such patients may benefit from more aggressive surgical management in terms of pain control and quality of life and should be treated with the intent to cure [35, 52]. The potential for a curative resection also depends on the source of the primary tumor. For instance, tumors of renal origin should be treated with the intent to cure [54]. Furthermore, local malignancies such as chordomas, sarcomas, chondrosarcomas, Pancoast tumors, giant cell tumors, and osteoblastomas should also be considered for curative en bloc resection [13].

Pain Control

Pain from metastatic lesions can be a result of inflammation and mechanical forces, as well as direct nerve compression or damage [31]. Radicular symptoms have been reported in up to 90 % of patients with lumbar epidural cord compression, 79 % of patients with cervical disease, and 55 % of patients with thoracic metastases [24]. Corticosteroids and opioids are the primary medications available for pain management secondary to cord or root compression. Radiation therapy remains the primary intervention reserved for patients with terminal disease who are experiencing significant pain. However, the beneficial effects of irradiation in relieving pain may take up to 2 weeks and may not provide adequate pain relief [55]. In cases where pain is refractory to radiation therapy, surgery remains a viable option. Many surgical procedures offer a significant benefit in pain relief, with recent series reporting pain relief success rates of greater than 90 % [10, 15, 56]. Percutaneous vertebroplasty and kyphoplasty are minimally invasive procedures that have been shown to improve pain in patients who may not be candidates for more aggressive decompressive surgery. Several series demonstrate both short- and long-term pain relief rates of 85–100 % associated with percutaneous vertebroplasty and kyphoplasty [57–60].

Diagnosis

Since the advent of minimally invasive techniques for tumor biopsy of the spine, such as CT-guided and fluoroscopic-guided biopsy, diagnosis is usually no longer a primary indication for surgical intervention. One study reported that a tissue diagnosis was possible in 86 % of patients using CT-guided biopsy [61].

Timing of Combined Therapy

In spite of having recent Class I evidence showing the benefit of surgery in the primary treatment for spinal metastases, radiation therapy remains the primary modality for treatment at many medical institutions. Following a radiologic diagnosis of spinal metastases, many patients are directly referred for radiation therapy without a surgeon seeing the patient [62]. The results of this are twofold. First, opting for radiation as a primary measure may not provide the same survival benefit for the patient as a wide marginal or radical excision could potentially provide. Second, patients who fail radiotherapy and ultimately require surgical decompression have significantly higher chances of developing wound infections, especially in cases where irradiation was administered within 1 week prior to surgery [62]. One series of 85 patients undergoing posterior decompression with or without instrumentation determined that patients with prior irradiation had a 32 % chance of developing wound infections, compared with a 12 % chance in the de novo surgery group. Multiple other studies have demonstrated similar results [34, 35, 43, 62, 63]. For these reasons, many surgeons currently advocate considering de novo surgery as the primary intervention for symptomatic metastatic spinal disease and have emphasized the spine surgeon's involvement in the decision to irradiate patients.

Deciding on a Surgical Approach

Once surgery has been decided upon, choosing the correct surgical approach is a key factor in providing the ideal degree of exposure for resection and subsequent stabilization. This decision is based on the anatomical location of the spinal metastases, the degree of surgical intervention a patient is able to tolerate, and the ability of the surgeon to perform a particular procedure safely. The Weinstein, Boriani, and Biagini staging system can be used to help guide surgeons in choosing an approach for surgical decompression based on the anatomical location of the tumor in regards to proximity to the dura as well as anterior to posterior localization [64]. This system maps tumors based on 12 radiating zones in a clockwise fashion, as well as five concentric layers. It can assist in deciding on a type of excisional procedure, including en bloc spondylectomy, vertebrectomy, sagittal resection, and posterior arch resection.

Decompressive Posterior Laminectomy

In the past, the primary surgical procedure utilized by neurosurgeons to relieve compression secondary to spinal metastases was the posterior laminectomy. This procedure was initially favorable because it could be performed by the majority of neurosurgeons within relatively fast time frames. For several reasons, however, this procedure fell out of favor for the primary treatment of spinal metastases. Class I evidence from a case-control study comparing decompressive laminectomy plus radiation therapy with radiation therapy alone did not show a significant functional benefit in ambulatory status following surgical intervention [30]. Class II and III evidence also failed to demonstrate significant functional benefits or improvement in pain [16, 24, 29, 65]. The inability of posterior procedures to provide adequate decompression in any cases has been largely attributed to the majority of metastatic lesions being located anterior to the thecal sac. Retraction of the thecal sac would thus be necessary to complete a gross total resection from a posterior approach in the majority of patients with metastases. In addition, the risk of spinal instability is especially concerning following laminectomy in cancer patients with preexisting disease in the anterior and middle spinal columns [10, 32]. Decompressive laminectomy is now primarily reserved for metastatic lesions located within the posterior spinal elements or in cases where patients cannot tolerate a more complex circumferential approach. In contrast, posterior laminectomies remain the procedure of choice for the majority of intradural extramedullary and intramedullary primary (nonmetastatic) lesions.

Some surgeons maintain that even patients with ventrally located neoplasms can be adequately and safely decompressed with posterior laminectomy if internal fixation is used in conjunction. This practice has been reported to realign the spine as well as distract the vertebral bodies out of the spinal canal [66]. This procedure remains a useful option in patients who are unable to undergo more extensive anterior approaches or for patients with multilevel disease [67].

Newer Approaches for Spinal Cord Decompression

Multiple studies have been published describing the efficacy of various circumferential approaches for pain relief and preservation or improvement of neurologic function [10–12, 15, 32, 45, 68–70]. Overall, the proportion of ambulatory patients who retained ambulatory function postoperatively (defined as the "success" of such a procedure) has ranged between 72 and 98 %, but has been reported as lower when looking at only posterior approaches [71]. The proportions of nonambulatory patients who regained ambulatory status postoperatively (defined as a "rescue" procedure) have been less consistent, ranging between 0 and 94 % in these series [71]. Finally, surgical morbidity rates for circumferential decompressions have ranged between 7 and 65 %, and mortality rates have ranged between 0 and 31 % [71]. The majority of series report mortality rates of less than 10 %.

Approaches to the spine can be broadly classified as anterior or posterior. Anterior approaches include traditional anterior cervical approaches, transthoracic, and transperitoneal approaches. Posterior approaches include traditional laminectomy and posterolateral approaches such as transpedicular, costotransversectomy, and lateral extracavitary (LECA) approaches. All of these approaches require subsequent reconstruction and stabilization.

Anterior Approaches

In general, an anterior approach is preferable for achieving adequate decompression in patients who are able to tolerate such an approach because spinal metastases tend to localize to the anterior spinal column. In general, series of anterior procedures demonstrate superior rates of neurologic function and survival times than do posterior procedures [10, 13, 66]. In addition to decompression, reconstruction of the vertebral body following resection is also facilitated by an anterior approach.

In the cervical spine, reconstruction following an extensive resection is accomplished using bone autograft or allograft, PMMA, or one of many titanium cages or spacers [72]. Stabilization is then usually achieved by way of anterior instrumentation, with plating being the most common technique in the cervical spine. In the thoracic spine, a transthoracic approach can be utilized for anterior decompression and subsequent instrumentation. The side of approach is based on the symmetry of disease, but the left side is often preferable in order to avoid the liver and to more easily identify the aorta. Rib resection, lung deflation, and chest tube insertion are hallmarks of this procedure at the thoracic level [41]. An anterior approach at the thoracolumbar junction (T11–L1) can be done via a thoracoabdominal approach. At this level, a portion of the diaphragm requires mobilization in order to achieve adequate exposure. At the lumbar level, dissection via the retroperitoneum is required, usually along the transversalis fascia. The psoas muscles and aorta are mobilized to provide exposure to the lumbar vertebrae [41].

Posterolateral Approaches

Lesions located in the posterior spinal elements should be approached in this fashion. Patients who may not be able to tolerate a more extensive anterior approach, or those with multilevel disease, may benefit from posterior decompression with stabilization. Finally, particular regional nuances may contribute to the decision to approach posteriorly. The disadvantages of a posterior approach include limited anterior exposure with limited tumor resection and higher rates of wound complications [48].

The cervicothoracic junction (C7–T4) marks a transition zone from the mobile, lordotic cervical spine to a rigid, kyphotic thoracic spine. The hardware failure rates with surgical decompression and subsequent instrumentation in this region are comparatively high, with two series reporting stabilization failure rates of 36 % [73, 74]. Le et al. advocate a posterior/posterolateral approach to the cervicothoracic junction because of lower incidences of hardware failure.

The transpedicular approach can be used for disease in the dorsal and anterior elements of the vertebrae. The advantages of using this approach over an anterior approach include early identification of the spinal canal, ability to resect tumor in the posterior elements, and the ability to provide long segment fixation [69, 75].

A costotransversectomy allows resection of the lamina, facet, transverse process, pedicle, rib head, and some of the vertebral body to provide adequate exposure. Advantages of this procedure include avoidance of a thoracotomy in patients who may not be able to tolerate one, access to multilevel or discontinuous spine disease, and the ability to perform both anterior and posterior fixation. Disadvantages with this procedure include a possibly limited or indirect exposure, possible entry into the lung space requiring chest tube placement, and possible injury to the nerve roots or dura resulting in a CSF fistula.

The LECA approach can be used for spinal decompression and fixation in the thoracolumbar spine (T4–L3) and provides good lateral exposure to the vertebral column without violation of the pleural or abdominal space or mobilization of the diaphragm [76]. Like the costotransversectomy, both anterior and posterior fixations are possible with the LECA. It is commonly used in patients requiring near complete resection of 1–3 vertebral bodies. Reconstruction of the vertebral body is then performed followed by posterior with or without anterior fixation [76].

Combined Anterior and Posterior Approaches

While providing the benefit of excellent exposure to the relevant elements of the spinal canal, anterior decompression also carries the potential drawback of decreased spinal stability. Several series report using anterior decompression with subsequent posterior instrumentation to further stabilize the spinal column [12, 32]. Particular indications for this combination approach include involvement of metastatic disease in all three spinal columns, significant instability, marked kyphosis, involvement of more than one vertebral body, junctional site involvement, and prior laminectomy [12, 32]. One study including 110 patients undergoing spinal decompression determined that approximately half (48 %) of all patients undergoing decompressive surgery required a combined anterior–posterior approach for added stability [12].

En Bloc Spondylectomy

In recent years, aggressive surgical resection of spinal metastases has made curative resection of spinal metastatic lesions a possible outcome. As mentioned, patients with solitary bone metastases or oligometastatic disease can be treated with intent to cure if the patient is a surgical candidate for an aggressive surgical procedure. Patient selection is especially crucial when evaluating patients for an en bloc spondylectomy, as this procedure tends to be long and complex with relatively significant blood loss and a frequent requirement for an open thoracotomy, significant reconstruction and sacrifice of neural and/or vascular structures [35]. Surgical planning in terms of approach and degree of resection has been greatly emphasized, with some surgeons favoring the use of a staging system such as the Boriani/Weinstein system in planning this type of procedure.

Results from recent series of en bloc resections show promising results. One such study reported a mortality rate of less than 1 %, a morbidity rate of less than 10 %, and a mean survival time of greater than 3 years with 48 % of patients showing neurological improvement [35]. Pain improved following surgery in 95 % of patients following surgery, with 76 % achieving total pain control. Another recent series of patients undergoing en bloc spondylectomy demonstrated morbidity and mortality rates less than 1 % [15].

Once an en bloc spondylectomy or vertebrectomy has been performed, vertebral body replacement or reconstruction is necessary to provide stabilization. There have been many materials and implants used to replace the vertebral body following vertebrectomy that have been described in the literature, including allograft, bone cement, ceramic, ceramic/glass, carbon fiber, and titanium spacers or cages [77]. Recently, expandable cages have been developed for replacing the vertebral body and disks. Such cages may offer a benefit because they can be placed through smaller access site and expanded in situ to restore anterior column height.

Percutaneous Vertebroplasty and Kyphoplasty

Vertebroplasty is a relatively noninvasive surgical procedure that has been increasingly utilized in recent years to treat pain and instability in vertebral body collapse by injecting cement into the vertebral bodies through a posterior approach. The procedure is often used for patients with severe, localized mechanical back pain without epidural involvement who may not be able to tolerate more aggressive procedures [78]. Kyphoplasty is a related procedure in which an inflatable balloon is used initially to restore the loss of vertebral height and create a cavity for subsequent injection of cement.

Because vertebroplasty and kyphoplasty are relatively quick percutaneous procedures, they can be used in cancer patients with limited survival time and poor surgical potential [78]. It has been shown that vertebroplasty can be used prior to the initiation of radiation therapy, without compromising its efficacy [50]. Many series have advocated this combination of vertebroplasty to confer stability followed by radiation therapy for its tumoricidal effects [58, 59, 79]. These procedures should not be used in patients with gross spinal instability, cord compression, or epidural extension that are able to undergo surgical intervention. Further contraindications for these procedures include vertebral collapse to less than one-third of its original height, coagulopathies, inability to lie prone, and inability to perform an emergent decompressive surgery if necessary [58, 59, 79].

Vertebroplasty has been shown to provide its benefit by restoring strength and stiffness to the spine and preventing micro-motion [80, 81]. Additionally, PMMA has been shown to destroy nerve endings that cause pain associated with micromotion [58, 79, 82]. It has also been postulated that PMMA may also provide an antitumor effect secondary to thermal effects, cytotoxicity, and ischemia that prevents tumor reinvasion [58, 82]. A biopsy can be done during the same procedure prior to the injection of the filling agent.

In a series of 101 patients, Deramond reported an improvement in pain and quality of life in 80 % of patients [58, 82]. Patients following vertebroplasty have experienced short-term (within 48 h) and long-term pain relief (at 3 months postoperatively) rates of 85–97 % and 89–100 %, respectively [57, 59]. At 6 months following vertebroplasty, pain relief was still reported by 76 % of patients, the majority of which developed either new metastases or epidural involvement of metastases [82].

Despite its many benefits and a low degree of invasiveness, vertebroplasty is not without complications. The overall complication rate has been reported as approximately 10 %, with the majority being short-term complications and only 1.7 % resulting in long-term complications [58]. Leakage of PMMA has been reported to occur in approximately 70–75 % of cases. In the majority this does not present a clinical problem [58, 78]. However significant clinical risks are increased with posterior cortical wall destruction or epidural involvement. The major clinical risk of this procedure is radiculopathy secondary to PMMA leakage into the neuroforamen or back pain caused by a local inflammatory reaction to PMMA [58, 81].

In summary, vertebroplasty and kyphoplasty are minimally invasive procedures that may be performed for selected patients with metastatic spine disease in order to provide fast pain relief and improved spinal stability. It is often the procedure of choice as a palliating measure for patients with limited survival or those who are otherwise unable to tolerate surgical intervention.

Conclusion and Considerations

In summary, surgical management remains a viable and increasingly efficacious option for the management of spinal tumors. The primary goals for surgery are neural decompression, spinal stabilization, curative resection, and pain management. Curative resection of solitary or localized metastatic disease is now a potential goal with aggressive surgical methods. Careful patient selection is the key factor for maximizing the potential benefits and avoiding the associated risks of any treatment modality, be it surgery or radiotherapy.

Case 45.1

A 54-year-old female developed 1 week of progressive lower extremity weakness and attendant bowel and bladder dysfunction. She was wheelchair-bound at the time of presentation, and a CT scan showed a pathologic fracture at T7 (Fig. 45.1a). Her past medical history was significant for invasive ductal carcinoma treated 10 years prior and in remission. An MRI demonstrated this to be consistent with a metastatic lesion with a soft tissue component compressing upon the spinal cord (Fig. 45.1b), and SPECT studies showed no evidence of other lesions (Fig. 45.1c). The patient underwent an urgent T7 corpectomy via a transthoracic approach. The vertebral body was replaced by a PEEK vertebrectomy spacer packed with rib autograft and supplemental plating was utilized (Fig. 45.1d, e). She went on to have a complete neurologic recovery, ambulating without assistance 5 days after surgery.

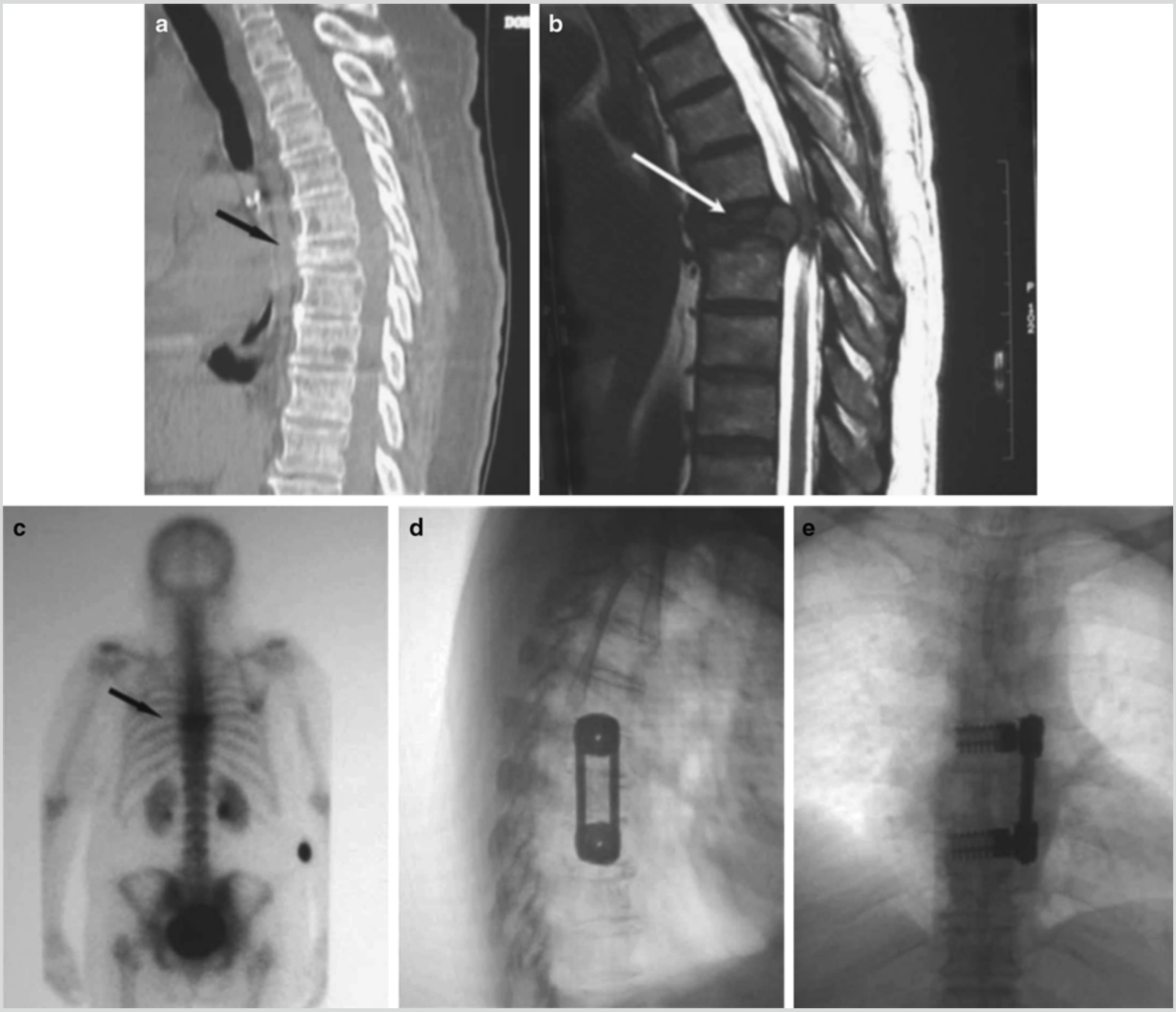

Fig. 45.1 (**a**–**e**) Plain CT scan showing a pathologic fracture at T7 (**a**). MRI thoracic spine T2WI revealed the cord compression (**b**), and SPECT studies showed no evidence of other lesions (**c**). The patient underwent an urgent T7 corpectomy via a transthoracic approach. The vertebral body was replaced by a PEEK vertebrectomy spacer packed with rib autograft and supplemental plating was utilized. Postoperative plain X-ray lateral (**d**) and AP view (**e**) showing the instrumentation

Case 45.2

A 54-year-old male with prostate cancer presented with worsening upper back pain, progressive inability to walk, and signs of myelopathy for 10 days prior to presentation to the emergency room. He was found to have multiple spinal lesions but only the lesion at T3 was causing spinal cord compression. MRI demonstrated diffusely abnormal signal intensity in T3 body with extension to right pedicle and lamina and epidural enhancement with spinal cord compression (Fig. 45.2a–c). There was no signal change in the spinal cord itself. CT scan demonstrated multiple lytic and blastic lesions in the thoracic spine with loss of height of T3 body and epidural breakthrough of soft tissue mass into the spinal canal (Fig. 45.2d). He underwent T3 vertebrectomy with reconstruction of anterior spinal column with a carbon fiber cage, along with supplemental posterior fusion from T2–T6 without complications (Fig. 45.2e). Postoperatively his motor strength returned to normal and he was discharged home after a brief stay at the rehab center. He subsequently underwent spinal radiation and hormonal therapy and was doing well 1 year after the surgery.

Fig. 45.2 (**a**–**e**) MRI demonstrating a diffusely abnormal signal intensity in T3 body with extension to right pedicle and lamina and epidural enhancement with spinal cord compression on axial (**a**) and sagittal (**b**–**d**) images. There was no signal change in the spinal cord itself. CT scan demonstrated multiple lytic and blastic lesions in the thoracic spine with loss of height of T3 body and epidural breakthrough of soft tissue mass into the spinal canal (**e**). The patient underwent T3 vertebrectomy with reconstruction of anterior spinal column with a carbon fiber cage, along with supplemental posterior fusion from T2–T6, as shown on postoperative AP X-ray (**f**)

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