A Systematic Review of Decompression Surgery for Spinal Metastasis

Wail Omar Algortashi¹*, Setah Rashd Alshammari¹, Sarah Ali Alanazi², Salem Abshan M Alshehri³, Abdulrahman Waleed Bagar⁴, Ibrahim Abdulmajeed Affan⁵, Abdullah Mohammed Aljubairy⁶, Sumayah Farah Almowallad⁷, Sami Amer M Alqarni⁸, Rana Hatem Moshref⁹, Nawaf Abdulmohsen AlzameL¹⁰, Aldhoha Ibrahim Heddawi¹, Mohammed Ahmed Alfaqih¹, Madkhali Jnadi Mohammed¹, Haitham Sulaiman Habtar³ and Dairi Abdulrhman Saleh⁴

₁Ibn Sina Collage-Intern, Saudi Arabia
²King Abdulaziz University, Saudi Arabia
³King Khalid University, Saudi Arabia
⁴Umm Al-Qura University, Saudi Arabia
⁵Battarjee Medical College, Saudi Arabia
⁶Almaarefa Colleges, Saudi Arabia
⁷Jazan University, Saudi Arabia
*Corresponding Author: Wail Omar Algorashi, Ibn Sina Collage-Intern, Saudi Arabia.


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Abstract

Background: Metastatic spread to the spinal column is a growing problem in patients with cancer since it triggers pain, instability, and neurologic deficit. If left untreated, progressive myelopathy results in the loss of motor, sensory, and autonomic functions. The goal of surgery is to achieve circumferential decompression of the neural elements while reconstructing and immediately stabilizing the spinal column.

Objective of the Study: Comprehensive systematic review of outcomes following decompression surgery for metastatic spinal tumors of varied primary tumor sites.

Methods: A Systematic search in the scientific database (Medline, Scopus, EMBASE, and Google Scholar) from 1990 to 2016 was conducted for all relevant retrospective studies including; retrospective, prospective and randomized controlled trials and cohort studies were analyzed and included based on the preset inclusion and exclusion criteria.

Results: An overall of fifteen Publications were included. 12 studies were retrospective; 1 was a longitudinal observational study; 1 was a randomized, multi-institutional, non-blinded trial; and 1 was a semi-prospective study. Out of which, 3 studies found that good preoperative Karnofsky Performance Status (KPS ≥ 80%) was a significant predictor of survival. Three studies reported improvement in neurological function following surgery and no study reported a significant effect of time-to-surgery following the onset of spinal cord compression symptoms on survival. The most commonly cited complication was wound infection or dehiscence. The most commonly reported primary tumor types included lung cancer, prostate cancer, breast cancer, renal cancer, and gastrointestinal cancer.

Conclusion: Spinal decompression Surgery and stabilisation have been shown to restore or maintain ambulation, provide pain relief, improve quality of life and survival.

Keywords: Decompression; Spinal Cord Compression; Spinal Metastases; Survival
Introduction

Spinal metastasis afflicts up to 10% of cancer patients as the first manifestation of the cancer [1], which in turn results in a number of primary tumors spreading to the spine, including lung, breast, prostate, renal, GI, thyroid, with lung being most common in males, and breast in the females [2].

In addition to that, it’s important to mention that the spine is the most frequent location for skeletal metastases, found in up to 40% of patients with cancer [3].

The most common presentations of SSM are axial spinal and neurological deficit. The clinical examination of a patient with suspected spinal metastases should include an assessment of local tenderness, objective deformity on clinical examination, spinal range of movement and signs of nerve root entrapment or cord compression. Plain radiographs are obtained routinely; and for a suspected or known malignancy, radionuclide studies are essential [4].

The incidence of reported spinal metastasis patients has been increasing due to advances in modern chemotherapy and early diagnosis leading to increase in median survival of the cancer [5]. Spinal column is the most common site of bone metastasis with almost 40% presence at autopsies [6], about 10% with metastatic disease will develop spinal metastasis, and about a third will become symptomatic, with the probability of 2.5% for developing symptomatic cord compression. Dorsal spine is the most common spinal region followed by lumbar then cervical [7]. The greater incidence in dorsal spine may be the result of large number of vertebra, or the water shed invascularity, Baston venous system, or lymphatics [2].

Spinal metastases can occur in 3 locations; extradural, intradural extramedullary, and intradural intramedullary. More than 98% of spinal metastases are extradural because the dura mater provides a relative barrier for metastatic disease [8]. Intradural, intradural extramedullary and intradural intramedullary disease account for less than 1% of spinal metastatic disease [9]. Both intradural extramedullary and intradural intramedullary disease most commonly originate from drop metastases in the setting of patients with either primary or metastatic brain disease [10]. Thoracic lesions (70%) are most often symptomatic due to the smaller space available for the spinal cord in this region, followed by lumbar (20%) and cervical (10%) lesions [11]. 80% percent of spinal metastases involve vertebral bodies rather than posterior vertebral elements [12].

Treatment for metastatic disease of the spine is multidisciplinary and may involve chemotherapy, corticosteroids, radiotherapy, percutaneous procedures (e.g., vertebroplasty, kyphoplasty) and surgery. Management is guided by three key issues; neurologic deficit, spinal instability and individual patient factors. Site-directed radiation, with or without chemotherapy, is the mainstay of treating painful lesions without neurological deficit. Evidence highlighting the benefits of surgical decompression, as well as improvements in anterior spinal surgical approach has further cemented the place of spinal surgery in the care of these patients [13].

The options for surgical treatment have improved markedly in recent years. The development of better instruments and techniques has spread the catchment net for patients suitable for surgery. Patients reporting mechanical instability of the spine and/or clinically significant narrowing of the spinal canal are included. The anatomy of the spine serves as an obstacle to radical tumour resection in all but a select minority of patients. Therefore, patients with a positive prognosis should undergo postoperative radiotherapy to consolidate their treatment, regardless of the resection achieved. Preoperative radiotherapy, however, should be avoided as it may impair wound healing [14].

A variety of surgical methods are available to treat spinal metastases.

Decompression surgery is the standard surgical technique used to treat metastatic disease of the thoracic and lumbar spine [4]. Location of metastatic disease determines the approach for decompression surgery. A ventral or dorsal approach, or both, can be used in the cervical, thoracic, and lumbar spine, depending on several factors. These include location of compression, goals of reconstruction if necessary, type of tumor, surgeon expertise, and patient-specific factors (e.g. comorbidities of body habitus) [15].

Posterior spinal decompression and stabilization can be considered the standard surgical technique to treat metastatic disease of the thoracic and lumbar spine. Cervical metastases may be treated with anterior decompression and corpectomy with vertebral body replacement [4].

The present study systematically reviews the current literature and highlight predictors of survival and outcomes for decompression surgery for spinal metastases.

Materials and Methods

Literature search

The present Systematic Review is reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Data Sources: Electronic databases were searched: Scopus, EMBASE, and Google scholar), PubMed/MEDLINE, Scopus, The Cochrane Library, and Web of Science. Econlit from 1990 to 2016.

Search terms included (decom-pr* OR separat*) AND (spine or spina*) AND metasta* AND (surge* OR surgi*).

Study Selection

Search results were screened by scanning abstracts for the following

Inclusion Criteria

1. Retrospective and prospective studies reporting outcomes of decompression surgery for spinal metastases
2. Intervention type: only decompression surgery was considered
3. Outcomes: polysomnography data and quantitative sleepiness data

Exclusion Criteria

1. Non–English language studies
2. Book chapters, and case reports
3. In-vitro studies and studies conducted on animal

Data Extraction and Study Quality Assessment

Reviewers independently reviewed studies, abstracted data, and resolved disagreements by consensus. Studies were evaluated for quality. A review protocol was followed throughout. Data collected included? If studies reported RDI, the study was reviewed to see if RDI scoring criteria were used [11]. Studies not reporting sufficient data were contacted at least twice to try to obtain the data.

Results

The initial search was broad, accepting any article related to Decompression surgery for spinal metastasis to ensure a comprehensive
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view of available work. Searches identified 1944 publications in addition to another 9 publications that were found through manual research. After removal of duplicates, abstracts and titles 798 publications were assessed as identified from title and abstract, and 350 papers were excluded. 79 papers full text could not be retrieved and another 85 papers with the same cohort. There were also 245 papers excluded because they did not have the same endpoint (didn’t conclude or touch base on the outcome of decompression surgery on Spinal metastasis).

Finally, 12 eligible articles met the inclusion and exclusion criteria and detailed as the focus for the present study.

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines in reporting the results 17 (Figure 1).

![PRISMA flow diagram showing the selection criteria of assessed the studies](image)

**Figure 1:** PRISMA flow diagram showing the selection criteria of assessed the studies [17].

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15 studies reported the predictors of survival for patients with spinal metastases who underwent decompression surgery – characteristics of the studies [17-30] can be seen in Table 1. Of these, 12 studies were retrospective; 1 was a longitudinal observational study; 1 was a randomized, multi-institutional, non-blinded trial; and 1 was a semi-prospective study that included both retrospectively and prospectively collected data. Surgical interventions included decompression whether with or without instrumentation and radiotherapy. Primary histology of tumors varied widely; however, prostate cancer (14 studies), lung cancer (11 studies), breast cancer (10 studies), and renal cancer (12 studies) were commonly reported in the included studies.

### Table 1: Characteristics of the included studies

| Study Type | Study Year | Authors | No. of Patients | Age (yrs)* | Surgery Type | Primary Tumor Site
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Randomized, multinational, multi-institutional trial</td>
<td>2005</td>
<td>Patchell, et al. [17]</td>
<td>101</td>
<td>60</td>
<td>Surgery followed by RT (50); RT alone (51)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lung (15); brain (16); prostate (17); rectal (17); sarcoma (17); kidney (5); melanoma (2); other (9)</td>
</tr>
<tr>
<td>2</td>
<td>Retrospective</td>
<td>2009</td>
<td>Choufani, et al. [18]</td>
<td>114</td>
<td>58</td>
<td>Decompression surgery</td>
</tr>
<tr>
<td>3</td>
<td>Retrospective</td>
<td>2010</td>
<td>Marking, et al. [19]</td>
<td>21</td>
<td>12</td>
<td>Surgical decompression &amp; instrumentation for high-grade epidural spinal cord compression from tumor followed by single-fraction high dose spinal radiotherapy (dose range 16-24 Gy, median 24 Gy)</td>
</tr>
<tr>
<td>4</td>
<td>Retrospective</td>
<td>2010</td>
<td>Lande, et al. [20]</td>
<td>79</td>
<td>65</td>
<td>Decompression &amp; stabilization</td>
</tr>
<tr>
<td>5</td>
<td>Retrospective observational study</td>
<td>2011</td>
<td>Padalkar &amp; Tow, 2011 [21]</td>
<td>102</td>
<td>65</td>
<td>Decompression w/ instrumentation (surgery)</td>
</tr>
<tr>
<td>6</td>
<td>Retrospective</td>
<td>2011</td>
<td>Park, et al. [22]</td>
<td>103</td>
<td>55</td>
<td>Decompression &amp; stabilization</td>
</tr>
<tr>
<td>7</td>
<td>Retrospective observational study</td>
<td>2012</td>
<td>Chou, et al. [23]</td>
<td>106</td>
<td>55</td>
<td>Single-stage FV, decompression</td>
</tr>
<tr>
<td>8</td>
<td>Retrospective</td>
<td>2012</td>
<td>Brooks, et al. [24]</td>
<td>126</td>
<td>66</td>
<td>Surgery RT (62); RT alone (64)</td>
</tr>
<tr>
<td>9</td>
<td>Retrospective</td>
<td>2013</td>
<td>[et al. 2013] [25]</td>
<td>27</td>
<td>61</td>
<td>Decompression &amp; stabilization</td>
</tr>
<tr>
<td>10</td>
<td>Semi-prospective study</td>
<td>2013</td>
<td>Spyratos, et al. [26]</td>
<td>291</td>
<td>61</td>
<td>Decompression &amp; stabilization</td>
</tr>
<tr>
<td>11</td>
<td>Retrospective</td>
<td>2013</td>
<td>Bishai, et al. [27]</td>
<td>2012</td>
<td>61</td>
<td>Decompression</td>
</tr>
<tr>
<td>12</td>
<td>Retrospective</td>
<td>2015</td>
<td>Lee, et al. [28]</td>
<td>32</td>
<td>67</td>
<td>Posterior decompression &amp; spine stabilization</td>
</tr>
<tr>
<td>13</td>
<td>Retrospective</td>
<td>2015</td>
<td>Lee, et al. [29]</td>
<td>64</td>
<td>57</td>
<td>Posterior decompression &amp; spine stabilization</td>
</tr>
<tr>
<td>15</td>
<td>Retrospective cohort study</td>
<td>2015</td>
<td>Qureshi, et al. [31]</td>
<td>191</td>
<td>65</td>
<td>Decompression w/ stabilization</td>
</tr>
</tbody>
</table>
In a multivariable analysis of 105 patients with predominantly lung cancer as the primary tumor site, Chong, et al. [23] found that a limited number (< 3 levels) of spinal metastases and postoperative adjuvant therapy (local irradiation only, chemotherapy only, or irradiation and systemic chemotherapy) were associated with increased survival (HR of 0.53 and 0.48, respectively, both p < 0.05). Padalkar, et al. [21] studied 102 patients and found that metastases to internal organs (p < 0.001) and increased number of extraspinal bony metastases (p < 0.01) were significantly associated with worse odds of survival. In a longitudinal observational study, Park., et al. [31] used a multivariable analysis to find that time to neurological deficit (risk ratio [RR] 2.28, p = 0.02), postoperative chemotherapy (RR 6.58, p < 0.001), and postoperative Eastern Cooperative Oncology Group (ECOG) performance status (RR 2.73, p = 0.04) were independent predictors of increased survival time. No study reported a significant effect of time-to-surgery following the onset of spinal cord compression symptoms on survival [26]. Quraishi, et al. [26] reported that there was no significant difference between 3 groups treated with surgery within 24 hours, between 24 and 48 hours, and over 48 hours from acute presentation of neurological symptoms with respect to survival (p = 0.99). Finally, in a randomized, multi-institutional, nonblinded trial, Patchell, et al. [17] found that surgical treatment followed by radiotherapy compared with radiotherapy alone resulted in increased median survival time (126 days vs 100 days, respectively; RR 0.6, p = 0.03).

Several studies established scoring systems for prediction of survival following decompression surgery for various primary tumor sites. Crnalic., et al. [31] established a scoring system for prediction of survival following decompression surgery based on the results of survival analyses of patients with prostate cancer metastatic to the spine. The authors included the hormone status of patients' prostate cancer, preoperative Karnofsky Performance Status (KPS), evidence of visceral metastasis, and preoperative serum prostate-specific antigen (PSA) in calculating the new prediction score. The authors found that hormone status was strongly associated with survival in their patients as well as in 2 other studies of spinal cord compression in patients with prostate cancer. Consequently, the authors assigned maximal weight to hormone status in their score. Additionally, the authors noted that KPS was the strongest predictor of survival in the hormone-refractory patients [31].

Lei., et al. [28] sought to establish a scoring system for survival and functional outcome among patients undergoing posterior decompression surgery for lung cancer metastatic to the spine. The authors found that preoperative ambulatory status (p < 0.01), visceral metastases (p < 0.001), and time to developing motor deficits (p < 0.001) were significant predictors of survival and were therefore included in the scoring system.29 In a separate study, Lei., et al. [29] also created a scoring system to predict survival prognosis among patients with metastatic non–small cell lung cancer causing spinal cord compression who underwent surgical decompression. The authors included the following components as part of their scoring system: ECOG performance status (p = 0.02), number of involved vertebrae (p = 0.02), visceral metastases (p = 0.02), and time to developing motor deficits (p < 0.01).

Three studies found that good preoperative KPS (≥ 80%) was a significant predictor of survival [21,31]. Padalkar and Tow22 determined that a high preoperative KPS was significantly associated with increased median survival times (median survival 13 months [95% CI 10.0 - 16.0 months]) compared with a moderate (50%-70%) KPS (median survival 4 months [95% CI 2.0 - 6.0 months]) and a poor (10% - 40%) KPS (median survival 2 months [95% CI 1.0 - 3.0]) in patients treated with decompression and instrumentation for spinal metastases (p < 0.001).

Two studies investigated survival based on Tokuhashi scores. Park., et al. [22] reported that the median overall survival times were significantly longer in patients with high (9 - 11) preoperative Tokuhashi scores (15.0 months [95% CI 9.3 - 20.7 months]) relative to patients with low (0 - 8) preoperative Tokuhashi scores (9.0 months [95% CI 7.5 - 10.5 months]) (p < 0.01).

One study found an association between Motzer scores and survival. Bakker, et al. [27] determined that among patients with renal cell carcinoma metastatic to the spine, intermediate (HR 17.4 [95% CI 1.82 -166], p = 0.01) and high (HR 39.3 [95% CI 3.10 - 499, p < 0.01]) Motzer scores were significantly associated with worse odds of survival (median survival of 6 months and 2 months, respectively).
**Discussion**

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Patients with a long life expectancy, the indicated procedure is anterior tumor resection with primary stabilizing instrumentation. Without reconstruction, can lead to a kyphotic deformity. For patients with a solitary spinal metastasis who are in good general health and any spinal cord compression (para- or tetraplegia). The secondary goals are to stabilize the affected segment of the spine and to enable included studies were classified according to the outcomes reported. Survival was the most commonly reported outcome. Different scoring algorithms have been proposed to improve survival prediction.

Table 2: Included studies and their findings related to survival outcomes.

<table>
<thead>
<tr>
<th>Study</th>
<th>Authors</th>
<th>Complications</th>
<th>Survival Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lei. et al. 2013</td>
<td>25% vs 42.6% (p = 0.005)</td>
<td>Overall complication rate 19%</td>
</tr>
<tr>
<td>2</td>
<td>Rades. et al. 2015</td>
<td>1%</td>
<td>Preop ambulatory status: HR 2.24, 95% CI 1.3–3.86; p = 0.004</td>
</tr>
<tr>
<td>3</td>
<td>Chong. et al. 2012</td>
<td>1%</td>
<td>No. of involved vertebrae: HR 2.46, 95% CI 1.39–4.35; p = 0.002</td>
</tr>
<tr>
<td>4</td>
<td>Rades. et al. 2013</td>
<td>1%</td>
<td>Visceral metastases vs none: HR 2.29, 95% CI 1.33–3.94; p = 0.003</td>
</tr>
<tr>
<td>5</td>
<td>Tow, 2011</td>
<td>1%</td>
<td>Prostate (p = 0.03), or GI cancer (p = 0.05)</td>
</tr>
<tr>
<td>6</td>
<td>Lei. et al. 2010</td>
<td>1%</td>
<td>Preop ambulatory status: HR 2.24, 95% CI 1.3–3.86; p = 0.004</td>
</tr>
<tr>
<td>7</td>
<td>Lei. et al. 2015</td>
<td>1%</td>
<td>Visceral metastases vs none: HR 2, 95% CI 1.10–3.62; p = 0.022</td>
</tr>
<tr>
<td>8</td>
<td>Lei. et al. 2012</td>
<td>1%</td>
<td>No. of involved vertebrae: HR 2.46, 95% CI 1.39–4.35; p = 0.002</td>
</tr>
<tr>
<td>9</td>
<td>Lei. et al. 2015</td>
<td>1%</td>
<td>Visceral metastases vs none: HR 2.29, 95% CI 1.33–3.94; p = 0.003</td>
</tr>
</tbody>
</table>

Group 1 vs 2: 25% vs 42.6% (p = 0.003–0.4; p = 0.005)

No. of involved vertebrae (1–2 vs ≥3) at 6 mos: 78% vs 22%; at 12 mos: 36%

No. of spinal metastases (<3 vs ≥3): HR univariate 2.28, 95% CI 1.33–3.90; p = 0.039

Primary origin w/good prognosis: HR 0.627, 95% CI 0.479–0.899; p = 0.039

Multivariate: preop KPS ≥80%: HR 6.1, 95% CI 1.3–28.5); p = 0.02

Multivariable analysis:

- Time to develop motor deficits: HR 3.44, 95% CI 1.9–6.22; p <0.001
- Visceral metastases vs none: HR 2.29, 95% CI 1.33–3.94; p = 0.003
- No. of involved vertebrae: HR 2.46, 95% CI 1.39–4.35; p = 0.002
- Visceral metastases vs none: HR 2, 95% CI 1.10–3.62; p = 0.022
- No. of involved vertebrae: HR 2.46, 95% CI 1.39–4.35; p = 0.002
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- Visceral metastases vs none: HR 2, 95% CI 1.10–3.62; p = 0.022

Median survival time of all patients after 1st spinal surgery was 10.2 mos, 95% CI 2.36–5.84. Estimated survival time after 1st reop was 8.3 months. 29 patients (74%) died by the time study was conducted. Median survival time after 1st op performed at level of interest could not be calculated.

The median survival time after last op was 9.1 mos (95% CI 6.4–13.7 mos). Patients w/melanoma lived significantly longer than patients w/lung (p = 0.003). Median survival time after adjuvant radiosurgery: 18 or 21 Gy: 180 days, 95% CI 146–NR

Maintenance of Frankel grade: RR 0.24, 95% CI 0.11–0.54; p = 0.0006

Maintenance of continence: RR 0.47, 95% CI 0.25–0.87; p = 0.016

Factors affecting patient’s OS significant in univariate analysis only (p < 0.05):

- Time to develop motor deficits: HR 3.44, 95% CI 1.9–6.22; p <0.001
- Visceral metastases vs none: HR 2.29, 95% CI 1.33–3.94; p = 0.003
- No. of involved vertebrae: HR 2.46, 95% CI 1.39–4.35; p = 0.002
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Padalkar, et al. [21] also found that increased KPS was significantly associated with greater median survival times in patients treated with decompression with instrumentation for spinal metastases. Crnalic, et al. [31] reported that a KPS of 80% - 100% was significantly associated with prolonged survival, with a median survival of 5 months.

**Post-decompression interventions**

White, et al. [13] recommended that reconstruction with autograft, allograft, or methylmethacrylate may follow decompression. Autograft and allograft hold potential for incorporation and biologic fusion, which can provide long-term stability. Solid fusion is often limited in the tumour patient from abnormal tumour biology, effects of radiation, and chemotherapeutics [13]. Lewandrowski, et al. also suggested that the use of methylmethacrylate has been suggested for patients with limited expected survival [32].

**Conclusion**

Spinal decompression Surgery and stabilisation have been shown to restore or maintain ambulation, provide pain relief, improve quality of life and survival.

**Bibliography**

