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EC NEUROLOGY
Research Article

A Systematic Review of Decompression Surgery for Spinal Metastasis

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Received: June 02, 2017; **Published:** June 06, 2017

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

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).

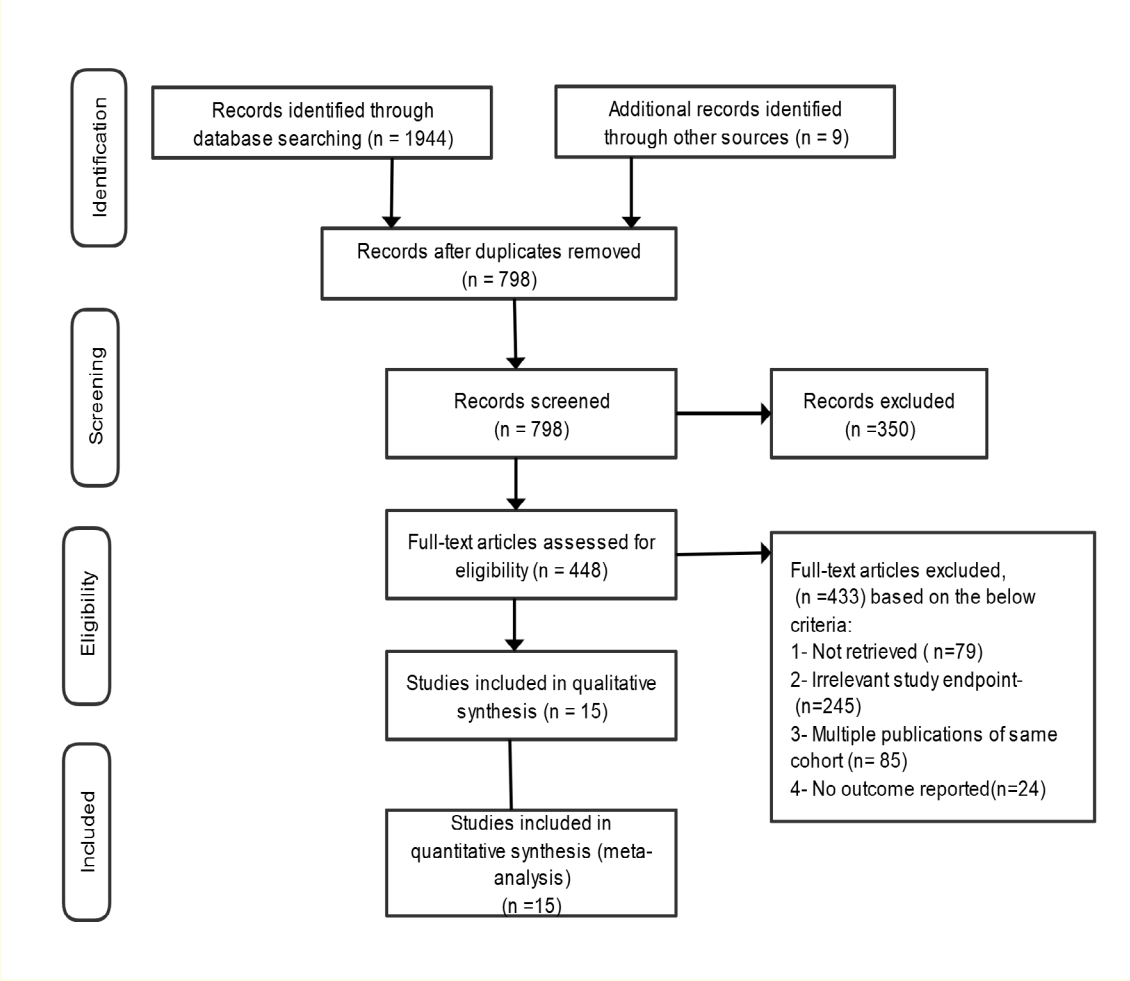

Figure 1: *PRISMA flow diagram showing the selection criteria of assessed the studies [17].*

Predictors of Survival

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 (6 studies) were commonly reported in the included studies.

#	Study Type	Study Year	Authors	No. of Patients	Age (yrs)*	Surgery Type	Primary Tumor Site
1	Randomized, multiinstitutional, nonblinded trial	2005	Patchell., *et al*. [17]	101	60	Surgery followed by RT (50); RT alone (51)	RT group/surgery group: Lung (13), (13); breast (6), (7); prostate (10), (9); other genitourinary (6), (5); GI (4), (2); melanoma (3), (3); head & neck (2), (1); unknown (3), (5); other (4), (5)
2	Retrospective	2009	Chaichana., *et al*. [18]	114	58	Decompression surgery	Lung (27); breast (26); prostate (20); kidney (21); GI (13); melanoma (7)
3	Retrospective	2010	Moulding., *et al*. 2010 [19]	21	52.9	Surgical decompression & instrumentation for high-grade, epidural, spinal cord compression from tumor, followed by single-fraction high-dose spinal radiosurgery (dose range 18–24 Gy, median 24 Gy)	Melanoma 5 (23.8%); renal cell 4 (19%); sarcoma 3 (14.3%); 1 angiosarcoma 1; leiomyosarcomas 2; colorectal carcinoma 2 (9.5%); thyroid 1 (4.8%); teratoma 1 (4.8%); hemangiopericytoma 1 (4.8%); cholangiocarcinoma 1 (4.8%); adenoid cystic carcinoma 1 (4.8%); hemangioma (epithelioid) 1 (4.8%); prostate 1 (4.8%)
4	Retrospective	2010	Laufer., *et al*., 2010 [20]	39	Median 61	Decompression surgery	Renal (12); prostate (7); neuroendocrine (4); head & neck (4); GI (4); sarcoma (2); thyroid (2); breast (1); cervical SCC (1); lymphoma (1); melanoma (1)
5	Retrospective	2011	Padalkar & Tow, 2011 [21]	102	Median 58.5	Decompression w/ instrumentation (in some)	Lung, osteosarcoma, stomach, bladder, esophagus, pancreas 20 (19.6%); liver, gallbladder, unidentified 6 (5.9%); others 30 (29.4%); kidney, uterus 10 (9.8%); rectum 3 (2.9%); thyroid, breast, prostate, carcinoid tumor 33 (32.4%)
6	Retrospective	2011	Park., *et al*. 2011 [22]	103	55	Decompression & fixation	Breast (7); colon (6); hepatobiliary (8); kidney (11); liver (15); lung (23); lymphoma (1); multiple myeloma (12); prostate (1); stomach (6); thymus (2); thyroid (2); uterus (1); bladder (1); unknown origin (7)
7	Retrospective observational study	2012	Chong., *et al*. 2012 [23]	105	58	Single-stage PDS, corpectomy	Lung cancer (43%); hepatobiliary cancer (25%); CRC (6.7%); breast cancer (3.8%); stomach cancer (3.8%); cervical cancer (2.9%); esophageal cancer (2.9%); kidney (1.9%); thyroid cancer (1.9%); gingival cancer (1); melanoma (1); mesothelioma (1); mixed germ cell tumor (1); osteosarcoma (1); prostate cancer (1); sarcoma (1); thymic cancer (1); undifferentiated carcinoma (1)
8	Retrospective	2012	Rades., *et al*. 2012 [24]	126		Surgery+RT (42); RT alone (84)	Breast cancer (15); prostate cancer (30); myeloma/lymphoma (18); lung cancer (24); other tumors (39)
9	Retrospective	2013	Ju., *et al*. 2013 [25]	27 (31 procedures)	65	Decompression surgery	Prostate (27)
10	Semi-prospective study	2013	Quraishi., *et al*. 2013 [26]	201	61	Decompression & stabilization	Breast (29); hematological (28); renal (26); prostate (26); lung (23); GI (11); sarcoma (9); others (49)
11	Retrospective	2014	Bakker., *et al*. 2014 [27]	21		Decompression surgery	Kidney
12	Retrospective	2015	Lei., *et al*. 2015 [28]	73 test group (n = 37); validation group (n = 36)	57	Posterior decompression & spine stabilization	Lung cancer
13	Retrospective	2015	Lei., *et al*. 2015 [29]	64	57	Posterior decompression & spine stabilization	Non–small cell lung cancer
14	Prospective observational study	2015	Park., *et al*. 2015 [22]	50	58	Wide decompression surgery + fixation procedure	Non–small cell lung cancer
15	Retrospective cohort	2015	Quraishi., *et al*. 2015 [30]	101	65	Decompression w/& w/o stabilization	Breast (14); lung (10); prostate (21); renal (11); myeloma (1); GI (8); other (25); unknown (11)

Table 1: *Characteristics of the included studies.*

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

The present study comprehensively reviews the literature on decompression surgery intervention for spinal metastases management. Included studies were classified according to the outcomes reported.

The main goals of the surgery are to reduce tumor bulk and to resect the structures bordering the spinal canal dorsally to decompress any spinal cord compression (para- or tetraplegia). The secondary goals are to stabilize the affected segment of the spine and to enable the patient to be mobilized without a corset.

Dunning., *et al.* [4] suggested that decompression alone, without instrumentation, should be performed only in exceptional cases. The dorsal portion of the spinal column normally plays the role of a tension band maintaining alignment of the spine; and thus, when left without reconstruction, can lead to a kyphotic deformity. For patients with a solitary spinal metastasis who are in good general health and have a long-life expectancy, the indicated procedure is anterior tumour resection with primary stabilizing instrumentation.

Studies included were intended for reviewing and reporting survival outcomes, Table 2 reported a wide range of predictors of survival, including Motzer score, Tokuhashi score, Frankel grade, KPS, and ECOG performance status.

#	Authors	Complications	Survival Data
1	Patchell., *et al.* [17]	Wound infections (3); failure of fixation requiring additional surgery (1); extended hospital stays (>20 days) occurred in 7 patients in the surgery group & 11 in the RT group	Surgical treatment resulted in significant differences in:
			Maintenance of continence: RR 0.47, 95% CI 0.25–0.87; p = 0.0116
			Maintenance of ASIA grade: RR 0.28, 95% CI 0.13–0.61; p = 0.001
			Maintenance of Frankel grade: RR 0.24, 95% CI 0.11–0.54; p = 0.00006
			Survival time: RR 0.6, 95% CI 0.38–0.96; p = 0.033
			30-day mortality rates were 6% in surgery group & 14% in RT group (p = 0.32). At Day 30 after treatment, % of patients w/Frankel grades at or above study entry level was significantly (p = 0.0008) higher in surgery group than in RT group (91% vs 61%).
2	Chaichana., *et al.* [18]	Wound dehiscence 10%; post-stop CSF leaks requiring operative intervention 3%; epidural hematoma requiring operative intervention 1%; periop death 3%	Lung vs breast vs prostate vs kidney vs GI vs melanoma median survival (mos): 4.3 vs 21 vs 3.8 vs 19.8 vs 5.1 vs 40.9
			Breast cancer group lived significantly longer after surgery than patients w/ primary lung (p = 0.002), prostate (p = 0.004), or GI (p = 0.01) cancer
			Patients w/primary kidney cancer lived significantly longer than patients w/ lung (p = 0.001), prostate (p = 0.006), or GI (p = 0.02) cancer
			Patients w/melanoma lived significantly longer than patients w/lung (p = 0.0006), prostate (p = 0.03), or GI cancer (p = 0.05)
3	Moulding., *et al.*, 2010 [19]	Acute Grade 1 skin reactions (3); acute neuritic pain immediately after radiosurgical treatment (1); Grade 2 esophagitis (dysphagia, burning) (3); Grade 4 esophagitis (1)	Median survival time after adjuvant radiosurgery:
			24 Gy: 310 days, 95% CI 169–NR
			18 or 21 Gy: 180 days, 95% CI 146–NR
			All: 310 days, 95% CI 169–NR
			1-yr risk of local failure according to radiosurgical dose group:
			24 Gy: 6.3%, 95% CI (0–18.5%)
			18 or 21 Gy: 20.0%, 95% CI (0–59%)
			All patients: 9.5%, 95% CI (0–22.3%)
4	Laufer., *et al.* 2010 [20]	Major surgical complication rate (5%)	Median time btwn 1st op & 1st resp at same spinal level due to tumor recurrence 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 was 21.6 mos (95% CI 16.5–34.2 mos), & after 2nd op it was 12.4 mos (95% CI 7.5–20.0 mos).
			The median survival time after last op was 9.1 mos (95% CI 6.4–13.7 mos).
			The median postop survival time did not significantly decrease w/an increasing no. of recurrences.
			In patients w/prostate cancer, median survival after 1st resp was 8.2 mos (95% CI 3.8–14.1 mos) & 6.0 mos after last operation (lower 95% confidence limit 2.4 mos—upper bound after 1st resp could not be estimated since >50% of these patients were ambulatory at the conclusion of the study (lower 95% confidence limit 5.7 mos).
			In patients w/renal cancer, outcomes were even more favorable. The median survival time after 1st resp was 13.7 mos (95% CI 6.4–21.8 mos), & after last operation was 9.2 mos (lower 95% confidence limit 6.3 mos—upper bound could not be calculated).
5	Padalkar & Tow, 2011 [21]		Odds of 6-mo survival according to Tomita score:
			Score 0–3 OR 36.7, 95% CI 3.9–346.2; p = 0.002
			Score 4–6 OR 26.2, 95% CI 2.9–239.5; p = 0.004
			Score 7–8 OR 7 95% CI 0.8–61.1; p = 0.078
			Median survival:
			KPS p < 0.001
			Extraspinal bone metastases: p = 0.006
			No. of vertebral levels involved: p = 0.08
			Metastases to internal organ: p = 0.0002
			Presence of spinal cord palsy p = 0.1
			Type of primary tumor: p = 0.9
6	Park., *et al.* 2011 [22]	Surgical complications requiring 2nd op, such as wound infections, extensive bleeding, & symptomatic recurrence 9.7% (10)	Significant predictors of OS (multivariate Cox proportional hazard model):
			Primary origin w/good prognosis: HR 0.627, 95% CI 0.479–0.899; p = 0.039)
			High Tokuhashi score: HR 0.524, 95% CI 0.335–0.820; p = 0.005)
			Postop ambulation, w/or w/o aid: HR 1.59, 95% CI 1.021–2.645; p = 0.048
7	Chong., *et al.* 2012 [23]	Surgical complications (11); CSF leakage (4); postop epidural hematoma (4); wound dehiscence (2); pneumothorax (1)	Median OS of patients after surgery: 6 mos
			1-yr survival rate: 34%; 2-yr survival rate: 14%
			Factors affecting patient's OS significant in univariate analysis only (p < 0.05):
			Age (<60 vs ≥60) yrs: HR 1.64, 95% CI 1.00–2.68; p = 0.05
			Primary cancer (rapid vs moderate & slow): HR 0.49, 95% CI 0.27–0.92; p = 0.03
			Visceral metastases (yes vs no): HR 0.58, 95% CI 0.35–0.96; p = 0.04
			Factors affecting patient's OS significant in both univariate & multivariate analyses (p < 0.05):
			No. of spinal metastases (<3 vs ≥3): HR univariate 2.28, 95% CI 1.33–3.90; p <0.01. HR multivariate 1.94, 95% CI 1.10–3.43; p = 0.02
			Postop adjuvant therapy (yes vs no): HR univariate 3.69, 95% CI 2.10–6.49; p <0.01. HR multivariate 3.23, 95% CI 1.80–5.77; p <0.01
8	Rades., *et al.* 2012 [24]	Wound infections, extensive bleeding, postop pneumonia, & pulmonary embolism in 7 patients (14%) of the Surgery+RT group	Survival rates for the entire cohort were 55% at 6 mos & 42% at 12 mos.
			Improved survival was associated with the following significant variables: female sex (p = 0.012), better ECOG performance status (p <0.001), favorable primary tumor type (p <0.001), involvement of only 1–2 vertebrae (p <0.001), absence of other bone metastases (p <0.001), absence of visceral metastases (p < 0.001), ambulatory status prior to therapy (p <0.001), slower development of motor deficits (p <0.001) & longer course of RT (p <0.001).
9	Ju., *et al.* 2013 [25]	16 complications occurred in 35% (11/31 procedures); death w/in 30 days of surgery of an unreported cause (1); acute inpatient rehabilitation after surgery (14) 52%	Median survival time of all patients after 1st spinal surgery was 10.2 mos, 95% CI 5.0–15.8 mos
		Major complications: instrumentation failure requiring reop; pneumothorax; spinal hematoma; small-bowel obstruction; deep wound infection; GI bleeding necessitating nasogastric tube placement; pulmonary embolism	Significant univariate predictors of survival:
		Minor complications: durotomy status after intraop closure; wound infection responsive to treatment w/antibiotics; UTI; pleural effusion; thrombocytopenia & anemia requiring multiple postop transfusions; transient lt recurrent laryngeal nerve dysfunction; instrumentation failure	Preop PSA ≥150: HR 3, 95% CI 1–9.4; p = 0.05
		Significant factors associated w/increased incidence of complications	Previous prostatectomy: HR 3.0, 95% CI 1.1–8.5; p = 0.04
		Age <65 yrs: OR 0.3, 95% CI 0.003–0.4; p = 0.005	Significant univariate & multivariate predictor of survival:
		Instrumentation spanning ≥7 spinal levels: OR 7.0, 95% CI 1.2–41.4; p = 0.03	Preop KPS ≥80%: HR 3.3, 95%CI 1.1–9.9; p = 0.03
			Multivariate: preop KPS ≥80%: HR 6.1, 95% CI 1.3–28.5]; p = 0.02
10	Quraishi., *et al.* 2013 [26]	Overall complication rate 19% (39/201); wound infection (15); included chest infection (8); neurological worsening (4); failure of the metal work (4); pulmonary embolization (3)	Group 1 vs 2 vs 3 neurological outcomes postop (Frankel Grades A–E):
			A: 2 vs 6 vs 0, p = 0.34 for 1 vs 2
			B: 6 vs 2 vs 1, p = 0.70 for 2 vs 3
			C: 20 vs 9 vs 2, p = 0.001 for 1 vs 3
			D: 33 vs 35 vs 10
			E: 23 vs 31 vs 21
			Mean survival days 84 vs 83 vs 34, p = 0.001
11	Bakker., *et al.* 2014 [27]		Univariate analysis:
			Cervical localization: HR 43.7, 95% CI 2.2–866; p = 0.01; curative intent: HR 0.3, 95% CI 0.1–0.9; p = 0.03; Frankel Grade C/D vs E: HR 3.2, 95% CI 1.05–9.49; p = 0.04; Motzer intermediate: HR 13.46, 95% CI 1.63–111; p = 0.01 (reference group Motzer favorable risk); high risk: HR 38.4, 95% CI 3.42–431; p = 0.003 (reference group Motzer favorable risk)
			Multivariable analysis:
			Motzer intermediate HR 17.4, 95% CI 1.82–166; p = 0.01; high risk HR 39.3, 95% CI 3.10–499; p = 0.005
12	Lei., *et al.* 2015 [28]	Postop wound infections (2); death w/in 4 wks (1)	Test group: univariate analysis of preop factors for survival in lung cancer patients w/MSCC at 6 & 12 mos:
			Ambulatory vs nonambulatory at 6 mos: 67% vs 33%; at 12 mos: 31% vs 13% (p = 0.0054)
			ECOG performance status (1–2 vs 3–4) at 6 mos: 73% vs 14%; at 12 mos 35% vs 0% (p = 0.0002)
			No. of involved vertebrae (1–2 vs ≥3) at 6 mos: 78% vs 22%; at 12 mos: 36% vs 7% (p = 0.0028)
			Visceral metastases (no vs yes), at 6 mos: 77% vs 26%; at 12 mos 36% vs 11% (p = 0.0118)
			Time to developing motor deficits (≤14 vs >14 days) at 6 mos 28% vs 72%; 6% vs 40% at 12 mos (p ≤ 0.0001)
			Median OS was 6.2 mos (95% CI, 2.9–8.8 mos) in the test group & 6.0 mos (95% CI 4.3–7.9 mos) in the validation group.
13	Lei., *et al.* 2015 [29]		Univariate analysis for survival (simple Cox regression):
			Preop ambulatory status: HR 2.24, 95% CI 1.3–3.86; p = 0.004
			ECOG performance: OR 2.78, 95% CI 1.54–5.02; p < 0.001
			No. of involved vertebrae: HR 2.46, 95% CI 1.39–4.35; p = 0.002
			Visceral metastases vs none: HR 2.29, 95% CI 1.33–3.94; p = 0.003
			Time to develop motor deficits: HR 3.44, 95% CI 1.9–6.22; p <0.001
			Multivariate analysis for survival (multiple Cox regression):
			Preop ambulatory status excluded
			ECOG performance: HR 2.18, 95% CI 1.15–4.16; p = 0.017
			No. of involved vertebrae: HR 2.05, 95% CI 1.11–3.76; p = 0.021
			Visceral metastases vs none: HR 2, 95% CI 1.10–3.62; p = 0.022
			Time to develop motor deficits: HR 2.7, 95% CI 1.45–5.03; p = 0.002
			For all patients, the overall median survival time was 6.3 mos (95% CI 4.5–7.4 mos), 6-mo & 12-mo survival rates were 52.6 & 23%, respectively.
14	Park., *et al.* 2016 [22]	Major complications 34.0% (17/50), 30-day mortality rate 10.0% (5/50)	Median survival after surgery:
			Time from neurological deficit ≥72 hrs: 3.1, 95% CI 1.9–4.3; p = 0.002
			Responsiveness to chemo: progressive disease 2.4, 95% CI 1.4–3.4; p < 0.001
			Chemo postop 9.9, 95% CI 6.8–13; p < 0.001
			Preop ambulatory status 9.9 95% CI 6.1–13.7; p = 0.031.
			Median OS time after surgery was 5.2 mos, 95% CI 2.36–5.84. Estimated survival rates at 3, 6, & 12 mos were 66.0%, 49.4%, & 22.4%, respectively.
15	Quraishi., *et al.* 2015 [30]	Group 1 (low-grade compression) vs Group 2 (high grade)	Group 1 (low-grade compression) vs Group 2 (high grade)
		Overall complication rate Group 1 vs 2: 25% vs 42.6% (p = 0.12)	Overall median survival: 326 days
		Postop wound infection Group 1 vs 2: 2.5% vs 16%	Mean survival Group 1 vs 2: 444 vs 412 days (p = 0.62)
			Median survival Group 1 vs 2: 376 vs 326 days

Table 2: *Chemo = Chemotherapy; CRC = Colorectal Cancer; CUP = Cancer of Unknown Primary; Dx = Diagnosis; GI = Gastrointestinal; OS = Overall Survival; MSCC = Metastatic Spinal Cord Compression; NSCLC = Non–Small Cell Lung Carcinoma; NR = Not Reached; PDS = Posterior Decompression and Stabilization; RCC = Renal Cell Carcinoma; RT = Radiotherapy; SCC = Small Cell Carcinoma; UTI = Urinary Tract Infection*

Survival was the most commonly reported outcome. Different scoring algorithms have been proposed to improve survival prediction among patients with spinal metastases who undergo decompression surgery. 2 studies found that KPS was associated with survival following decompression surgery [9,33]. Ju., *et al.* [25] found that a better preoperative KPS (defined as KPS ≥ 80%) was the only significant predictor of survival in a multivariable study of patients with prostate cancer metastatic to the spine (HR 6.1 [95% CI 1.3 - 28.5], p = 0.02).

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.

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