

Supplementary Table 1. 47 papers were included in this study, consisting of 807 patients. Class II evidence was available in 3 papers, Class III in 3 papers, Class IV in 15 papers, and Class V in 26 papers.

Author	Study Design and Class of Evidence	Demographics	Inclusion Criteria	Location	Treatment	Primary Endpoints/Results
Han et al. (2015)	Retrospective Review <i>Level IV</i>	N=30 Gender=83.3% (25/30) Male	Inclusion: All patients presented with epidural compression from clear cell renal cell carcinoma (CCRCC). Pain was the most common reported symptom.	Cervical: 13 Thoracic: 6 Lumbar: 15 Sacrum: 5	All patients had surgery for decompression and surgical excision. A total of 35 procedures were performed. Pre-operative embolization in 17/30 patients	<u>Mean survival (N=30)</u> 17 months (12-32)
Petteys et al. (2015)	Retrospective Review <i>Level IV</i>	N=30 Gender: 23/30 (76.7%) male. Mean age: 57.6 years (29-76). KPS 80-100: N=20 50-70: N=5 10-40: N=5 Significant pain in 21/30 (70%) Neurologic Dysfunction in 9/30 (30%)	Inclusion: 30 patients with metastatic RCC treated with surgery from January 2000-December 2011 were included in this study	Not stated	30 patients underwent a total of 40 spine operations. <u>Pre-op RT</u> 15 (50%) <u>Pre-op chemo/immunotherapy</u> 12 (40%) <u>Pre-op transarterial embolization</u> 24 (80%)	<u>Median survival (n):</u> Median overall survival (30)=11.4 months. <u>Survival by Tokuhashi score (n)</u> 12-15 (15)= 32.9 months. 9-11 (7)= 11.7 months. 0-8 (8): 5.4 months.
Sellin et al. (2015)	Retrospective Review <i>Level IV</i>	N=37 Median age=37 years Gender=75.7% (28/37) male. Median age=62.2 years Of 37 patients 32 had no neurologic deficit prior to SRS.	Inclusion: 37 patients with metastatic RCC to the spine were treated with stereotactic radiosurgery (SRS) from 2005-2012.	Cervical=2 Thoracic=13 Lumbosacral=22	37 patients were treated with SRS for 40 sites of metastasis. 5 patients went on to receive surgery.	<u>Median overall survival (N=37):</u> 16.3 months (7.4-25.3). <u>Median survival by presence/absence of neurologic deficit</u> Pre-op neurologic deficit (N=5): 7.4 months No pre-op neuro deficit (N=32): 22.1
Thibault et al. (2014)	Prospective Study <i>Level II</i>	N=37 Median Age=63 years (33-82) Gender=67.6% (25/37) male.	Inclusion: 37 patients with metastatic RCC to the spine were treated. Exclusion: 37 patients had RCC involvement in 71 vertebral segments.	71 segments in 37 patients: Cervical: 9 Thoracic: 33 Lumbar: 21 Sacral: 8	All patients were treated with stereotactic body radiotherapy (SBRT). 17/71 segments underwent surgery before SBRT, 10/71 underwent surgery following SBRT.	<u>Median overall survival (N=37)</u> 26.6 months (0.4-189) 1-year overall survival: 64% 1-year local control (LC)=83%
Bakker et al. (2014)	Retrospective Review <i>Level IV</i>	N=21	Inclusion: 21 patients presented with epidural metastases due to RCC from 2006-2012.	20/21 had metastases in the thoracic or lumbar spine. Location for remaining patient not stated.	All 21 patients were treated with pre-operative embolization and intralesional tumor resection.	<u>Median survival:</u> <ul style="list-style-type: none"> • Motzer favorable risk: 25 months (11-75) • Motzer intermediate risk: 6 months (1-25) • Motzer poor risk: 2 months (2-4)
Sohn et al. (2014)	Retrospective Review <i>Level III</i>	N=26 (13 SRS, 13 RT)	Inclusion: 26 patients with metastatic RCC to the spine.	<u>SRS</u> Cervical=3 Thoracic=10 Lumbar=4 Sacral=0	13 patients were treated with SRS, consisting of Novalis shaped beam radiosurgical unit or Cyberknife. The other	<u>Median survival:</u> RT (N=13): 7 months SRS (N=13): 15 months

				RT Cervical=1 Thoracic=6 Lumbar=10 Sacral=3	13 patients were treated with RT.	
Tatsui et al. (2014)	Retrospective Review <i>Level IV</i>	N=267 Median age: 58 years Gender: 206/207 (77.2%) Male	Inclusion: 267 patients with metastatic RCC to the spine. Exclusion: Demographics reported by number of treatments, not individual patients.	Cervical=29 Thoracic=177 Lumbar=88 Sacral=19	108 patients had immunotherapy/chemotherapy prior to spine surgery. 99 patients had RT prior to spine surgery. All patients had surgery for spine metastases	<u>Median overall survival (N=267)</u> 11.3 months <u>Survival By Fuhrman Grade</u> Grade 3 or less: 14.3 months Grade 4: 6.1 months Pre-operative <u>Survival by preoperative neurologic deficit</u> Neurologic deficit: 5.9 months No pre-op neuro deficit: 13.5 months
Balagamwala et al. (2012)	Retrospective Review <i>Level IV</i>	N=57 patients undergoing 88 treatments Median age=57.5 (41-88) Gender= 72/88 male (for 88 treatments) Median KPS=80 (50-100)	Inclusion: 57 patients with metastatic RCC to the spine were treated. Exclusion: Demographics reported by number of treatments, not individual patients.	Not Stated	All 57 patients received SBRT for RCC spine metastases for a total of 88 treatments. 24/88 spine segments had prior surgery	<u>Median overall survival (N=57)</u> 8.3 months (1.5-38)
Gerszten et al. (2007)	Prospective Study <i>Level II</i>	N=48 patients with 60 metastatic lesions. Mean age: 62 years (45-84) Gender= 28/48 (58.3%)	Inclusion: 48 patients with 60 metastatic RCC lesions to the spine were treated. Exclusion: Survival not reported	60 lesions: Cervical=6 Thoracic=26 Lumbar=18 Sacral=10	All 48 patients were treated with SRS. 42/60 lesions had previous EBRT. 4 patients underwent further open decompressive surgery.	Of patients with pre-operative pain, 89.5% (34/38) improved long-term. Of patients with pre-op neuro deficit, 0% (0/2) improved.
Nguyen et al. (2010).	Prospective Study <i>Level II</i>	N=48 patients with 55 lesions Median age=63 (41-88) years. Gender=75% (36/38) male KPS 100=1 KPS 90=12 KPS 80=23 KPS 70=9 KPS 60=3	Inclusion: 48 patients with 55 metastatic RCC lesions to the spine were treated.	55 lesions: Cervical=6 Thoracic=26 Lumbar=23	All 48 patients were treated with SBRT. 26/48 had previous RT 28/48 had previous spine surgery	<u>Median overall survival (N=48)</u> 22 months 38% (14/37) of patients with pre-existing pain had long-term improvement in pain.
Quraishi et al. (2013)	Retrospective Cohort Study <i>Level III</i>	N=25 Gender=68% (17/25) male.	Inclusion: All patients had metastatic RCC to the spine. 17/25 presented with pain and neurologic dysfunction.	Cervical=2 Thoracic=21 Lumbar=2	Pre-operative embolization and surgical intervention performed for all 25 patients.	<u>Mean overall survival</u> 14.1 months
Donnelly et al. (2015)	Case Report <i>Level V</i>	N=1, Male 59 years-old	Inclusion: patient with severe progressive low back pain due to compression fracture and focal kyphosis at L1	L1	Pre-operative embolization with surgical excision.	Survival not stated. Disease metastasized to the brain, requiring SRS.
Taylor et al. (2015)	Case Series <i>Level IV</i>	N=2 (1 RCC, 1 melanoma) Age: 57 years Gender: Female	Inclusion: Patient with epidural involvement of RCC. Exclusion: Patient with melanoma.	C1	Surgical intervention with post-operative SRS to C1	Improvement of symptoms with local tumor control. Survival not stated.
Wasserman et al.	Case Report	N=1 Age=67 years	Inclusion: Patient with known metastatic RCC	T5-6 foramen and T5 DRG	Surgical intervention	Time from primary to metastasis was 54 months.

(2015)	Level V	Gender=Female				Survival not stated.
Reddy et al. (2015)	Case Report Level V	N=1, Male Age: 66 years	Inclusion: 11 years following diagnosis of primary RCC, patient presented with back pain due to T-spine metastasis	T12	Radiation followed by surgery due to progression of symptoms	<u>Survival from diagnosis of metastatic spine disease</u> 38 months
Dessauvague et al. (2015)	Case Series Level IV	N=2 Gender: 1. 1 Male 2. 1 Female (Mother of #1) Age: 1. 28 2. 54	Inclusion: Both patients had VHL syndrome with metastatic RCC	1. C6-7 2. Thoracic intramedullary	Both patients received surgical intervention	<u>Survival for 1</u> 24 months <u>Survival for 2</u> Not stated
Huelsman et al.	Case Report Level V	N=1 Gender: Male Age: 73 years	Inclusion: Patient with known systemic metastatic RCC presented with hematuria and osseous metastasis	Thoracic and lumbar spine	Sunitinib and radiation	<u>Survival</u> 20 months Diagnosis of spinal metastases occurred 19 months following diagnosis of primary.
Salapura et al. (2014)	Case Report Level V	N=1 Gender: Male Age: 71 years	Inclusion: Patient with known papillary RCC Fuhrman Grade 3 presented with spine met	L1	L1 treated with external beam radiation therapy (EBRT)	Still alive at 36 months following treatment of spine met
Srinivasan et al. (2014)	Case Report Level V	N=1 Gender: Male Age: 40 years	Inclusion: patient presented with Cauda equina syndrome from metastatic RCC	L4-S2 intradural	Subtotal tumor excision followed by palliative RT, cisplatin, and irinotecan.	Gradual improvement in lower extremity strength but died during second cycle of chemotherapy (time not known).
Aparici et al. (2016)	Case Report Level V	N=1 Gender: Male Age: 60 years	Inclusion: History of PRCC	L1	EBRT	Still alive at 36 months following spine treatment <u>Time from diagnosis of primary to spine met</u> 48 months
Bai et al. (2014)	Case Report Level V	N=1 Gender: Male Age: 76 years	Inclusion: Decreased motor and sensation in lower extremities due to metastatic RCC	T6	Decompressive surgical intervention without pre-operative embolization.	Survival not reported <u>Time from diagnosis of primary to metastasis</u> 12 months
Ben et al. (2015)	Case Report Level V	N=1 Gender: Male Age: 44 years	Inclusion=Patient presented with back pain. Synchronous diagnosis of RCC was made	L1 and pelvis	Not stated	Survival not stated Diagnosis of spine disease and primary made at the same time (synchronous)
Bourlon et al. (2014)	Case Report Level V	N=1 Gender: Female Age: 71 years	Inclusion: Patient had known Fuhrman Grade 2 RCC	C1	Surgical resection followed by IMRT and pazopanib.	Alive with stable disease 36 months after diagnosis of spine met. T <u>Time from primary to spine met</u> 48 months
Heary et al. (2014)	Case Report Level V	N=1 Gender: Male Age: 54 years	Inclusion: Patient presented with bilateral LE weakness and diminished sensation. Synchronous diagnosis of metastatic RCC was made at the same surgical site of a previous meningioma (WHO I)removal.	T2-T4 intradural	Surgical resection of intradural RCC	<u>Survival</u> 12 months Synchronous diagnosis of metastatic RCC
Hong et al. (2014)	Case Report Level V	N=1 Gender=Male Age=56 years	Inclusion: Patient with known Stage 3, Fuhrman Grade 2 RCC presented with spine metastasis.	T3, L1, and L3	Palliative RT to thoracic and lumbar spine	<u>Survival</u> 3 months
Norberg et al. (2014)	Case Report Level V	N=1 Gender: Male Age: 56 years	Inclusion: Patient presented with hematuria and back pain. Synchronous diagnosis of	T6, T8, T9, T11	Not treated; patient had rapid deterioration.	<u>Survival</u> 1 week after diagnosis of spine met

			metastatic RCC was made.			
Olaniran et al. (2014)	Case Report <i>Level V</i>	N=1 Gender: Female Age: 20 years	Inclusion: Patient presented with back pain and LE weakness. Synchronous diagnosis of metastatic RCC was made.	L2, L3	Oral sunitinib with targeted RT. This was followed by an IL-2 clinical trial.	Survival not stated Synchronous diagnosis.
Kato et al. (2013)	Case Report <i>Level V</i>	N=1 Gender: Male Age: 60 years	Inclusion: Patient with a synchronous diagnosis of Fuhrman Grade 2 metastatic RCC.	T12	Surgical resection followed by post-operative RT and immunotherapy.	Synchronous diagnosis. Survival not stated.
Strong et al. (2013)	Case Series <i>Level IV</i>	N=2 1 Male, 72 years 1 Female, 49 years	Inclusion: 2 patients with metastatic RCC.	M: L4 intradural F: L2	Both patients had surgical resection of spine lesion.	Both patients alive at 24 month follow-up.
Ji et al. (2013)	Case Report <i>Level V</i>	N=1 Gender: Male Age: 68 years	Inclusion: Patient with known RCC presented with lower back pain from spine met.	T12-L1 IDEM (intradural extramedullary)	Surgical resection of metastatic spine lesion.	Still alive at 24-month follow up <u>Time from diagnosis of primary to spine met</u> 192 months
Park et al. (2013)	Case Report <i>Level V</i>	N=1 Gender: Male Age: 44 years	Inclusion: Patient with known RCC presented with rapid progressive paraparesis, bowel/bladder incontinence, and LE numbness.	T12 intramedullary	RT, sunitinib followed by surgical resection	Alive at 6 month follow-up <u>Time from diagnosis of primary to spine met</u> 6 months
Clarençon et al. (2013)	Case Report <i>Level V</i>	N=1 Gender=Male Age=71 years	Inclusion: patient presented with low back pain and LE paresthesias.	Sacrum	Pre-operative embolization with cryoablation and sacroplasty.	Survival not known
Dobson et al. (2013)	Case Report <i>Level V</i>	N=1 Gender=Femle Age=81 years	Inclusion: Patient presented with sciatica, fecal incontinence, and urinary retention. Diagnosis of synchronous metastatic RCC was made.	L2 intradural	Surgical resection with post-operative RT	Still alive at 36 months following spine treatment. Synchronous diagnosis of metastatic RCC.
Quraishi et al. (2013)	Case Series <i>Level IV</i>	Gender (N=6) 1. M 2. F 3. M 4. F 5. F 6. M Age (years): 1. 68 2. 59 3. 66 4. 65 5. 45 6. 79 Frankel Grade: 1. D 2. D 3. D 4. E 5. C 6. E	Inclusion: All patients had metastatic RCC to the spine	Location of affected levels not stated.	All patients were surgically treated; 1. L5 decompression 2. L5-S1 decompression 3. L5-S2 decompression 4. L4-S1 corpectomy 5. L5 laminectomy/kyphoplasty, L3-iliac wing fixation 6. L5-S1 decompression	Survival: 1. 603 days 2. 581 days 3. 486 days 4. 171 days 5. 98- days 6. 150 days
Azad et al. (2013)	Case Report <i>Level V</i>	N=1 Gender=Male Age=60 years	Inclusion: Patient with metastatic RCC to the spine	T9 and L4	Pazopanib and RT	Alive at 5 months following spine treatment
Hennessey et al. (2013)	Case Report <i>Level V</i>	N=1 Gender: Male, 21 years	Inclusion: Patient presented with with back pain, LE weakness and hyper-reflexia. Synchronous diagnosis of metastatic mixed	T12, L3, L4	Pre-operative embolization and surgical treatment at L4. Post-operative sunitinib.	<u>Survival</u> 8 months

			collecting duct RCC was made.			
Inoue et al. (2013)	Case Report <i>Level V</i>	N=1 Gender=Male Age=49 years	Inclusion: Patient presented with thoracic kyphosis and gait disturbances. Synchronous diagnosis of metastatic RCC was made.	T11	RT, sorafenib, sunitinib followed by surgical resection.	Alive at 1 year follow-up Synchronous diagnosis of metastatic RCC to the spine.
Quraishi et al. (2013)	Case Report <i>Level V</i>	N=1 Gender: Male, 54 years	Inclusion: Patient with neck and L arm pain, sensory loss, UE weakness, and hematuria. Synchronous diagnosis of metastatic RCC was made.	C5-6 with spinal cord compression	Pre-operative embolization followed by surgical resection.	<u>Survival</u> 12 months Synchronous diagnosis of metastatic RCC to the spine.
Yuasa et al. (2013)	Case Report <i>Level V</i>	N=1 Gender: Male, 65 years	Inclusion: Patient with known RCC presented with bilateral LE paralysis.	Thoracic (level not specified)	RT to T5-8 followed by sunitinib and sorafenib	Alive 4 months following spine treatment. <u>Time from diagnosis of primary to spine met</u> 2 months Complete neurologic recovery.
Kim et al. (2009)	Case Report <i>Level V</i>	N=1 Gender: Male Age: 41 years	Inclusion: Patient with known RCC presented with pain from spine metastasis.	L2 IDEM	Surgical resection	Time from diagnosis of primary to spine met=12 months Asymptomatic and alive at 12 month follow-up.
Donovan et al. ()	Case Report <i>Level V</i>	N=1 Age: 41 years Gender=Female	Inclusion: Patient presented with left-sided numbness with right-sided weakness. Synchronous diagnosis of metastatic RCC was made.	C4 intramedullary	Surgical resection of spine lesion followed by RT for tumors in spine, ribs, skull, and femur.	<u>Survival</u> 2 months Synchronous diagnosis of metastatic RCC.
Jackson et al. (2001)	Retrospective Review <i>Level IV</i>	N=79 Mean age: 55 years (16-82) Gender= 63/79 (80%)	Inclusion: 79 patients with metastatic RCC to the spine were identified upon retrospective review at a single institution from 1993-1999.	107 lesions: O-C junction: 2 Cervical: 7 Cervicothoracic: 5 Thoracic: 40 Thoracolumbar: 19 Lumbar: 28 Lumbosacral junction: 2 Sacrum: 2	All patients had surgical intervention. <u>Pre-operative Medical intervention</u> 1. RT: 40/79 (51%) 2. And/or Chemotherapy/immunotherapy: 48/79 (61%) <u>Pre-operative embolization</u> 47 operations.	<u>Median overall survival (N=79)</u> 2.3 months <u>Mean overall survival (by Kaplan-Meier) (N=79)</u> 12 months <u>Mean for those with known survival (N=57)</u> 7.75 months
Sundaresan et al. (1986)	Retrospective Cohort <i>Level III</i>	N=43 Gender: 32/43 Male (74.4%)	Inclusion: Retrospective review identified 43 patients treated with metastatic RCC to the spine over a 7-year period.	Not stated	32 patients were treated with surgical intervention. 11 patients were treated with RT	Median survival for patients treated with surgery: 13 months (N=32) Median survival for patients with RT alone: 3 months (N=11)
Sundaresan et al. (1990)	Retrospective Review <i>Level IV</i>	N=30 Gender not known	Inclusion: Retrospective over a 5-year period identified 30 patients surgically treated for metastatic RCC to the spine.	Not stated	All 30 patients were treated with surgery. 17/30 patients had surgery after failed RT.	Median survival=16 months. 27/30 (90%) had neurologic improvement after surgery.
King et al. (1991)	Retrospective Review <i>Level IV</i>	N=33 Gender= 18/30 Male (60%)	Inclusion: 33 patients with metastatic RCC to the spine were treated over a 5-year period.	Cervical=8 Thoracic=6 Lumbar=19	All 33 patients were treated with decompressive surgery.	<u>Mean overall survival (N=31)</u> 8 months

			20/33 had neurologic dysfunction.			2 still alive
Tomita et al. (1994)	Case Series <i>Level V</i>	Gender (N=4) 1. Female 2. Male 3. Male 4. Male Age (years): 1. 67 2. 75 3. 52 4. 57	Inclusion: 24 patients were included in this series. 4 had metastatic RCC to the spine.	1. L3 2. L3 3. L2 4. L4	All 4 with metastatic RCC were treated with total en bloc spondylectomy (TES)	<u>Survival</u> 1. Alive at 32 months 2. Alive at 16 months 3. Alive at 8 months 4. Alive at 6 months
Sakaura et al.	Retrospective review <i>Level IV</i>	N=3, all Male <u>Age (years)</u> 1. 68 2. 65 3. 62	Inclusion: 12 patients underwent TES for metastatic spine lesions over a 6 year period. 2 had metastatic RCC to the spine.	1. T11 2. L2 3. T6	All patients were surgically treated with TES	<u>Survival</u> 1. 64 months 2. 16 months 3. Alive at 60 months
Giehl et al. (1999)	Case Series <i>Level IV</i>	N=11	Inclusion: All 11 patients had metastatic RCC to the spine	Not Stated	All patients were treated with surgical intervention	<u>Median overall survival</u> 10 months for patients with multiple osseous lesions, several years for solitary lesion

Abbreviations: RCC: Renal Cell Carcinoma; IDEM: Intradural extramedullary; SRS: Stereotactic radiosurgery; RT: Radiation therapy; KPS: Karnofsky Performance Status