National Institute for Health and Care Excellence

Final

Spinal metastases and metastatic spinal cord compression

[K] Evidence reviews for prognostic tools – spinal instability

NICE guideline number NG234

Evidence reviews underpinning recommendation 1.9.1 in the NICE guideline

September 2023

Final

These evidence reviews were developed by NICE

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Contents

Prognostic tools - spinal instability **6**
Review question 6
Introduction 6
Summary of the protocol 6
Methods and process 6
Prognostic evidence 7
Summary of included studies 7
Summary of the evidence 8
Economic evidence 8
Economic model 8
The committee's discussion and interpretation of the evidence 8
Recommendations supported by this evidence review 10
References – included studies 10
Appendices **11**
Appendix A Review protocols **11**
Review protocol for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression? 11
Appendix B Search strategy (clinical/economic) **20**
Literature search strategies for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression? 20
Appendix C Prognostic evidence study selection **22**
Study selection for: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression? 22
Appendix D Evidence tables **23**
Evidence tables for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression? 23
Appendix E Forest plots **27**
Forest plots for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression? 27
Appendix F Modified GRADE tables **28**
GRADE tables for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without

spinal cord compression? 28

Appendix G Economic evidence study selection 29

Study selection for: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression? 29

Appendix H Economic evidence tables 30

Economic evidence tables for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression? 30

Appendix I Economic model 31

Economic model for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression? 31

Appendix J Excluded studies 32

Excluded studies for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression? 32

Appendix K Research recommendations – full details 54

Research recommendations for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression? 54

Appendix L Study data (thresholds and true positive, false positive, false negative, true negative values) 55

Study data extracted for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression? 55

Prognostic tools - spinal instability

Review question

What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?

Introduction

Scoring systems to evaluate spinal instability in people with spinal metastases or direct malignant infiltration of the spine can be used to inform surgical decision making and to aid communication within the multidisciplinary team. The review aims to evaluate the accuracy of such scoring systems.

Summary of the protocol

See Table 1 for a summary of the Population, Index test (clinical prediction model) and Outcome (PIO) characteristics of this review.

Table 1: Summary of the protocol (PIO table)

Population	• Adults with:
	  ○ metastatic spinal disease
	  ○ direct malignant infiltration of the spine
	• Adults with confirmed spinal cord or nerve root compression because of
	  ○ metastatic spinal disease
	  ○ direct malignant infiltration.

Index test (clinical prediction model)	• Multivariable prognostic tools such to predict spinal stability, for example:
	  ○ Spine Instability Neoplastic Score (SINS)
	  ○ MM (multiple myeloma) spinal stability scoring system

Outcome	**Critical** Accuracy of the scoring system for: • Spinal stability **Important** Accuracy of the scoring system for: • Neurological and functional status • Quality of life • Pain • Performance status • Evidence of cord compression • Spinal deformity

For further details see the review protocol in appendix A.

Methods and process

This evidence review was developed using the methods and process described in Developing NICE guidelines: the manual. Methods specific to this review question are described in the review protocol in appendix A and the methods document (supplementary document 1).

Declarations of interest were recorded according to NICE's conflicts of interest policy.

Prognostic evidence

Included studies

Two studies were included for this review, 1 systematic review (Kim 2021) and 1 retrospective cohort study (Ehresman 2020) which was used to update the meta-analysis of the systematic review.

Both studies evaluated the accuracy of the Spinal Instability Neoplastic Score (SINS) to predict vertebral compression fractures after treatment in patients with spinal metastases.

The included studies are summarised in Table 2.

See the literature search strategy in appendix B and study selection flow chart in appendix C.

Excluded studies

Studies not included in this review are listed, and reasons for their exclusion are provided in appendix K.

Summary of included studies

Summaries of the studies that were included in this review are presented in Table 2.

Table 2: Summary of included studies.

Study	Population	Clinical prediction tool	Outcomes
Ehresman 2020 Retrospective cohort study USA	N=105 Patients with spinal metastasis treated with SBRT or neurosurgery Age, mean (SD) years: 61.2 (SD not reported) Sex: female n=48, male n=57.	• SINS to predict VCF	Accuracy of the scoring system for spinal stability: • Sensitivity • Specificity
Kim 2021 Systematic review International	N=7 studies including 798 patients People with spinal metastasis treated with SBRT or conventional RT Age, mean (SD) years: mean ages of the patients included across studies ranged from 57 to 67 (SD not reported) Sex: not reported.	• SINS to predict VCF	Accuracy of the scoring system for spinal stability: • Sensitivity • Specificity

RT: radiotherapy; SBRT: stereotactic body radiotherapy; SD: standard deviation; SINS: spinal instability neoplastic score; VCF: vertebral compression fractures

See the full evidence tables in appendix D, the forest plots in appendix E and for study data see appendix L.

Summary of the evidence

The evidence was limited to studies validating the SINS score to predict vertebral compression fractures (VCF) following treatment. The evidence indicates that SINS score of 7 or more has a sensitivity of 75% and specificity of 58% for the prediction of new VCF after treatment.

The positive likelihood ratio of 1.8 indicates that SINS score of 7 is not a useful test for identifying those who will develop VCF. The negative likelihood ratio of 0.44 suggests SINS score of 7 is a potentially useful test for identifying those who will not develop VCF.

Assuming that 20% of patients will develop a VCF, a SINS score of 7 or more has a positive predictive value of 31% and a negative predictive value of 90%. This means that 31% of patients in the SINS ≥ 7 group go on to develop VCFs, whereas 90% in the SINS <7 group do not develop VCF. This suggests that SINS <7 may be useful for identifying people at lower VCF risk but SINS ≥ 7 is not particularly useful for identifying people at high VCF risk.

The quality of the evidence for these outcomes was low.

See appendix F for full GRADE tables.

Economic evidence

Included studies

A systematic review of the economic literature was conducted but no economic studies were identified which were applicable to this review question.

A single economic search was undertaken for all topics included in the scope of this guideline. See supplement 2 for details.

Excluded studies

Economic studies not included in this review are listed, and reasons for their exclusion are provided in supplement 2.

Economic model

No economic modelling was undertaken for this review because the committee agreed that other topics were higher priorities for economic evaluation.

The committee's discussion and interpretation of the evidence

The outcomes that matter most

The critical outcome for this review was accuracy of the scoring system for predicting spinal stability. An unstable spine typically requires surgical intervention or immobilisation, so an accurate assessment of the risk of spinal instability contributes to decisions about treatment, in particular avoiding over or under treatment. The committee thought that these scoring systems might also be able to predict some of the consequences of an unstable spine including neurological and functional status, quality of life, pain, performance status, evidence of cord compression and spinal deformity. The accuracy of these predictions was an important outcome.

The quality of the evidence

The quality of the evidence was assessed using modified GRADE and was of low quality. This was because of a serious risk of bias in the included studies and serious imprecision in the pooled outcome.

The evidence was limited to a single scoring system (SINS) at a single threshold and there was no evidence about using these scoring systems to predict neurological and functional status, quality of life, pain, performance status, evidence of cord compression and spinal deformity.

There was no evidence about the calibration of SINS, that is how well the score on SINS relates to absolute risk of spinal instability.

Due to the low quality of the evidence the committee made a weaker recommendation for scoring systems making the use of this optional rather than routine. The committee based this recommendation on their experience and knowledge of other scoring systems as well as the evidence about SINS.

Benefits and harms

The committee discussed the evidence that suggests that SINS <7 may be useful for identifying people at low vertebral compression fracture risk. They agreed that a scoring system for spinal stability could be a helpful addition to clinical assessment, informing management decisions (for example if the spine is stable people would no longer have to be immobilised) and is likely to improve patient outcomes. Whilst they acknowledged that the test did not reliably identify people at high risk (it did not meet their agreed decision thresholds for a useful test), they thought it had value in prompting less experienced clinicians to assess and think about the main features needed to determine spinal stability. Scoring systems also allow assessments to be formalised and standardised, documented and audited, helping to improve sharing of information between healthcare professionals.

They did not want to limit their recommendation to the SINS scoring system, because they acknowledged that other scoring systems may be developed or SINS could be revised or updated. They therefore decided to mention SINS as an example.

Cost effectiveness and resource use

No economic evidence was identified for this topic from the systematic search of previously published evidence. The committee considered cost effectiveness based on their own experience and knowledge.

The committee considered based on their own experience that a scoring system would lead to the standardisation of assessment and may speed up assessments reducing the time needed by clinicians. Standardised assessments with better documentation and auditing may also speed up treatment decision making and prevent repeated assessments where the original was insufficient or where documentation cannot be located. The committee thought there may be some initial upfront costs from implementing scoring systems and documentation systems, but these are likely to be small and a one off.

Evidence was weak around how effective the identified scoring systems were for spinal instability. However, the committee considered, based on their clinical experience, that they may improve the efficiency of treatment decisions around MSCC. This will lead to improved quality of life and potential cost savings through the avoidance of inappropriate or less effective interventions.

Recommendations supported by this evidence review

This evidence review supports recommendation 1.9.1 in the NICE guideline.

References – included studies

Prognostic

Ehresman 2020

Ehresman, J, Schilling A, Pennington Z, et al. A novel MRI-based score assessing trabecular bone quality to predict vertebral compression fractures in patients with spinal metastasis. Journal of Neurosurgery: Spine, 32, 499-506, 2020

Kim 2021

Kim Y, Lee C, Yang S, et al. Accuracy and precision of the spinal instability neoplastic score (SINS) for predicting vertebral compression fractures after radiotherapy in spinal metastases: a meta-analysis. Scientific reports, 11, 5553, 2021

Appendices

Appendix A Review protocols

Review protocol for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?

Table 3: Review protocol

ID	Field	Content
0.	PROSPERO registration number	CRD42022326751
1.	Review title	The prognostic value of scoring systems for spinal instability in people with spinal metastases or direct malignant infiltration of the spine.
2.	Review question	What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?
3.	Objective	To establish the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression.
4.	Searches	The following databases will be searched: • Cochrane Central Register of Controlled Trials (CENTRAL) • Cochrane Database of Systematic Reviews (CDSR) • Cumulative Index to Nursing and Allied Health Literature (CINAHL) • Embase • Epistemonikos • International Health Technology Assessment (IHTA) database • MEDLINE & MEDLINE In-Process Searches will be restricted by:

ID	Field	Content
		• Date: 1990 onwards (see rationale under Section 10) • English language studies • Human studies Other searches: Inclusion lists of systematic reviews With the agreement of the guideline committee, the searches will be re-run between 6-8 weeks before final submission of the review and further studies retrieved for inclusion. The full search strategies for MEDLINE database will be published in the final review.
5.	Condition or domain being studied	Spinal instability relating to spinal metastases, direct malignant infiltration of the spine, spinal cord compression.

6.	Population	Inclusion:
		• Adults with:
		  ○ metastatic spinal disease
		  ○ direct malignant infiltration of the spine
		• Adults with confirmed spinal cord or nerve root compression because of
		  ○ metastatic spinal disease
		  ○ direct malignant infiltration.
		
		Exclusion:
		• Adults with suspected metastatic spinal disease and suspected direct malignant infiltration of the spine.
		• Adults with spinal cord compression because of primary tumours of the spinal cord, meninges or nerve roots.
		• Adults with spinal cord compression because of non-malignant causes.
		• Adults with primary bone tumours of the spinal column.
		• Children and young people under the age of 18.

7.	Presence or absence of a prognostic, risk or predictive factor	Multivariable prognostic tools to predict spinal stability, for example:

ID	Field	Content
		• Spine Instability Neoplastic Score (SINS) • MM (multiple myeloma) spinal stability scoring system
8.	Confounding factors	• Primary tumour type • Performance status • Bone metastases • Bone lesion • Number of involved vertebrae • Neurological status • Tumour location on spine • Spine alignment • Bone density and existing fractures • Pain
9.	Types of study to be included	Observational studies (where neither control nor intervention were assigned by the investigator) including: • Systematic reviews of observational studies. • Prospective and retrospective cohort studies • Case control studies Prospective study designs will be prioritised over retrospective study designs. Population-based studies and multicentre studies will be prioritised.
10.	Other exclusion criteria	Inclusion: • Full text papers • Validated clinical prediction tools will be prioritised for inclusion (where the scoring system has been evaluated in a separate population than that used to derive the model) Exclusion: • Conference abstracts • Articles published before 1990. MRI has regularly used in diagnosis since the early 1990s. IMRT was

ID	Field	Content
		not commercially available until 1994. • Papers that do not include methodological details will not be included as they do not provide sufficient information to evaluate risk of bias/ study quality • Studies using qualitative methods only • Non-English language articles
11.	Context	Metastatic spinal cord compression in adults: risk assessment, diagnosis and management (2008) NICE guideline will be updated by this review question
12.	Primary outcomes (critical outcomes)	Accuracy of the scoring system for: • Spinal stability
13.	Secondary outcomes (important outcomes)	Accuracy of the scoring system for: • Neurological and functional status • Quality of life • Pain • Performance status • Evidence of cord compression • Spinal deformity
14.	Data extraction (selection and coding)	All references identified by the searches and from other sources will be uploaded into EPPI and de-duplicated. Titles and abstracts of the retrieved citations will be screened to identify studies that potentially meet the inclusion criteria outlined in the review protocol. Dual sifting will be performed on at least 10% of records; 90% agreement is required. Disagreements will be resolved via discussion between the two reviewers, and consultation with senior staff if necessary. The full set of records will not be dual screened because the population, interventions and relevant study designs are relatively clear and should be readily identified from titles and abstracts.

ID	Field	Content
		Full versions of the selected studies will be obtained for assessment. Studies that fail to meet the inclusion criteria once the full version has been checked will be excluded at this stage. Each study excluded after checking the full version will be listed, along with the reason for its exclusion. A standardised form will be used to extract data from studies. The following data will be extracted: study details (reference, country where study was carried out, type and dates), participant characteristics, inclusion and exclusion criteria, details of the interventions if relevant, setting and follow-up, relevant outcome data and source of funding. One reviewer will extract relevant data into a standardised form, and this will be quality assessed by a senior reviewer. PICOTS will be extracted from each study. For prediction models, development stage and validation status will be extracted.
15.	Risk of bias (quality) assessment	Risk of bias of individual studies will be assessed using the preferred checklist as described in Developing NICE guidelines: the manual. Quality assessment of individual studies will be performed using the following: • PROBAST tool for clinical prediction models The quality assessment will be performed by one reviewer and this will be quality assessed by a senior reviewer.
16.	Strategy for data synthesis	Depending on the availability of the evidence, the findings will be summarised narratively or quantitatively. Data Synthesis Where possible meta-analysis to combine the effect estimates across studies for each clinical prediction model will be conducted, if studies have comparable populations. We will extract either OR HR; however we will conduct separate meta-analysis for those studies reporting OR and those reporting HR, as it is inappropriate to pool OR and HR. If no meta-analysis is conducted a narrative summary of the available results for each factor will be pro-

ID	Field	Content
		vided. Calibration and discrimination will be assessed for clinical description models. Heterogeneity in the effect estimates of the individual studies will be assessed using the I2 statistic. I2 values of greater than 50% and 80% will be considered as significant and very significant heterogeneity, respectively. In the case of serious or very serious unexplained heterogeneity (remaining after pre-specified subgroup and stratified analyses) meta-analysis will be done using a random effects model. Default MIDs will be used for odds ratios, unless the committee pre-specifies published or other MIDs for specific outcomes • For odds ratios and hazard ratios: 0.8 and 1.25. Validity The confidence in the findings across all available evidence will be evaluated for each outcome using an adaptation of the 'Grading of Recommendations Assessment, Development and Evaluation (GRADE) toolbox' developed by the international GRADE working group: http://www.gradeworkinggroup.org/
/17.	Analysis of sub-groups	Evidence will be stratified by: • Primary cancer type • Ambulant versus non ambulant patients • Neurological symptoms versus none • Bladder and bowel symptoms Where evidence is stratified or subgrouped the committee will consider on a case by case basis if separate recommendations should be made for distinct groups. Separate recommendations may be made where there is evidence of a differential effect of interventions in distinct groups. If there is a lack of evidence in one group, the committee will consider, based on their experience, whether): it is reasonable to extrapolate and assume the interventions will have similar effects in that group compared with others.

ID	Field	Content			
18.	Type and method of review	☐	Intervention		
		☐	Diagnostic		
		☒	Prognostic		
		☐	Qualitative		
		☐	Epidemiologic		
		☐	Service Delivery		
		☐	Other (please specify)		
19.	Language	English			
20.	Country	England			
21.	Anticipated or actual start date	09/09/21			
22.	Anticipated completion date	23/08/23			
23.	Stage of review at time of this submission	Review stage		Started	Completed
		Preliminary searches		☑	☑
		Piloting of the study selection process		☑	☑
		Formal screening of search results against eligibility criteria		☑	☑
		Data extraction		☑	☑
		Risk of bias (quality) assessment		☑	☑
		Data analysis		☑	☑
24.	Named contact	5a. Named contact: National Institute for Health and Care Excellence (NICE) 5b Named contact e-mail: metastaticspinal@nice.org.uk			

ID	Field	Content	
		5e Organisational affiliation of the review: National Institute for Health and Care Excellence (NICE)	
25.	Review team members	National Institute for Health and Care Excellence (NICE) Technical Team	
26.	Funding sources/sponsor	This systematic review is being completed by the National Institute for Health and Care Excellence (NICE).	
27.	Conflicts of interest	All guideline committee members and anyone who has direct input into NICE guidelines (including the evidence review team and expert witnesses) must declare any potential conflicts of interest in line with NICE's code of practice for declaring and dealing with conflicts of interest. Any relevant interests, or changes to interests, will also be declared publicly at the start of each guideline committee meeting. Before each meeting, any potential conflicts of interest will be considered by the guideline committee Chair and a senior member of the development team. Any decisions to exclude a person from all or part of a meeting will be documented. Any changes to a member's declaration of interests will be recorded in the minutes of the meeting. Declarations of interests will be published with the final guideline.	
28.	Collaborators	Development of this systematic review will be overseen by an advisory committee who will use the review to inform the development of evidence-based recommendations in line with section 3 of Developing NICE guidelines: the manual. Members of the guideline committee are available on the NICE website: [NICE guideline webpage].	
29.	Other registration details	N/A	
30.	Reference/URL for published protocol	https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=326751	
31.	Dissemination plans	NICE may use a range of different methods to raise awareness of the guideline. These include standard approaches such as: • notifying registered stakeholders of publication • publicising the guideline through NICE's newsletter and alerts • issuing a press release or briefing as appropriate, posting news articles on the NICE website, using social media channels, and publicising the guideline within NICE.	
32.	Keywords	Humans; Prognosis; Spinal Neoplasms; Spine	
33.	Details of existing review of same topic by same authors	N/A	
34.	Current review status	☐	Ongoing

ID	Field	Content	
		☒	Completed but not published
		☐	Completed and published
		☐	Completed, published and being updated
		☐	Discontinued
35..	Additional information	N/A	
36.	Details of final publication	www.nice.org.uk	

CHARMS: CHecklist for critical Appraisal and data extraction for systematic Reviews of prediction Modelling Studies; CDSR: Cochrane Database of Systematic Reviews; CENTRAL: Cochrane Central Register of Controlled Trials; DARE: Database of Abstracts of Reviews of Effects; GRADE: Grading of Recommendations Assessment, Development and Evaluation; HR: hazard ratio; HTA: Health Technology Assessment; IMRT: intensity modulated radiotherapy; MID: minimal important difference; MRI: magnetic resonance imaging; NHS: National health service; NICE: National Institute for Health and Care Excellence; OR: odds ratio; PROBAST: Prediction model Risk Of Bias ASsessment Tool; RCT: randomised controlled trial; RoB: risk of bias; SD: standard deviation

Appendix B Search strategy (clinical/economic)

Literature search strategies for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?

Database: Medline – OVID interface

#	Searches
1	Spinal Cord Compression/
2	exp Spinal Cord Neoplasms/ or Spinal Neoplasms/
3	((cauda equina or cervical* or cervicothoracic or cord* or coccyx or duralsac* or dural sac* or intervertebr* or lumbar or lumbosac* or lumbo sac* or medulla* or orthothoracic or sacral or sacrum or spinal or spine* or thecal sac* or thoracic or vertebr* or epidural or extradural or extra dural) adj3 (infiltrat* or invad* or invasion or metast* or oligometast*)).ti,ab.
4	(((cauda equina or cervical* or cervicothoracic or cord* or coccyx or duralsac* or dural sac* or intervertebr* or lumbar or lumbosac* or lumbo sac* or medulla* or orthothoracic or sacral or sacrum or spinal or spine* or thecal sac* or thoracic or vertebr* or epidural or extradural or extra dural or ((axon* or neuron* or nerve*) adj2 root)) adj3 (collaps* or compress* or pinch* or press*)) and (adeno* or cancer* or carcinoma* or chordoma* or intraepithelial* or intra epithelial* or malignan* or metast* or neoplas* or oligometast* or tumo?r*)).ti,ab.
5	(mescc or mscc).ti,ab.
6	or/1-5
7	Algorithms/ or exp Decision Support Techniques/ or Health Status Indicators/ or exp "Severity of Illness Index"/ or Models, Statistical/ or Nomograms/
8	(algorithm* or framework* or index or indices or instrument* or model* or nomogra* or protocol* or rule* or scale* or score* or scoring or statistic* or system* or tool*).ti,ab,kw.
9	(anzuategui or bauer or bollen or buddhasothorn or BSH-MSCC or ECOG or frankel or karnofsky or katagiri or harrington or lei or linden or MSTFI or NESMS or NOMS or north or OSRI or rades or SINS or sioutos or SORG or tokuhashi or tomita or weinstein or WBB).ti,ab,kw.
10	or/7-9
11	6 and 10
12	exp Prognosis/
13	(predict* or prognos*).ti.
14	((predict* or prognos*) adj2 (calculat* or calibrat* or classif* or criteria or discriminat* or estimat* or evaluat* or factor* or measur* or multivariab* or multi variab* or outcome* or reclassif* or stratif* or valid* or value* or variab*)).ab.
15	exp Mortality/ or Survival/ or exp Survival Analysis/
16	((predict* or prognos*) adj3 (death? or life expectan* or mortality or surviv*)).ti,ab.
17	validation study.pt.
18	or/12-17
19	11 and 18
20	meta-analysis/ or meta-analysis as topic/ or "systematic review"/
21	(meta analy* or metanaly* or metaanaly* or ((evidence or systematic*) adj2 (overview* or review*))).ti,ab.
22	(reference list* or bibliograph* or hand search* or manual search* or relevant journals).ab.
23	(search strategy or search criteria or systematic search or study selection or data extraction or (search* adj4 literature)).ab.
24	(medline or pubmed or cochrane or embase or psychlit or psyclit or psychinfo or psycinfo or cinahl or science citation index or bids or cancerlit).ab.
25	cochrane.jw.
26	or/20-25
27	19 and 26
28	Observational Studies as Topic/
29	Observational Study/
30	Epidemiologic Studies/
31	exp Case-Control Studies/
32	exp Cohort Studies/
33	Cross-Sectional Studies/
34	Controlled Before-After Studies/
35	Historically Controlled Study/
36	Interrupted Time Series Analysis/
37	Comparative Study.pt.
38	case control$.tw.
39	case series.tw.
40	(cohort adj (study or studies)).tw.
41	cohort analy$.tw.
42	(follow up adj (study or studies)).tw.
43	(observational adj (study or studies)).tw.
44	longitudinal.tw.
45	prospective.tw.
46	retrospective.tw.
47	cross sectional.tw.

#	Searches
48	or/28-47
49	19 and 48
50	27 or 49
51	letter/ or editorial/ or news/ or exp historical article/ or Anecdotes as Topic/ or comment/ or case report/ or (letter or comment*).ti.
52	randomized controlled trial/ or random*.ti,ab.
53	51 not 52
54	(animals/ not humans/) or exp animals, laboratory/ or exp animal experimentation/ or exp models, animal/ or exp rodentia/ or (rat or rats or mouse or mice).ti.
55	53 or 54
56	50 not 55
57	limit 56 to english language
58	limit 57 to yr="1990 -Current"

Health economics search

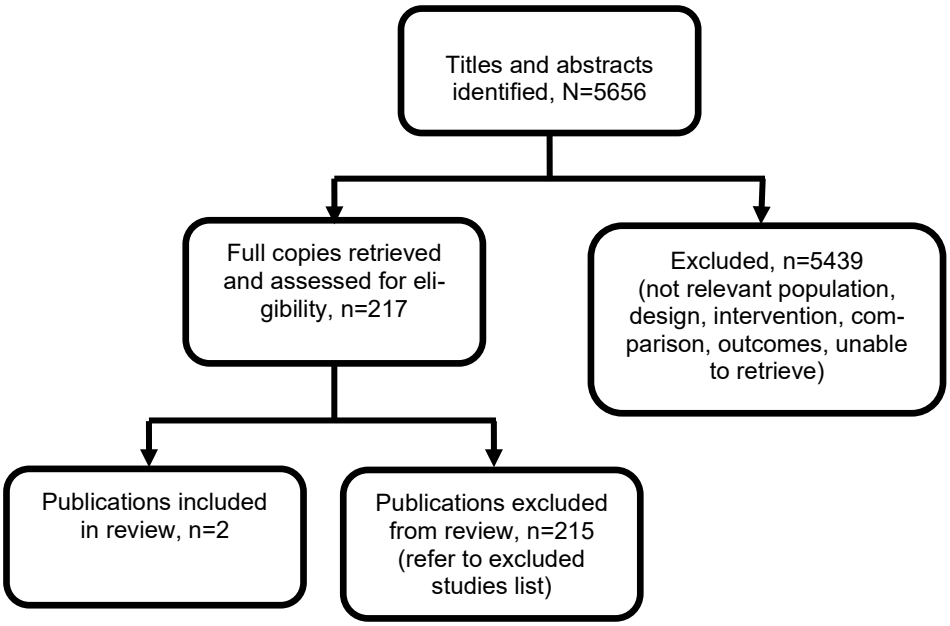
Database: Medline – OVID interface

#	Searches
1	exp Spinal Cord Neoplasms/ or Spinal Neoplasms/
2	((spine or spinal or vertebr*) adj2 (adeno* or cancer* or carcinoma* or intraepithelial* or intra epithelial* or malignan* or neoplas* or tumo?r*)).tw.
3	((spine or spinal or vertebr*) and (metast* or oligometast*)).tw.
4	or/1-3
5	Spinal Cord Compression/
6	((cauda equina or cervical* or cervicothoracic or cord* or coccyx or duralsac* or dural sac* or intervertebr* or lumbar or lumbosac* or lumbo sac* or medulla* or orthothoracic or sacral or sacrum or spinal or spine* or thecal sac* or thoracic or vertebr* or epidural or extradural or extra dural or ((axon* or neuron* or nerve*) adj2 root)) and (collaps* or compress* or pinch* or press*) and (adeno* or cancer* or carcinoma* or chordoma* or intraepithelial* or intra epithelial* or malignan* or metast* or neoplas* or oligometast* or tumo?r*)).tw.
7	(myelopath* or myeloradiculopath* or radiculopath*).tw,hw. or (radicular adj2 (disorder* or syndrome*)).tw.
8	(mescc or mscc).tw.
9	or/5-8
10	((adeno* or cancer* or carcinoma* or intraepithelial* or intra epithelial* or malignan* or metast* or neoplas* or tumo?r*) adj3 (escap* or infiltrat* or invasiv* or metast* or spread*) adj5 (cauda equina or cervical* or cervicothoracic or cord* or coccyx or duralsac* or dural sac* or intervertebr* or lumbar or lumbosac* or lumbo sac* or medulla* or orthothoracic or sacral or sacrum or spinal or spine* or thecal sac* or thoracic or vertebr* or epidural or extradural or extra dural or ((axon* or neuron* or nerve*) adj2 root))).tw.
11	or/4,9-10
12	Economics/ or Value of life/ or exp "Costs and Cost Analysis"/ or exp Economics, Hospital/ or exp Economics, Medical/ or Economics, Nursing/ or Economics, Pharmaceutical/ or exp "Fees and Charges"/ or exp Budgets/
13	(cost* or economic* or pharmacoeconomic*).ti.
14	(budget* or financ* or fee or fees or price* or pricing* or (value adj2 (money or monetary))).ti,ab.
15	(cost* adj2 (effective* or utilit* or benefit* or minimi* or unit* or estimat* or variable*)).ab.
16	or/12-15
17	11 and 16
18	limit 17 to english language
19	limit 18 to yr="2005 -Current"

Appendix C Prognostic evidence study selection

Study selection for: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?

Figure 1: Study selection flow chart



Appendix D Evidence tables

Evidence tables for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?

Ehresman 2020

Ehresman, J, Schilling A, Pennington Z, et al. A novel MRI-based score assessing trabecular bone quality to predict vertebral compression fractures in patients with spinal metastasis. Journal of Neurosurgery: Spine, 32, 499-506, 2020

Study details

Country/ies where study was carried out	USA
Study type	Retrospective cohort study
Study dates	2012 to 2019
Inclusion criteria	Patients who had undergone either radiation therapy or surgical intervention at Johns Hopkins Hospital, at least 18 years old, had a diagnosis of spinal metastasis, had undergone T1- weighted non–contrast-enhanced MRI of the lumbar spine without previous lumbar instrumentation, had presented with no more than one previous VCF, and had attended follow-up examinations for at least 6 months after the diagnosis of spine metastasis.
Exclusion criteria	Early surgical intervention at the index level, before the lesion could be monitored for at least 6 months. Presentation with multiple compression fractures or a diagnosis of infection.
Patient characteristics	N=105 Sex [male/female]: 57/48 Age, mean (SD), years: 61.2 (not reported) Primary cancer types [percentage of each]: Not reported. Ambulant patients [percentage who were ambulant]: Not reported. Patients with neurological symptoms [percentage with neurological symptoms]: Not reported. Patients with bladder or bowel symptoms [percentage with bladder/bowel symptoms]: Not reported.
Predictors	• SINS (at threshold of 7) • VBQ (a new MRI-based prediction model - not included in our analysis due to lack of external validation)
Reference standard	Repeated MRI every 3 months for the 1st year of spinal metastases diagnosis, every 4 months for the 2nd year, and

	every 6 months thereafter.
Type of prediction study	Model development (VBQ model) and external validation (SINS model) study.
Duration of follow-up	Median 26 months for those with VCF and 34 months for those without VCF
Setting	Tertiary care
Sources of funding	Not reported
Results	See Appendix L Study data

Critical appraisal - PROBAST tool

Section	Question	Answer
Selection of participants	Risk of bias for selection of participants	Unclear *(Limited to patients treated with SBRT or surgery. Patients were excluded if they had early surgical intervention, before the lesion could be monitored for 6 months. Those with multiple fractures at presentation were excluded.)*
Selection of participants	Concerns about applicability of selection of participants	Unclear. *Potentially a lower risk group.*
Predictors or their assessment	Risk of bias for predictors or their assessment	Unclear *(The SINS score was calculated retrospectively using medical records, so the investigators would have known the outcome (blinding not mentioned).)*
Predictors or their assessment	Concerns about applicability of predictors or their assessment	Low
Outcome or its determination	Risk of bias for outcome or its determination	Low
Outcome or its determination	Concerns about applicability of outcome or its determination	Low
Analysis	Risk of bias for analysis	Low
Overall Risk of bias and Applicability	Risk of bias	Unclear
Overall Risk of bias and Applicability	Concerns about applicability	Unclear

Kim 2021

Kim Y, Lee C, Yang S, et al. Accuracy and precision of the spinal instability neoplastic score (SINS) for predicting vertebral compression fractures after radiotherapy in spinal metastases: a meta-analysis. Scientific reports, 11, 5553, 2021

Study details

Country/ies where study was carried out	Systematic review includes studies from Canada, USA, Japan, Korea, Spain, Brazil and international multicentre studies.
Study type	Systematic review of retrospective cohort studies
Study dates	Search was done in January 2020. Included studies were published from 2011 to 2018
Inclusion criteria	Published studies that: • used the SINS to predict VCFs in patients with spinal metastases • reported the numbers of patients for 2 or 3 SINS categories and the number of VCFs • studies that used data with sufficient information to assess true-positive (TP; fracture in the unstable group), true-negative (TN; no fracture in the stable group), false-positive (FP; fracture in the stable group), and false-negative (FN; no fracture in the unstable group) cases.
Exclusion criteria	Duplicate studies, narrative reviews, letters, editorials, comments, and case reports. Studies were also excluded if they included primary tumours, used the SINS to predict other outcomes (such as overall survival); or did not report target outcomes.
Patient characteristics	7 studies (N=798 patients) reported the accuracy of the SINS: Cunha 2012, Sahgal 2013, Thibault 2014, Thibault 2015, Aiba 2016, Shi 2018 and Lee 2018. People with spinal metastasis treated with SBRT or conventional RT. Most studies included multiple primary cancer types, but Thibault (2014, 2015) was limited to renal cancer, Aiba (2016) NSC lung cancer and Lee (2018) colorectal cancer. Age, mean (SD), years: mean age of the included patients by study ranged from 57 to 67 years (SD not reported). Sex [male/female]:: not reported
Predictors	SINS (at threshold of 7)
Reference standard	MRI
Type of prediction study	Model external validation
Duration of follow-up	Mean follow up ranged from 5.9 months to 12.3 months
Setting	Tertiary care

Sources of funding	Not reported
Results	See Appendix L Study data

Critical appraisal – ROBIS checklist

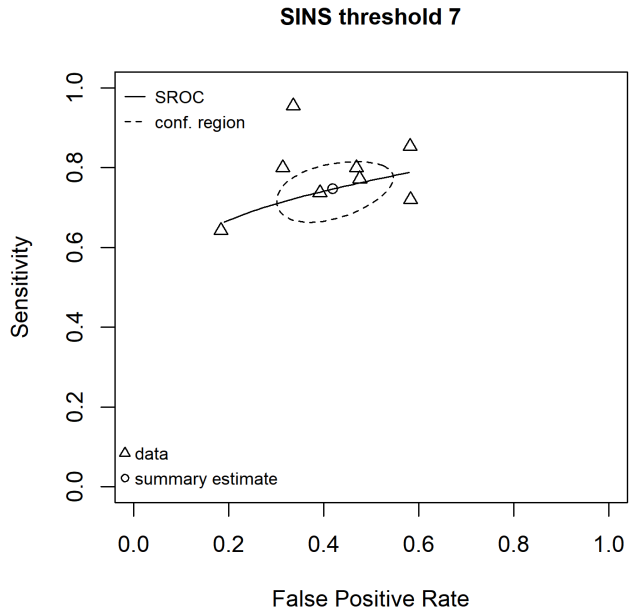
Section	Question	Answer
Study eligibility criteria	Concerns regarding specification of study eligibility criteria	Low
Identification and selection of studies	Concerns regarding methods used to identify and/or select studies	Low
Data collection and study appraisal	Concerns regarding methods used to collect data and appraise studies	Unclear. (*Details of treatment [such as type of RT] not provided).*
Synthesis and findings	Concerns regarding the synthesis and findings	Unclear. (*Between study heterogeneity not addressed. No funnel plot or sensitivity analyses.)*
Overall study ratings	Overall risk of bias	Unclear
Overall study ratings	Applicability as a source of data	Fully applicable

Appendix E Forest plots

Forest plots for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?

This section includes forest plots only for outcomes that are meta-analysed. Outcomes from single studies are not presented here; the quality assessment for such outcomes is provided in the GRADE profiles in appendix F.

Figure 2: Accuracy of Spinal Instability Neoplastic Score (at a threshold of 7) to predict vertebral compression fractures



SROC: summary receiver operating characteristic curve.

Data from Kim (2021) systematic review updated with Ehresman (2020)

Appendix F Modified GRADE tables

GRADE tables for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?

Table 4: Evidence profile for Spinal Instability Neoplastic Score to predict vertebral compression fractures

No. of studies	Study design	Sample size	Prevalence of VCF (%)	Sensitivity (95% CI)	Specificity (95% CI)	Likelihood ratios (95% CI)	Risk of bias	Inconsistency	Indirectness	Imprecision[1]	Quality	Importance
Prognostic accuracy at threshold of 7												
8[2]	Cohort studies	1373	Median 18 (range 11 to 53)	0.75 [0.68-0.80]	0.58 [0.48-0.68]	LR+ 1.80 [1.45–2.26]	Serious[3]	Not serious	Not serious	Serious[4]	LOW	CRITICAL
						LR- 0.44 [0.35–0.55]				Serious[5]	LOW	

CI, confidence interval; LR+, positive likelihood ratio; LR-, negative likelihood ratio; VCF: vertebral compression fractures
1. Precision ratings based on positive and negative likelihood ratios
2. Ehresman 2020, Kim 2021 systematic review (Aiba 2016, Cunha 2012, Lee 2018, Saghal 2013, Shi 2018, Thibault 2014, Thibault 2015)
3. Serious risk of bias as per ROBIS and PROBAST
4. LR+ 95% CI crosses 1 default MID (2,5)
5. LR- 95% CI crosses 1 default MID (0.2,0.5)

Appendix G Economic evidence study selection

Study selection for: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?

No economic evidence was identified which was applicable to this review question.

Appendix H Economic evidence tables

Economic evidence tables for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?

No evidence was identified which was applicable to this review question.

Appendix I Economic model

Economic model for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?

No economic analysis was conducted for this review question.

Appendix J Excluded studies

Excluded studies for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?

Excluded prognostic studies

Table 5: Excluded studies and reasons for their exclusion

Study	Reason for exclusion
Ahmed, A Karim; Goodwin, C Rory; Heravi, Amir; Kim, Rachel; Abu-Bonsrah, Nancy; Sankey, Eric; Kerekes, Daniel; De la Garza Ramos, Rafael; Schwab, Joseph; Sciubba, Daniel M; Predicting survival for metastatic spine disease: a comparison of nine scoring systems.; The spine journal; 2018; vol. 18 (no. 10); 1804-1814	Outcomes do not match review protocol – overall survival not spinal stability
Abbouchie, Hussein, Chao, Michael, Tacey, Mark et al. (2020) Vertebral fractures following stereotactic body radiotherapy for spine metastases. Journal of medical imaging and radiation oncology 64(2): 293-302	Outcomes do not match review protocol– does not report data relevant to prognostic value of a scoring system
Afsar, Afifa; Qadeer, Mohsin; Sharif, Salman (2017) Surgically treated spinal metastases: Do prognostic scores have a role?. Surgical neurology international 8: 158	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Aiba, Hisaki, Kimura, Tomoki, Yamagami, Takaya et al. (2016) Prediction of skeletal-related events in patients with non-small cell lung cancer. Supportive care in cancer : 24(8): 3361-7	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Amelot, A., Cristini, J., Salaud, C. et al. (2017) Overall survival in spine myeloma metastases: Difficulties in predicting with prognostic scores. Spine 42(6): 400-406	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Anonymous. (2022) Erratum to: Validation and simplification of a score predicting survival in patients irradiated for metastatic spinal cord compression (Cancer, 116, 15, (3670-3673), 10.1002/cncr.25223). Cancer 128(3): 633-634	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Anzuategui, Pedro Reggiani, Cunha, Luiz Antonio Munhoz da, Mello, Glauco Jose Pauka et al. (2019) Spinal Metastasis Surgery: A Proposal for a Predictive Model of Morbidity and Mortality. Revista brasileira de ortopedia 54(6): 665-672	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Aoude, A, Fortin, M, Aldebeyan, Sulta et al. (2018) The revised Tokuhashi score; analysis of parameters and assessment of its accuracy in determining survival in patients afflicted with spinal metastasis. European spine journal, 27(4): 835-840	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Aoude, Ahmed and Amiot, Louis-Philippe (2014) A comparison of the modified Tokuhashi and	Outcomes do not match review protocol – does

Study	Reason for exclusion
Tomita scores in determining prognosis for patients afflicted with spinal metastasis. Canadian journal of surgery. Journal canadien de chirurgie 57(3): 188-93	not report data relevant to prognostic value of a scoring system
Armstrong, Terri S, Gning, Ibrahima, Mendoza, Tito R et al. (2010) Reliability and validity of the M. D. Anderson Symptom Inventory-Spine Tumor Module. Journal of neurosurgery. Spine 12(4): 421-30	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Atkinson, R.A., Davies, B., Jones, A. et al. (2016) Survival of patients undergoing surgery for metastatic spinal tumours and the impact of surgical site infection. Journal of Hospital Infection 94(1): 80-85	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Balain, B; Jaiswal, A; Trivedi, J M; Eisenstein, S M; Kuiper, J H; Jaffray, D C; The Oswestry Risk Index: an aid in the treatment of metastatic disease of the spine.; The bone & joint journal; 2013; vol. 95b (no. 2); 210-6	Outcomes do not match review protocol – overall survival
Balagamwala, Ehsan H, Miller, Jacob A, Reddy, Chandana A et al. (2018) Recursive partitioning analysis is predictive of overall survival for patients undergoing spine stereotactic radiosurgery. Journal of neuro-oncology 137(2): 289-293	Publication type – conference abstract
Bartels, R.H.M.A., Feuth, T., Rades, D. et al. (2011) External validation of a model to predict the survival of patients presenting with a spinal epidural metastasis. Cancer and Metastasis Reviews 30(2): 153-159	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Bartels, Ronald H M A, de Ruiter, Godard, Feuth, Ton et al. (2016) Prediction of life expectancy in patients with spinal epidural metastasis. Neuro-oncology 18(1): 114-8	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Bollen, Laurens, Groenen, Karlijn, Pondaag, Willem et al. (2017) Clinical Evaluation of the Spinal Instability Neoplastic Score in Patients Treated With Radiotherapy for Symptomatic Spinal Bone Metastases. Spine 42(16): e956-e962	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Bollen, Laurens; Wibmer, Christine; Van der Linden, Yvette M; Pondaag, Willem; Fiocco, Marta; Peul, Wilco C; Marijnen, Corrie A M; Nelissen, Rob G H; Leithner, Andreas; Dijkstra, Sander P D; Predictive Value of Six Prognostic Scoring Systems for Spinal Bone Metastases: An Analysis Based on 1379 Patients.; Spine; 2016; vol. 41 (no. 3); e155-62	Outcomes do not match review protocol – overall survival
Bongers, Michiel E R, Karhade, Aditya V, Villavieja, Jemma et al. (2020) Does the SORG algorithm generalize to a contemporary cohort of patients with spinal metastases on external validation?. The spine journal, 20(10): 1646-1652	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Buergy, Daniel, Siedlitzki, Lena, Boda-Heggemann, Judit et al. (2016) Overall survival after reirradiation of spinal metastases - independent validation of predictive models. Radiation oncology (London, England) 11: 35	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system

Study	Reason for exclusion
Cai, Zhenyu, Tang, Xiaodong, Yang, Rongli et al. (2019) Modified score based on revised Tokuhashi score is needed for the determination of surgical intervention in patients with lung cancer metastases to the spine. World journal of surgical oncology 17(1): 194	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Carrwik, Christian; Olerud, Claes; Robinson, Yohan (2020) Predictive Scores Underestimate Survival of Patients With Metastatic Spine Disease: A Retrospective Study of 315 Patients in Sweden. Spine 45(6): 414-419	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Chang, Sam Yeol, Ha, Jae Hong, Seo, Sang Gyo et al. (2018) Prognosis of Single Spinal Metastatic Tumors: Predictive Value of the Spinal Instability Neoplastic Score System for Spinal Adverse Events. Asian spine journal 12(5): 919-926	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Chantharakhit, Chaichana and Sujaritvanichpong, Nantapa (2022) Prognostic Scoring System Development for Malignant Spinal Cord Compression. Asian Pacific journal of cancer prevention, 23(2): 623-630	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Chao S, Koyfman S, Woody N, et al. (2012) Recursive partitioning analysis index is predictive for overall survival in patients undergoing spine stereotactic body radiation therapy for spinal metastases. International journal of radiation oncology, biology, physics 82(5): 1738-43	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Chen, Huajiang, Xiao, Jianru, Yang, Xinghai et al. (2010) Preoperative scoring systems and prognostic factors for patients with spinal metastases from hepatocellular carcinoma. Spine 35(23): e1339-46	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Chen, Qing, Chen, Xiaohui, Zhou, Lei et al. (2021) The emergence of new prognostic scores in lung cancer patients with spinal metastasis: A 12-year single-center retrospective study. Journal of Cancer 12(18): 5644-5653	Outcomes do not match review protocol – overall survival
Chen, S., Yang, M., Zhong, N. et al. (2021) Quantified CIN Score From Cell-free DNA as a Novel Noninvasive Predictor of Survival in Patients With Spinal Metastasis. Frontiers in Cell and Developmental Biology 9: 767340	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Choi, D., Ricciardi, F., Arts, M. et al. (2018) Prediction accuracy of common prognostic scoring systems for metastatic spine disease. Spine 43(23): 1678-1684	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Choi D, Pavlou M, Omar R, et al. (2019) A novel risk calculator to predict outcome after surgery for symptomatic spinal metastases; use of a large prospective patient database to personalise surgical management. European journal of cancer, 107: 28-36	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Chow, Edward; Harris, Kristin; Fung, Kinwah (2006) Successful validation of a survival prediction model in patients with metastases in the spinal column. International journal of radiation	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool

Study	Reason for exclusion
oncology, biology, physics 65(5): 1522-7	
Cook, William H and Baker, Joseph F (2020) Retrospective evaluation of prognostic factors in metastatic spine disease: serum albumin and primary tumour type are key. ANZ journal of surgery 90(6): 1070-1074	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Crnalic, Sead, Lofvenberg, Richard, Bergh, Anders et al. (2012) Predicting survival for surgery of metastatic spinal cord compression in prostate cancer: a new score. Spine 37(26): 2168-76	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Cui, Yunpeng, Lei, Mingxing, Pan, Yuanxing et al. (2020) Scoring Algorithms for Predicting Survival Prognosis in Patients With Metastatic Spinal Disease: The Current Status and Future Directions. Clinical spine surgery 33(8): 296-306	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Dakson, Ayoub, Leck, Erika, Brandman, David M et al. (2020) The clinical utility of the Spinal Instability Neoplastic Score (SINS) system in spinal epidural metastases: a retrospective study. Spinal cord 58(8): 892-899	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Dardic, M, Wibmer, Christine, Berghold, A et al. (2015) Evaluation of prognostic scoring systems for spinal metastases in 196 patients treated during 2005-2010. European spine journal, 24 (10): 2133-41	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
De la Garza Ramos, R., Goodwin, C.R., Jain, A. et al. (2016) Development of a Metastatic Spinal Tumor Frailty Index (MSTFI) Using a Nationwide Database and Its Association with Inpatient Morbidity, Mortality, and Length of Stay After Spine Surgery. World Neurosurgery 95: 548-555	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
De la Garza Ramos, Rafael, Benton, Joshua A, Gelfand, Yaroslav et al. (2021) A Novel Clinical Scoring System for Perioperative Morbidity in Metastatic Spinal Tumor Surgery: The Spine Oncology Morbidity Assessment Score. Spine 46(3): e161-e166	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
De la Garza Ramos, Rafael, Naidu, Ishan, Choi, Jong Hyun et al. (2021) Comparison of three predictive scoring systems for morbidity in oncological spine surgery. Journal of clinical neuroscience, 94: 13-17	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Denisov, Anton A; Zaborovsky, Nikita S; Ptashnikov, Dmitry A; Mikhailov, Dmitry A; Masevnin, Sergey V; Smekalenkov, Oleg A; Comparison of prognostic scales for patients with metastatic spine disease.; Orthopedic reviews; 2020; vol. 12 (no. 4); 8822	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Derincek, Alihan, Guler, Umit O, Uysal, Mustafa et al. (2020) Spinal Metastatic Disease: Survival Analysis of 146 Patients and Evaluation of 4 Different Preoperative Scoring Systems. Clinical spine surgery 33(2): e81-e86	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Donnellan, Christopher J, Roser, Sophia, Maharaj, Monish M et al. (2020) Outcomes for Vertebrectomy for Malignancy and Correlation to the Spine Instability Neoplastic Score (SINS): a 10-	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system

Study	Reason for exclusion
Year Single-Center Perspective. World neurosurgery 138: e151-e159	
Douglas, S; Schild, S E; Rades, D (2012) Metastatic spinal cord compression in patients with cancer of unknown primary. Estimating the survival prognosis with a validated score. Strahlentherapie und Onkologie, 188(11): 1048-51	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Douglas, Sarah; Schild, Steven E; Rades, Dirk (2012) A new score predicting the survival of patients with spinal cord compression from myeloma. BMC cancer 12: 425	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Eap, C; Tardieux, E; Goasgen, O; Bennis, S; Mireau, E; Delalande, B; Cvitkovik, F; Baussart, B; Aldea, S; Jovenin, N; Gaillard, S; Tokuhashi score and other prognostic factors in 260 patients with surgery for vertebral metastases.; Orthopaedics & traumatology, surgery & research : OTSR; 2015; vol. 101 (no. 4); 483-8	Outcomes do not match review protocol – overall survival
Ehresman, Jeff, Lubelski, Daniel, Pennington, Zach et al. (2021) Utility of prediction model score: a proposed tool to standardize the performance and generalizability of clinical predictive models based on systematic review. Journal of neurosurgery. Spine: 1-9	Outcomes do not match review protocol – not spinal stability outcomes
Enkaoua, E A, Doursounian, L, Chatellier, G et al. (1997) Vertebral metastases: a critical appreciation of the preoperative prognostic tokuhashi score in a series of 71 cases. Spine 22(19): 2293-8	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Feng, Jiang-Tao, Yang, Xiong-Gang, Wang, Feng et al. (2019) Prognostic Discrepancy on Overall Survival Between Ambulatory and Nonambulatory Patients with Metastatic Spinal Cord Compression. World neurosurgery 121: e322-e332	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Finnigan, Renee, Burmeister, Bryan, Barry, Tamara et al. (2015) Technique and early clinical outcomes for spinal and paraspinal tumours treated with stereotactic body radiotherapy. Journal of clinical neuroscience 22(8): 1258-63	Outcomes do not match review protocol - predictive factors/association between Spinal Instability Neoplastic Score and incidence of vertebral compression factor
Fisher, CG, DiPaola, CP, Ryken, TC et al. (2010) A novel classification system for spinal instability in neoplastic disease: an evidence-based approach and expert consensus from the Spine Oncology Study Group. Spine 35(22): E1221-9	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Fisher, Charles G, Schouten, Rowan, Versteeg, Anne L et al. (2014) Reliability of the Spinal Instability Neoplastic Score (SINS) among radiation oncologists: an assessment of instability secondary to spinal metastases. Radiation oncology (London, England) 9: 69	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Foerster, Robert, Habermehl, Daniel, Bruckner, Thomas et al. (2014) Spinal bone metastases in gynecologic malignancies: a retrospective analysis of stability, prognostic factors and survival. Radiation oncology (London, England) 9: 194	Outcomes do not match review protocol – study of prognostic factors

Study	Reason for exclusion
Fox, S., Spiess, M., Hnenny, L. et al. (2017) Spinal Instability Neoplastic Score (SINS): Reliability Among Spine Fellows and Resident Physicians in Orthopedic Surgery and Neurosurgery. Global Spine Journal 7(8): 744-748	Outcomes do not match review protocol - evaluates spinal surgery trainees use of tool (and only reports inter and intra observer reliability)
Gakhar H, Swamy G, Bommireddy, R, et al. A study investigating the validity of modified Tokuhashi score to decide surgical intervention in patients with metastatic spinal cancer.; European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society; 2013; vol. 22 (no. 3); 565-8	Outcomes do not match review protocol – overall survival
Gallizia, E, Apicella, G, Cena, T et al. (2017) The spine instability neoplastic score (SINS) in the assessment of response to radiotherapy for bone metastases. Clinical & translational oncology, 19, 1382-1387	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Gao, Qing-Peng, Yang, Da-Zhi, Yuan, Zheng-Bin et al. (2021) Prognostic factors and its predictive value in patients with metastatic spinal cancer. World journal of clinical cases 9(20): 5470-5478	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Gao, Zhong-Yu, Zhang, Tao, Zhang, Hui et al. (2021) Establishment and validation of nomogram model for survival predicting in patients with spinal metastases secondary to lung cancer. Neurological research 43(4): 327-335	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Ghori, Ahmer K, Leonard, Dana A, Schoenfeld, Andrew J et al. (2015) Modeling 1-year survival after surgery on the metastatic spine. The spine journal 15(11): 2345-50	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Gjyshi, Olsi, Boyce-Fappiano, David, Pezzi, Todd A et al. (2020) Spine stereotactic radiosurgery for metastases from hepatobiliary malignancies: patient selection using PRISM scoring. Journal of neuro-oncology 148(2): 327-334	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Goodwin, C Rory, Schoenfeld, Andrew J, Abu-Bonsrah, Nancy A et al. (2016) Reliability of a spinal metastasis prognostic score to model 1-year survival. The spine journal, 16(9): 1102-8	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Gruenberg, Marcelo; Mereles, Maximiliano E; Willhuber, Gaston O Camino; Usefulness of Tokuhashi Score in Survival Prediction of Patients Operated for Vertebral Metastatic Disease.; Global spine journal; 2017; vol. 7 (no. 3); 260-265	Outcomes do not match review protocol – overall survival
Hacking, H.G.A.; Van As, H.H.J.; Lankhorst, G.J. (1993) Factors related to the outcome of inpatient rehabilitation in patients with neoplastic epidural spinal cord compression. Paraplegia 31(6): 367-374	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – reports individual prognostic factors
Han, Shuai, Wang, Ting, Jiang, Dongjie et al. (2015) Surgery and survival outcomes of 30 patients with neurological deficit due to clear cell renal cell carcinoma spinal metastases. Europe-	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – reports individual prognostic

Study	Reason for exclusion
an spine journal 24(8): 1786-91	factors
Hardisty, Michael, Wright, Trinette, Campbell, Mikki et al. (2020) CT based quantitative measures of the stability of fractured metastatically involved vertebrae treated with spine stereotactic body radiotherapy. Clinical & experimental metastasis 37(5): 575-584	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
He, Xin, Jiao, Yong-Qiang, Yang, Xiong-Gang et al. (2020) A Novel Prediction Tool for Overall Survival of Patients Living with Spinal Metastatic Disease. World neurosurgery 144: e824-e836	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Hernandez-Fernandez, Alberto, Velez, Roberto, Lersundi-Artamendi, Ana et al. (2012) External validity of the Tokuhashi score in patients with vertebral metastasis. Journal of cancer research and clinical oncology 138(9): 1493-500	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – reports individual prognostic factors
Hersh, Andrew M, Pennington, Zach, Hung, Bethany et al. (2021) Comparison of frailty metrics and the Charlson Comorbidity Index for predicting adverse outcomes in patients undergoing surgery for spine metastases. Journal of neurosurgery. Spine: 1-9	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – reports individual prognostic factors
Hessler, Christian, Vettorazzi, Eik, Madert, Juergen et al. (2011) Actual and predicted survival time of patients with spinal metastases of lung cancer: evaluation of the robustness of the Tokuhashi score. Spine 36(12): 983-9	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – reports individual prognostic factors
Hu, Ming-Hsiao, Yen, Hung-Kuan, Chen, I-Hsin et al. (2022) Decreased psoas muscle area is a prognosticator for 90-day and 1-year survival in patients undergoing surgical treatment for spinal metastasis. Clinical nutrition (Edinburgh, Scotland) 41(3): 620-629	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system –evaluates impact of adding an individual prognostic factor to a range of prognostic tools.
Hutton, Jonathon and Leung, John (2013) Treatment of spinal cord compression: are we overusing radiotherapy alone compared to surgery and radiotherapy?. Asia-Pacific journal of clinical oncology 9(2): 123-8	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – reports individual prognostic factors for prediction of treatment outcome.
Jensen, Garrett, Tang, Chad, Hess, Kenneth R et al. (2017) Internal validation of the prognostic index for spine metastasis (PRISM) for stratifying survival in patients treated with spinal stereotactic radiosurgery. Journal of radiosurgery and SBRT 5(1): 25-34	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Kanda, Yutaro, Kakutani, Kenichiro, Sakai, Yoshitada et al. (2021) Surgical outcomes and risk factors for poor outcomes in patients with cervical spine metastasis: a prospective study. Journal of orthopaedic surgery and research 16(1): 423	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – reports individual prognostic factors
Karhade, A.V., Thio, Q.C.B.S., Ogink, P.T. et al. (2019) Development of Machine Learning Algorithms for Prediction of 30-Day Mortality after Surgery for Spinal Metastasis. Clinical Neurosurgery 85(1): e83-e91	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Karhade, Aditya V, Ahmed, Ali K, Pennington, Zach et al. (2020) External validation of the	Index test does not match review protocol - does

Study	Reason for exclusion
SORG 90-day and 1-year machine learning algorithms for survival in spinal metastatic disease. The spine journal : official journal of the North American Spine Society 20(1): 14-21	not report on the prognostic value of a validated clinical tool
Karhade, Aditya V, Thio, Quirina C B S, Ogink, Paul T et al. (2019) Predicting 90-Day and 1-Year Mortality in Spinal Metastatic Disease: Development and Internal Validation. Neurosurgery 85(4): e671-e681	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – reports individual prognostic factors - compares performance of modelling techniques
Katagiri, H, Takahashi, M, Wakai, K et al. (2005) Prognostic factors and a scoring system for patients with skeletal metastasis. The Journal of bone and joint surgery. British volume 87(5): 698-703	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – reports individual prognostic factors
Kato, Satoshi, Murakami, Hideki, Demura, Satoru et al. (2019) Kidney and Thyroid Cancer-Specific Treatment Algorithm for Spinal Metastases: A Validation Study. World neurosurgery 122: e1305-e1311	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Kerstens, Peter; Yi, Ma; James, Melissa (2019) Radiotherapy for metastatic spinal cord compression; can the Rades score predict survival?. Asia-Pacific journal of clinical oncology 15(6): 331-336	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – reports individual prognostic factors
Kim, H., Chang, S.Y., Son, J. et al. (2021) The effect of adding biological factors to the decision-making process for spinal metastasis of non-small cell lung cancer. Journal of Clinical Medicine 10(5): 1-10	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool - adds additional factors to an existing tool
Kim, Junhyung, Lee, Sun-Ho, Park, Se-Jun et al. (2014) Analysis of the predictive role and new proposal for surgical strategies based on the modified Tomita and Tokuhashi scoring systems for spinal metastasis. World journal of surgical oncology 12: 245	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – reports individual prognostic factors
Kobayashi, Kazuyoshi, Ando, Kei, Nakashima, Hiroaki et al. (2020) Prognostic Factors in the New Katagiri Scoring System After Palliative Surgery for Spinal Metastasis. Spine 45(13): e813-e819	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – reports individual prognostic factors
Kowalchuk, R.O., Mullikin, T.C., Harmsen, W.S. et al. (2022) Development and Internal Validation of a Recursive Partitioning Analysis-Based Model Predictive of Pain Flare Incidence After Spine Stereotactic Body Radiation Therapy. Practical Radiation Oncology	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system - predicts pain flare after stereotactic body radiation therapy
Kowalchuk, Roman O, Johnson-Tesch, Benjamin A, Marion, Joseph T et al. (2022) Development and Assessment of a Predictive Score for Vertebral Compression Fracture After Stereotactic Body Radiation Therapy for Spinal Metastases. JAMA oncology 8(3): 412-419	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Kumar, Naresh; Tan, Jonathan J H; Zaw, Aye S, et al. Evaluation of scoring systems and prognostic factors in patients with spinal metastases from nasopharyngeal carcinoma.; The spine	Outcomes do not match review protocol

Study	Reason for exclusion
journal, 14, 2946-53, 2014	
Kwan, Kenny Yat Hong, Lam, Tai Chung, Choi, Horace Cheuk Wai et al. (2018) Prediction of survival in patients with symptomatic spinal metastases: Comparison between the Tokuhashi score and expert oncologists. Surgical oncology 27(1): 7-10	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Lakomkin, Nikita, Zuckerman, Scott L, Stannard, Blaine et al. (2019) Preoperative Risk Stratification in Spine Tumor Surgery: A Comparison of the Modified Charlson Index, Frailty Index, and ASA Score. Spine 44(13): e782-e787	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Lee, Chang-Hyun, Chung, Chun Kee, Jahng, Tae-Ahn et al. (2015) Which one is a valuable surrogate for predicting survival between Tomita and Tokuhashi scores in patients with spinal metastases? A meta-analysis for diagnostic test accuracy and individual participant data analysis. Journal of neuro-oncology 123(2): 267-75	Study design does not match review protocol - systematic review without pooled results/ quantitative data, checked for relevant studies
Lee, Chang-Hyun, Hong, Jae Taek, Lee, Sun-Ho et al. (2021) Is the Spinal Instability Neoplastic Score Accurate and Reliable in Predicting Vertebral Compression Fractures for Spinal Metastasis? A Systematic Review and Qualitative Analysis. Journal of Korean Neurosurgical Society 64(1): 4-12	Study design does not match review protocol - systematic review without pooled results/ quantitative data, checked for relevant studies
Lee, Sun-Ho, Tatsui, Claudio E, Ghia, Amol J et al. (2016) Can the spinal instability neoplastic score prior to spinal radiosurgery predict compression fractures following stereotactic spinal radiosurgery for metastatic spinal tumor? a post hoc analysis of prospective phase II single-institution trials. Journal of neuro-oncology 126(3): 509-17	Other protocol criteria – reports data from a study that are also reported in a systematic review that has been included in this review (Sahgal 2013, reported in Kim 2021).
Lei, M., Liu, S., Yang, S. et al. (2016) Validation of a model with which to predict the survival prognosis of patients with spinal cord compression resulted from metastatic cancers. European Journal of Surgical Oncology 42(12): 1924-1930	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Lei, Mingxing, Liu, Yaosheng, Tang, Chuanghao et al. (2015) Prediction of survival prognosis after surgery in patients with symptomatic metastatic spinal cord compression from non-small cell lung cancer. BMC cancer 15: 853	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Lei, Mingxing, Liu, Yaosheng, Yan, Liang et al. (2016) A validated preoperative score predicting survival and functional outcome in lung cancer patients operated with posterior decompression and stabilization for metastatic spinal cord compression. European spine journal 25(12): 3971-3978	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Leithner, Andreas, Radl, Roman, Gruber, Gerald et al. (2008) Predictive value of seven preoperative prognostic scoring systems for spinal metastases. European spine journal 17(11): 1488-95	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Li, Zemin, Long, Houqing, Guo, Rui et al. (2018) Surgical treatment indications and outcomes in	Outcomes do not match review protocol – does

Study	Reason for exclusion
patients with spinal metastases in the cervicothoracic junction (CTJ). Journal of orthopaedic surgery and research 13(1): 20	not report data relevant to prognostic value of a scoring system
Iinuma, M.; Akazawa, T.; Torii, et al. Optimization of the revised tokuhashi scoring system: New prognostic criteria for metastatic spinal tumor in surgical cases; Spine Surgery and Related Research; 2021; vol. 5 (no. 5); 81-85	Outcomes do not match review protocol
Liu, Shuzhong, Zhou, Xi, Song, An et al. (2020) Clinical Characteristics and Prognostic Analysis of Gynecologic Cancer with Spinal Metastases: A Single-Center Retrospective Study. Cancer management and research 12: 7515-7525	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Liu, Yujie, Li, Lin, Jiang, Dongjie et al. (2021) A Novel Nomogram for Survival Prediction of Patients with Spinal Metastasis From Prostate Cancer. Spine 46(6): e364-e373	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Liu, Yujie, Yang, Minglei, Li, Bo et al. (2019) Development of a novel model for predicting survival of patients with spine metastasis from colorectal cancer. European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society 28(6): 1491-1501	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Majeed, H, Kumar, S, Bommireddy, R et al. (2012) Accuracy of prognostic scores in decision making and predicting outcomes in metastatic spine disease. Annals of the Royal College of Surgeons of England 94(1): 28-33	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Massaad, E., Hadzipasic, M., Alvarez-Breckenridge, C. et al. (2020) Predicting tumor-specific survival in patients with spinal metastatic renal cell carcinoma: Which scoring system is most accurate?. Journal of Neurosurgery: Spine 33(4): 529-539	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Masuda, Kenji, Ebata, Ko, Yasuhara, Yoshimasa et al. (2018) Outcomes and Prognosis of Neurological Decompression and Stabilization for Spinal Metastasis: Is Assessment with the Spinal Instability Neoplastic Score Useful for Predicting Surgical Results?. Asian spine journal 12(5): 846-853	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Matsumiya, H., Todo, Y., Okamoto, K. et al. (2016) A prediction model of survival for patients with bone metastasis from uterine cervical cancer. Journal of Gynecologic Oncology 27(6): e55	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Mezei, Tamas, Horvath, Anna, Pollner, Peter et al. (2020) Research on the predicting power of the revised Tokuhashi system: how much time can surgery give to patients with short life expectancy?. International journal of clinical oncology 25(4): 755-764	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Mikula, Anthony L, Pennington, Zach, Lakomkin, Nikita et al. (2022) Independent predictors of vertebral compression fracture following radiation for metastatic spine disease. Journal of neu-	Other protocol criteria - not available

Study	Reason for exclusion
rosurgery. Spine: 1-7	
Mizumoto, M., Harada, H., Asakura, H. et al. (2008) Prognostic factors and a scoring system for survival after radiotherapy for metastases to the spinal column: A review of 544 patients at Shizuoka Cancer Center Hospital. Cancer 113(10): 2816-2822	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Mohd Rothi, Illina; Deverall, Hamish H; Baker, Joseph F (2019) The modified Frailty Index does not correlate with survival in surgically-treated patients with metastatic spine disease. Journal of clinical neuroscience : official journal of the Neurosurgical Society of Australasia 66: 178-181	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Mollahoseini, R.; Farhan, F.; Khajoo, A.; Jouibari, M.A.M.; Gholipour, F.; Is Tokuhashi score suitable for evaluation of life expectancy before surgery in iranian patients with spinal metastases?; Journal of Research in Medical Sciences; 2011; vol. 16 (no. 9); 1183-1188	Outcomes do not match review protocol – overall survival
Morgen, Soren Schmidt, Fruergaard, Sidsel, Gehrchen, Martin et al. (2018) A revision of the Tokuhashi revised score improves the prognostic ability in patients with metastatic spinal cord compression. Journal of cancer research and clinical oncology 144(1): 33-38	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Morgen, Soren Schmidt, Nielsen, Dennis Hallager, Larsen, Claus Falck et al. (2014) Moderate precision of prognostic scoring systems in a consecutive, prospective cohort of 544 patients with metastatic spinal cord compression. Journal of cancer research and clinical oncology 140(12): 2059-64	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Nater, Anick, Chuang, Junior, Liu, Kuan et al. (2020) A Personalized Medicine Approach for the Management of Spinal Metastases with Cord Compression: Development of a Novel Clinical Prediction Model for Postoperative Survival and Quality of Life. World neurosurgery 140: 654-663e13	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Nater, Anick, Tetreault, Lindsay A, Kopjar, Branko et al. (2018) Predictive factors of survival in a surgical series of metastatic epidural spinal cord compression and complete external validation of 8 multivariate models of survival in a prospective North American multicenter study. Cancer 124(17): 3536-3550	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – study of prognostic factors
Nenclares, P, Guardado, S, Asiain, L et al. (2020) A new and simple scoring system to predict overall survival after irradiation for metastatic spinal cord compression. Clinical & translational oncology : official publication of the Federation of Spanish Oncology Societies and of the National Cancer Institute of Mexico 22(3): 440-444	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Ogihara, Satoshi, Seichi, Atsushi, Hozumi, Takahiro et al. (2006) Prognostic factors for pa-	Outcomes do not match review protocol – does not report data relevant to prognostic value of a

Study	Reason for exclusion
tients with spinal metastases from lung cancer. Spine 31(14): 1585-90	scoring system – stud of prognostic factors
Oh, I.-S.; Kim, S.-I.; Ha, K.-Y. (2011) Significant predictive values for the life expectancy in patients with spinal metastasis following surgical treatment. European Journal of Orthopaedic Surgery and Traumatology: 1-8	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – study of prognostic factors
Osong, B., Sanli, I., Willems, P.C. et al. (2021) Overall survival nomogram for patients with spinal bone metastases (SBM). Clinical and Translational Radiation Oncology 28: 48-53	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Pahuta, Markian A, Werier, Joel, Wai, Eugene K et al. (2019) Back to Bayesian: A strategy to enhance prognostication of metastatic spine disease. International journal of clinical practice 73(4): e13322	Study design does not match review protocol – expert review/narrative
Papastefanou, Sotiris, Alpantaki, Kalliopi, Akra, Gabriel et al. (2012) Predictive value of Tokuhashi and Tomita scores in patients with metastatic spine disease. Acta orthopaedica et traumatologica turcica 46(1): 50-6	Study design does not match review protocol – expert review/narrative
Park, Hae Jin, Kim, Hee Jung, Won, Jong-Ho et al. (2015) Stereotactic Body Radiotherapy (SBRT) for Spinal Metastases: Who Will Benefit the Most from SBRT?. Technology in cancer research & treatment 14(2): 159-67	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – study of prognostic factors
Park, S.; Lee, C.; Chung, S.; Lee, K.; How Accurately Can Tokuhashi Score System Predict Survival in the Current Practice for Spinal Metastases? Journal of Spinal Disorders and Techniques; 2015; vol. 28 (no. 4); e219-e224	Outcomes do not match review protocol – overall survival
Park, SeJun, Lee, ChongSuh, Chung, SungSoo et al. (2015) How accurately can tokuhashi score system predict survival in the current practice for spinal metastases?: prospective analysis of 145 consecutive patients between 2007 and 2013. Journal of spinal disorders & techniques 28(4): e219-24	Other protocol criteria – duplicate publication
Paulino Pereira, Nuno Rui, Janssen, Stein J, van Dijk, Eva et al. (2016) Development of a Prognostic Survival Algorithm for Patients with Metastatic Spine Disease. The Journal of bone and joint surgery. American volume 98(21): 1767-1776	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Paulino Pereira, Nuno Rui, Mclaughlin, Lily, Janssen, Stein J et al. (2017) The SORG nomogram accurately predicts 3- and 12-months survival for operable spine metastatic disease: External validation. Journal of surgical oncology 115(8): 1019-1027	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Pelegrini de Almeida, Leandro; Vidaletti, Tamara; Martins de Lima Cecchini, Andre; Sfreddo, Ericson; Martins de Lima Cecchini, Felipe; Falavigna, Asdrubal; Reliability of Tokuhashi Score to Predict Prognosis: Comparison of 117 Patients.; World neurosurgery; 2018; vol. 111; e1-e6	Outcomes do not match review protocol – overall survival

Study	Reason for exclusion
Pennington, Zach, Ahmed, A Karim, Westbroek, Erick M et al. (2019) SINS Score and Stability: Evaluating the Need for Stabilization Within the Uncertain Category. World neurosurgery 128: e1034-e1047	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Petteys, Rory J; Spitz, Steven M; Rhee, Jay; Goodwin, C Rory; Zadnik, Patricia L; Sarabia-Estrada, Rachel; Groves, Mari L; Bydon, Ali; Witham, Timothy F; Wolinsky, Jean-Paul; Gokaslan, Ziya L; Sciubba, Daniel M; Tokuhashi score is predictive of survival in a cohort of patients undergoing surgery for renal cell carcinoma spinal metastases.; European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society; 2015; vol. 24 (no. 10); 2142-9	Outcomes do not match review protocol – overall survival
Phinyo, Phichayut, Boonyanaruthee, Chonmavadh, Paholpak, Permsak et al. (2020) Natural disease progression and novel survival prediction model for hepatocellular carcinoma with spinal metastases: a 10-year single-center study. World journal of surgical oncology 18(1): 135	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Pollner, Peter, Horvath, Anna, Mezei, Tamas et al. (2018) Analysis of Four Scoring Systems for the Prognosis of Patients with Metastasis of the Vertebral Column. World neurosurgery 112: e675-e682	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Quraishi, N A; Manoharan, S R; Arealis, G; Khurana, A; Elsayed, S; Edwards, K L; Boszczyk, B M; Accuracy of the revised Tokuhashi score in predicting survival in patients with metastatic spinal cord compression (MSCC).; European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society; 2013; vol. 22suppl1; 21-6	Outcomes do not match review protocol – overall survival
Quraishi, Nasir A, Arealis, George, Salem, Khalid M I et al. (2015) The surgical management of metastatic spinal tumors based on an Epidural Spinal Cord Compression (ESCC) scale. The spine journal : official journal of the North American Spine Society 15(8): 1738-43	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, D., Bartscht, T., Janssen, S. et al. (2016) Forecasting survival probabilities after radiotherapy of metastatic epidural spinal cord compression from colorectal cancer in the elderly. Anticancer Research 36(4): 1829-1833	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, D., Douglas, S., Veninga, T. et al. (2012) A survival score for patients with metastatic spinal cord compression from prostate cancer. Strahlentherapie und Onkologie 188(9): 802-806	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, D., Douglas, S., Veninga, T. et al. (2010) Validation and simplification of a score predicting survival in patients irradiated for metastatic	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system

Study	Reason for exclusion
spinal cord compression. Cancer 116(15): 3670-3673	
Rades, D., Evers, J.N., Bajrovic, A. et al. (2014) Metastatic spinal cord compression: A validated survival score for elderly patients. Strahlentherapie und Onkologie 190(10): 919-924	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, D., Evers, J.N., Rudat, V. et al. (2014) A validated score estimating ambulatory status following radiotherapy of elderly patients for metastatic spinal cord compression. BMC Cancer 14(1): 589	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, D.; Hueppe, M.; Schild, S.E. (2013) A score to identify patients with metastatic spinal cord compression who may be candidates for best supportive care. Cancer 119(4): 897-903	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, D., Huttenlocher, S., Bajrovic, A. et al. (2015) A new instrument for estimating the survival of patients with metastatic epidural spinal cord compression from esophageal cancer. Radiology and Oncology 49(1): 86-90	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, D., Veninga, T., Bajrovic, A. et al. (2013) A validated scoring system to identify long-term survivors after radiotherapy for metastatic spinal cord compression. Strahlentherapie und Onkologie 189(6): 462-466	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, D, Douglas, S, Huttenlocher, S et al. (2012) Prognostic factors and a survival score for patients with metastatic spinal cord compression from colorectal cancer. Strahlentherapie und Onkologie : 188(12): 1114-8	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, D; Douglas, S; Schild, S E (2013) A validated survival score for breast cancer patients with metastatic spinal cord compression. Strahlentherapie und Onkologie 189(1): 41-6	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, Dirk; Bajrovic, Amira; Bartscht, Tobias (2017) Predictive Factors and a Survival Score for Patients Irradiated for Metastatic Spinal Cord Compression from Carcinoma of the Salivary Glands. Anticancer research 37(12): 7011-7015	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, Dirk, Cacicedo, Jon, Lomidze, Darejan et al. (2022) A New and Easy-to-Use Survival Score for Patients Irradiated for Metastatic Epidural Spinal Cord Compression. Practical radiation oncology	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, Dirk, Conde, Antonio J, Garcia, Raquel et al. (2015) A new instrument for estimation of survival in elderly patients irradiated for metastatic spinal cord compression from breast cancer. Radiation oncology (London, England) 10: 173	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, Dirk, Conde-Moreno, Antonio J, Cacicedo, Jon et al. (2015) Metastatic Spinal Cord Compression: A Survival Score Particularly Developed for Elderly Prostate Cancer Patients. Anticancer research 35(11): 6189-92	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, Dirk, Conde-Moreno, Antonio J,	Outcomes do not match review protocol – does

Study	Reason for exclusion
Cacicedo, Jon et al. (2016) Estimating the Survival of Elderly Patients with Renal Cell Carcinoma Presenting with Malignant Spinal Cord Compression. Anticancer research 36(1): 409-13	not report data relevant to prognostic value of a scoring system
Rades, Dirk, Conde-Moreno, Antonio J, Cacicedo, Jon et al. (2018) A scoring system to predict local progression-free survival in patients irradiated with 20 Gy in 5 fractions for malignant spinal cord compression. Radiation oncology (London, England) 13(1): 257	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, Dirk, Conde-Moreno, Antonio J, Garcia, Raquel et al. (2015) A Tool to Estimate Survival of Elderly Patients Presenting with Metastatic Epidural Spinal Cord Compression (MESCC) from Cancer of Unknown Primary. Anticancer research 35(11): 6219-22	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, Dirk, Conde-Moreno, Antonio J, Segedin, Barbara et al. (2016) A Prognostic Instrument to Estimate the Survival of Elderly Patients Irradiated for Metastatic Epidural Spinal Cord Compression From Lung Cancer. Clinical lung cancer 17(4): 279-84	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, Dirk, Conde-Moreno, Antonio Jose, Cacicedo, Jon et al. (2016) A predictive tool particularly designed for elderly myeloma patients presenting with spinal cord compression. BMC cancer 16: 292	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Rades, Dirk, Douglas, Sarah, Huttenlocher, Stefan et al. (2011) Validation of a score predicting post-treatment ambulatory status after radiotherapy for metastatic spinal cord compression. International journal of radiation oncology, biology, physics 79(5): 1503-6	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Rades, Dirk, Douglas, Sarah, Veninga, Theo et al. (2012) A validated survival score for patients with metastatic spinal cord compression from non-small cell lung cancer. BMC cancer 12: 302	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, Dirk; Dunst, Juergen; Schild, Steven E (2008) The first score predicting overall survival in patients with metastatic spinal cord compression. Cancer 112(1): 157-61	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Rades, Dirk, Haus, Rapha, Schild, Steven E et al. (2019) Prognostic factors and a new scoring system for survival of patients irradiated for bone metastases. BMC cancer 19(1): 1156	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Rades, Dirk, Huttenlocher, Stefan, Bartscht, Tobias et al. (2015) Predicting the survival probability of gastric cancer patients developing metastatic epidural spinal cord compression (MESCC). Gastric cancer, 18: 881-4	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Rades, Dirk, Motisi, Laura, Veninga, Theo et al. (2019) Predictors of Outcomes and a Scoring System for Estimating Survival in Patients Treated With Radiotherapy for Metastatic Spinal Cord Compression From Small-Cell Lung Cancer. Clinical lung cancer 20(4): 322-329	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool

Study	Reason for exclusion
Rades, Dirk, Schild, Steven E, Karstens, Johann H et al. (2015) Predicting survival of patients with metastatic epidural spinal cord compression from cancer of the head-and-neck. Anticancer research 35(1): 385-8	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Ragel, Brian T, Mendez, Gustavo A, Reddington, Justin et al. (2017) Life Expectancy and Metastatic Spine Scoring Systems: An Academic Institutional Experience. Clinical spine surgery 30(8): 335-342	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Ribas, Eduardo Carvalhal; Mathias Junior, Luis Roberto; Guirado, Vinicius Monteiro; et al. Survival score scales of patients operated with spinal metastases: retrospective application in a Brazilian population.; Arquivos de neuro-psiquiatria; 2016; vol. 74 (no. 1); 44-9	Outcomes do not match review protocol – overall survival
Sanli, I, Osong, B, Dekker, A et al. (2022) Radiomics biopsy signature for predicting survival in patients with spinal bone metastases (SBMs). Clinical and translational radiation oncology 33: 57-65	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Schoenfeld, A.J., Le, H.V., Marjoua, Y. et al. (2016) Assessing the utility of a clinical prediction score regarding 30-day morbidity and mortality following metastatic spinal surgery: the New England Spinal Metastasis Score (NESMS). Spine Journal 16(4): 482-490	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Schoenfeld, Andrew J, Blucher, Justin A, Barton, Lauren B et al. (2020) Design of the prospective observational study of spinal metastasis treatment (POST). The spine journal 20(4): 572-579	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Schoenfeld, Andrew J, Ferrone, Marco L, Blucher, Justin A et al. (2022) Prospective comparison of the accuracy of the New England Spinal Metastasis Score (NESMS) to legacy scoring systems in prognosticating outcomes following treatment of spinal metastases. The spine journal 22(1): 39-48	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Schoenfeld, Andrew J, Ferrone, Marco L, Schwab, Joseph H et al. (2021) Prospective validation of a clinical prediction score for survival in patients with spinal metastases: the New England Spinal Metastasis Score. The spine journal 21(1): 28-36	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Shah, Akash A, Karhade, Aditya V, Park, Howard Y et al. (2021) Updated external validation of the SORG machine learning algorithms for prediction of ninety-day and one-year mortality after surgery for spinal metastasis. The spine journal 21(10): 1679-1686	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Shi, Diana D, Chen, Yu-Hui, Lam, Tai Chung et al. (2018) Assessing the utility of a prognostication model to predict 1-year mortality in patients undergoing radiation therapy for spinal metastases. The spine journal : official journal of the North American Spine Society 18(6): 935-940	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system

Study	Reason for exclusion
Shi, Diana D, Hertan, Lauren M, Lam, Tai Chung et al. (2018) Assessing the utility of the spinal instability neoplastic score (SINS) to predict fracture after conventional radiation therapy (RT) for spinal metastases. Practical radiation oncology 8(5): e285-e294	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Smeijers, S and Depreitere, B (2021) Prognostic scores for survival as decisional support for surgery in spinal metastases: a performance assessment systematic review. European spine journal 30(10): 2800-2824	Study design does not match review protocol - systematic review without pooled results/ quantitative data, checked for relevant studies
Sutcliffe, P, Connock, M, Shyangdan, D et al. (2013) A systematic review of evidence on malignant spinal metastases: natural history and technologies for identifying patients at high risk of vertebral fracture and spinal cord compression. Health technology assessment (Winchester, England) 17(42): 1-274	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – study of prognostic factors
Szoverfi, Zsolt, Lazary, Aron, Bozsodi, Arpad et al. (2014) Primary Spinal Tumor Mortality Score (PSTMS): a novel scoring system for predicting poor survival. The spine journal 14(11): 2691-700	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Tabourel, Gaston; Terrier, Louis-Marie; Dubory, Arnaud; Cristini, Joseph; Nail, Louis-Romee Le; Cook, Ann-Rose; Buffenoir, Kevin; Pascal-Moussellard, Hugues; Carpentier, Alexandre; Mathon, Bertrand; Amelot, Aymeric; Are spine metastasis survival scoring systems outdated and do they underestimate life expectancy? Caution in surgical recommendation guidance.; Journal of neurosurgery. Spine; 2021; vol. 35 (no. 4); 527-534	Outcomes do not match review protocol – overall survival
Tabouret, Emeline; Cauvin, Cecile; Fuentes, Stephane; Esterni, Benjamin; Adetchessi, Tarek; Salem, Naji; Madroszyk, Anne; Goncalves, Anthony; Casalonga, Francois; Gravis, Gwenaelle; Reassessment of scoring systems and prognostic factors for metastatic spinal cord compression.; The spine journal, 2015; vol. 15 (no. 5); 944-50	Outcomes do not match review protocol – overall survival
Tan, Jiong Hao; Tan, Kimberly-Anne; Zaw, Aye Sandar; Thomas, Andrew Cherian; Hey, Hwee Weng; Soo, Ross Andrew; Kumar, Naresh; Evaluation of Scoring Systems and Prognostic Factors in Patients With Spinal Metastases From Lung Cancer.; Spine; 2016; vol. 41 (no. 7); 638-44	Outcomes do not match review protocol – overall survival
Tan, J.J.H.; Zaw, A.S.; Malhotra, R.; Wai, K.L.; Tan, J.Y.H.; Kumar, N.; Survival prognostication in patients with skeletal metastases from nasopharyngeal carcinoma: An evaluation of the Scandinavian sarcoma group, Katagiri and Bauer scoring systems; Annals of the Academy of Medicine Singapore; 2016; vol. 45 (no. 2); 51-60	Outcomes do not match review protocol – overall survival
Tan, Jonathan, Tan, Kimberly Anne, Zaw, Aye Sandar et al. (2017) 43 - Evaluation of prognos-	Outcomes do not match review protocol – does not report data relevant to prognostic value of a

Study	Reason for exclusion
tic factors and a modification to the modified tokuhashi score in patients with spinal metastases from breast cancer. Spine Journal 17: 16-s16	scoring system – study of prognostic factors
Tan, Kimberly-Anne; Tan, Jiong Hao; Zaw, Aye Sandar; Tan, Joel Yong Hao; Hey, Hwee Weng Dennis; Kumar, Naresh; Evaluation of Prognostic Factors and Proposed Changes to the Modified Tokuhashi Score in Patients With Spinal Metastases From Breast Cancer.; Spine; 2018; vol. 43 (no. 7); 512-519	Outcomes do not match review protocol – overall survival
Tang, Chad, Hess, Kenneth, Bishop, Andrew J et al. (2015) Creation of a Prognostic Index for Spine Metastasis to Stratify Survival in Patients Treated With Spinal Stereotactic Radiosurgery: Secondary Analysis of Mature Prospective Trials. International journal of radiation oncology, biology, physics 93(1): 118-25	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Tokuhashi, Y., Matsuzaki, H., Toriyama, S. et al. (1990) Scoring system for the preoperative evaluation of metastatic spine tumor prognosis. Spine 15(11): 1110-1113	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Tokuhashi, Y, Matsuzaki, H, Kawano, H et al. (1994) [The indication of operative procedure for a metastatic spine tumor: a scoring system for the preoperative evaluation of the prognosis]. Nihon Seikeigeka Gakkai zasshi 68(5): 379-89	Other protocol criteria – not available in English
Tokuhashi, Yasuaki, Matsuzaki, Hiromi, Oda, Hiroshi et al. (2005) A revised scoring system for preoperative evaluation of metastatic spine tumor prognosis. Spine 30(19): 2186-91	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool - describes development of the revised Tokuhashi Scoring System - no external validation reported
Tokuhashi, Yasuaki; Uei, Hiroshi; Oshima, Masashi (2017) Classification and scoring systems for metastatic spine tumors: a literature review. Spine surgery and related research 1(2): 44-55	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Tokuhashi, Yasuaki, Uei, Hiroshi, Oshima, Masashi et al. (2014) Scoring system for prediction of metastatic spine tumor prognosis. World journal of orthopedics 5(3): 262-71	Study design does not match review protocol - systematic review without pooled results/ quantitative data, checked for relevant studies
Uei, Hiroshi and Tokuhashi, Yasuaki (2018) Prognostic factors in patients with metastatic spine tumors derived from lung cancer-a novel scoring system for predicting life expectancy. World journal of surgical oncology 16(1): 131	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – study of prognostic factors
Uei, Hiroshi and Tokuhashi, Yasuaki (2020) Prognostic scoring system for metastatic spine tumors derived from hepatocellular carcinoma. Journal of orthopaedic surgery (Hong Kong) 28(1): 2309499019899167	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Ulmar, Benjamin, Naumann, Ulrike, Catalkaya, Sibel et al. (2007) Prognosis scores of Tokuhashi and Tomita for patients with spinal metastases of renal cancer. Annals of surgical oncology 14(2): 998-1004	Index test does not match review protocol

Study	Reason for exclusion
Ulmar, Benjamin, Reichel, Heiko, Catalkaya, Sibel et al. (2007) Evaluation and modification of the Tomita score in 217 patients with vertebral metastases. Onkologie 30(89): 414-8	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Ulmar, B; Huch, K; Naumann, U; Catalkaya, S; Cakir, B; Gerstner, S; Reichel, H; Evaluation of the Tokuhashi prognosis score and its modifications in 217 patients with vertebral metastases.; European journal of surgical Oncology; 2007; vol. 33 (no. 7); 914-9	Outcomes do not match review protocol – overall survival
Ulmar, Benjamin, Richter, Marcus, Cakir, Balkan et al. (2005) The Tokuhashi score: significant predictive value for the life expectancy of patients with breast cancer with spinal metastases. Spine 30(19): 2222-6	Outcomes do not match review protocol – overall survival
van der Linden, Yvette M, Dijkstra, Sander P D S, Vonk, Ernest J A et al. (2005) Prediction of survival in patients with metastases in the spinal column: results based on a randomized trial of radiotherapy. Cancer 103(2): 320-8	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Vanek, Petr, Bradac, Ondrej, Trebicky, Ferdinand et al. (2015) Influence of the Preoperative Neurological Status on Survival After the Surgical Treatment of Symptomatic Spinal Metastases With Spinal Cord Compression. Spine 40(23): 1824-30	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Verlaan, J.-J., Choi, D., Versteeg, A. et al. (2016) Characteristics of patients who survived <, 3 months or >2 years after surgery for spinal metastases: Can we avoid inappropriate patient selection?. Journal of Clinical Oncology 34(25): 3054-3061	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – study of prognostic factors
Veronesi, Francesca, Borsari, Veronica, Martini, Lucia et al. (2021) The Impact of Frailty on Spine Surgery: Systematic Review on 10 years Clinical Studies. Aging and disease 12(2): 625-645	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Versteeg, Anne L, Verlaan, Jorrit-Jan, Sahgal, Arjun et al. (2016) The Spinal Instability Neoplastic Score: Impact on Oncologic Decision-Making. Spine 41suppl20: 231-s237	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Walker, Allison, Bassale, Solange, Shukla, Rakendu et al. (2022) A Prognostic Index for Predicting Survival of Patients Undergoing Radiation Therapy for Spine Metastasis Using Recursive Partitioning Analysis. Journal of palliative medicine 25(1): 21-27	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – study of prognostic factors
Wang, Miao; Bunger, Cody Eric; Li, Haisheng; Wu, et al. Predictive value of Tokuhashi scoring systems in spinal metastases, focusing on various primary tumor groups: evaluation of 448 patients in the Aarhus spinal metastases database.; Spine; 2012; vol. 37 (no. 7); 573-8	Outcomes do not match review protocol – overall survival
Wang, S., Liu, Q., Lei, M. et al. (2018) Validation of a scoring system predicting survival and function outcome in patients with metastatic epidural spinal cord compression (MESCC): A prospec-	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool

Study	Reason for exclusion
tive and multicenter study. International Journal of Clinical and Experimental Medicine 11(3): 2465-2470	
Wanman, Johan, Jernberg, Johannes, Gustafsson, Patrik et al. (2021) Predictive Value of the Spinal Instability Neoplastic Score for Survival and Ambulatory Function After Surgery for Metastatic Spinal Cord Compression in 110 Patients with Prostate Cancer. Spine 46(8): 550-558	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Wei, Daniel, Nistal, Dominic A, Sobotka, Stanislaw et al. (2019) New Predictive Index for Survival in Symptomatic Spinal Metastases. World neurosurgery 123: e133-e140	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Westermann, Leonard; Olivier, Alain Christoph; Samel, Christina; Eysel, Peer; Herren, Christian; Sircar, Krishnan; Zarghooni, Kourosh; Analysis of seven prognostic scores in patients with surgically treated epidural metastatic spine disease.; Acta neurochirurgica; 2020; vol. 162	Outcomes do not match review protocol
Whitehouse, S, Stephenson, J, Sinclair, V et al. (2016) A validation of the Oswestry Spinal Risk Index. European spine journal, 25(1): 247-251	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Wibmer, Christine, Leithner, Andreas, Hofmann, Gunter et al. (2011) Survival analysis of 254 patients after manifestation of spinal metastases: evaluation of seven preoperative scoring systems. Spine 36(23): 1977-86	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Xing, D., Dong, Z., Zheng, X. et al. (2019) The protective effects of surgery according to the spinal instability neoplastic score for patients with the EGFR mutation, lung adenocarcinoma, and spinal metastatic instability. International Journal of Clinical and Experimental Medicine 12(11): 12764-12772	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Yamashita, Takayuki, Aota, Yoichi, Kushida, Kazuyoshi et al. (2008) Changes in physical function after palliative surgery for metastatic spinal tumor: association of the revised Tokuhashi score with neurologic recovery. Spine 33(21): 2341-6	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – study of prognostic factors
Yang, Jiun-Jen; Chen, Chih-Wei; Fourman, Mitchell S, et al. International external validation of the SORG machine learning algorithms for predicting 90-day and one-year survival of patients with spine metastases using a Taiwanese cohort. Spine Journal, 21, 1670-16, 2021	Outcomes do not match review protocol – overall survival
Yang, Minglei, Ma, Xiaoyu, Wang, Pengru et al. (2022) Prediction of Survival Prognosis for Spinal Metastasis From Cancer of Unknown Primary: Derivation and Validation of a Nomogram Model. Global spine journal: 21925682221103833	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Yang, Minglei, Xu, Wei, Liu, Tielong et al. (2019) Development and Validation of a Novel Survival Prediction Model in Patients With Spinal Metas-	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool

Study	Reason for exclusion
tasis From Non-small Cell Lung Cancer. Spine 44(4): 246-257	
Yang, Xiong-Gang, Feng, Jiang-Tao, Wang, Feng et al. (2019) Development and validation of a prognostic nomogram for the overall survival of patients living with spinal metastases. Journal of neuro-oncology 145(1): 167-176	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – prognostic factor study
Yang, Xiong-Gang, Wang, Feng, Feng, Jiang-Tao et al. (2019) Recursive Partitioning Analysis (RPA) of Prognostic Factors for Overall Survival in Patients with Spinal Metastasis: A New System for Stratified Treatment. World neurosurgery 127: e124-e131	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Yeung, Y.-N.; Cheung, K.-K.; Lam, T.-C.; Cheng, H.-O.; Chow, Y.-Y.; A Study of the Predictive Value of the Modified Tokuhashi Score in Metastatic Spinal Tumour Causing Cord Compression in a Southern Chinese Population; Journal of Orthopaedics, Trauma and Rehabilitation; 2014; vol. 18 (no. 1); 15-21	Outcomes do not match review protocol – overall survival
Yilmazlar, Selcuk, Dogan, Seref, Caner, Basak et al. (2008) Comparison of prognostic scores and surgical approaches to treat spinal metastatic tumors: a review of 57 cases. Journal of orthopaedic surgery and research 3: 37	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system
Yu, Wenxi; Tang, Lina; Lin, Feng; Yao, Yang; Shen, Zan; Accuracy of Tokuhashi score system in predicting survival of lung cancer patients with vertebral metastasis.; Journal of neuro-oncology; 2015; vol. 125 (no. 2); 427-33	Outcomes do not match review protocol – overall survival
Zakaria, Hesham Mostafa, Wilkinson, Brandon Michael, Pennington, Zach et al. (2020) Sarcopenia as a Prognostic Factor for 90-Day and Overall Mortality in Patients Undergoing Spine Surgery for Metastatic Tumors: A Multicenter Retrospective Cohort Study. Neurosurgery 87(5): 1025-1036	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – prognostic factor study
Zang, Shizhao, He, Qin, Bao, Qiyuan et al. (2019) Establishment and validation of a novel survival prediction scoring algorithm for patients with non-small-cell lung cancer spinal metastasis. International journal of clinical oncology 24(9): 1049-1060	Index test does not match review protocol - does not report on the prognostic value of a validated clinical tool
Zeng, JC, Song, YM, Liu, H et al. (2007) [The predictive value of the Tokuhashi revised scoring system for the survival time of patients with spinal metastases]. Sichuan da xue xue bao. Yi xue ban = Journal of Sichuan University. Medical science edition 38(3): 488-91	Other protocol criteria – not available in English
Zhang, Dan, Xu, Wei, Liu, Tielong et al. (2013) Surgery and prognostic factors of patients with epidural spinal cord compression caused by hepatocellular carcinoma metastases: retrospective study of 36 patients in a single center. Spine 38(17): e1090-5	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – study of prognostic factors
Zhao, C., Wang, Y., Cai, X. et al. (2020) Prognostic significance of a novel score model based	Index test does not match review protocol - does

Study	Reason for exclusion
on preoperative indicators in patients with breast cancer spine metastases. Cancer Management and Research 12: 11501-11513	not report on the prognostic value of a validated clinical tool
Zhong, N., Leng, A., He, S. et al. (2019) Surgical outcomes and prognostic factors for patients with gastric cancer spinal metastasis. Cancer Management and Research 11: 6971-6979	Outcomes do not match review protocol – does not report data relevant to prognostic value of a scoring system – study of prognostic factors
Zoccali, C., Skoch, J., Walter, C.M. et al. (2016) The Tokuhashi score: effectiveness and pitfalls. European Spine Journal 25(3): 673-678	Study design does not match review protocol - systematic review without pooled results/ quantitative data, checked for relevant studies

Excluded economic studies

No economic evidence was identified for this review. See supplementary material 2 for further information.

Appendix K Research recommendations – full details

Research recommendations for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?

No research recommendations were made for this review question.

Appendix L Study data (thresholds and true positive, false positive, false negative, true negative values)

Study data extracted for review question: What is the prognostic value of validated scoring systems in evaluating spinal instability in people with spinal metastases or direct malignant infiltration of the spine, with or without spinal cord compression?

Key to variables:

- **study**: study ID (including source systematic review if applicable)
- **scoring_system**: clinical prediction tool used
- **threshold**: threshold value used to dichotomise stable/unstable predictions
- **follow_up**: median follow up (months) for spinal stability outcome
- **TP, FP, FN, TN:** true positive, false positive, false negative, true negative

Table 6: Study data extracted

study	scoring_system	threshold	follow_up	TP	FP	FN	TN
Ehresman 2020	SINS	7	30	36	9	20	40
Aiba 2016 (Kim 2021)	SINS	7	10	12	15	3	17
Cunha 2012(Kim 2021)	SINS	7	5.4	14	58	5	90
Lee 2018 (Kim 2021)	SINS	7	10	21	42	1	83
Saghal 2013 (Kim 2021)	SINS	7	11.5	44	168	13	185
Shi 2018 (Kim 2021)	SINS	7	5.9	36	116	14	83
Thibault 2014 (Kim 2021)	SINS	7	12.3	8	16	2	35
Thibault 2015 (Kim 2021)	SINS	7	8	29	89	5	64