Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

The evolving landscape of metastatic spinal cord compression research: a bibliometric analysis

Meiling Zhang
Joint Logistics Assurance Force Nine Eight One Hospital
Fengyan Wang
Joint Logistics Assurance Force Nine Eight One Hospital
Xiaocui Wu
Joint Logistics Assurance Force Nine Eight One Hospital
Xin Wang
Chengde Medical College
Xuelong Song
Joint Logistics Assurance Force Nine Eight One Hospital
Xuelei Wang
Joint Logistics Assurance Force Nine Eight One Hospital
Longhua Zhang
Joint Logistics Assurance Force Nine Eight One Hospital
Liqun Ren
Chengde Medical College
Zhijie Wang
South Campus, Chengde Medical College Affiliated Hospital
Tianyi Wang
Joint Logistics Assurance Force Nine Eight One Hospital
Lin Yang
yanglin@cdmc.edu.cn

Joint Logistics Assurance Force Nine Eight One Hospital

Research Article

Keywords: metastatic spinal cord compression, bibliometric analysis, research hotspots, CiteSpace, bibliometrix

Posted Date: August 23rd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10272963/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Metastatic spinal cord compression (MSCC) is a serious complication of advanced cancer that can cause severe neurological impairment and substantially reduce quality of life. This study aimed to map the publication landscape, identify major contributors, and examine the thematic evolution of MSCC research through bibliometric analysis.

Methods

English-language articles and reviews published between 1990 and 2025 were retrieved from the Web of Science Core Collection. Records were manually screened for relevance and standardized before analysis. Bibliometric indicators, collaboration patterns, citation structures, and keyword trends were examined using bibliometrix and CiteSpace.

Results

A total of 678 publications were included. Publication output showed an overall upward trend, with an annual growth rate of 5.97%. The United States ranked first in publication output, total citations, and h-index. Rades D was the most productive and highly cited author, while the International Journal of Radiation Oncology Biology Physics was the leading journal. Radiotherapy, survival, prognostic factors, surgery, and quality of life remained central themes. Recent keyword bursts indicated increasing scholarly attention to separation surgery, body radiotherapy, surgical resection, and outcome assessment.

Conclusions

MSCC research has expanded steadily and evolved into an increasingly multidisciplinary and individualized field. Current research hotspots emphasize advanced local therapies, coordinated treatment planning, and refined outcome assessment, thereby helping to clarify emerging directions in the field.

1 Introduction

Metastatic spinal cord compression (MSCC) is a serious complication of advanced cancer and an oncologic emergency, as delayed treatment may lead to irreversible neurological injury, loss of ambulation, and substantial deterioration in quality of life[1]. It usually occurs when metastatic lesions compress the spinal cord or cauda equina, causing pain, motor weakness, sensory deficits, and, in

advanced cases, sphincter dysfunction[2, 3]. MSCC is most often associated with breast, lung, and prostate cancers, but it may occasionally be the first presentation of an undiagnosed malignancy[4].

MSCC usually develops in the context of spinal metastases, which are a major source of pain, disability, and treatment complexity in oncology. Metastatic tumors account for approximately 75% of spinal tumors, whereas primary spinal neoplasms are relatively uncommon[5]. Spinal metastases can cause pain, mechanical instability, pathological fracture, and neural compression[6, 7]. With population ageing and improved survival after cancer treatment, the clinical burden of spinal metastases is increasing[8].

Early recognition and timely intervention are critical for preserving neurological function[9]. Emerging diagnostic approaches, including advanced MRI interpretation and biomarker-informed assessment, may improve risk stratification and treatment planning in selected patients[10, 11]. However, the extent to which these developments have altered the structure and thematic priorities of the MSCC literature has not been clearly characterized. A systematic mapping of publication patterns, influential contributors, and evolving research topics may help identify both established knowledge domains and emerging areas of interest.

Bibliometric analysis provides quantitative approaches for examining publication output, citation relationships, collaboration networks, and thematic evolution[12, 13]. Using articles and reviews on MSCC indexed in the Web of Science Core Collection (WoSCC), this study characterized temporal trends in publications and citations, identified the most influential countries, authors, journals, and publications, and explored the evolution of major research themes and emerging topics.

2 Methods

2.1 Data source and search strategy

Bibliographic records were retrieved from the Science Citation Index Expanded of the WoSCC. To minimize variation caused by database updates, the search was conducted and completed on 8 March 2026. The search query was: TS = (“metastatic spinal cord compression” OR (metast* NEAR/3 “spinal cord compression”)). To evaluate the sensitivity of the search strategy, we additionally performed an expanded search incorporating common alternative terms and abbreviations, including “MESCC,” “malignant spinal cord compression,” and “metastatic epidural spinal cord compression.” The expanded search retrieved the same set of records as the primary search strategy. Therefore, the more concise proximity-based query was retained for the final analysis. The initial search yielded 920 records. Publications from 1 January 1990 to 31 December 2025 were included. Only English-language articles and reviews were included. Other document types were excluded, including meeting abstracts (n = 130), editorial material (n = 34), letter (n = 22), correction (n = 9), note (n = 6), proceedings papers (n = 6), and data paper (n = 1). The final dataset comprised 678 publications.

2.2 Data extraction and preprocessing

Full records and cited references of all retrieved publications were exported from WoSCC in plain-text format for bibliometric analysis. Duplicate checking was performed first using CiteSpace, and no duplicates were found. Before analysis, author names, journal titles, countries, and keywords were manually standardized. Abbreviations, singular and plural forms, spelling variants, and synonymous terms referring to the same concept were merged. For example, “MSCC” was merged with “metastatic spinal cord compression,” and lexical variants of radiotherapy- and surgery-related terms were harmonized. Potential author-name variants were assessed using initials, affiliations, and co-authorship information to reduce erroneous splitting or merging.

2.3 Analysis and visualization

Bibliometric analyses were performed using the bibliometrix package in R through its Biblioshiny interface (version 5.0)[14] and CiteSpace (version 6.4.R1 Advanced)[15]. The main bibliometric indicators included publication counts, citation counts, and network relationships among authors, journals, references, and keywords. In CiteSpace, the time span was set from 1990 to 2025, with 1 year per slice. Nodes were selected using the g-index with k set to 10.

3 Results

3.1 Temporal trends in publications and citations

A total of 678 MSCC-related publications were included in the final analysis, comprising 578 articles and 100 reviews. These publications appeared in 233 sources and involved 2,724 authors. The dataset showed an annual growth rate of 5.97%, an average of 29.67 citations per document, and an international co-authorship rate of 23.45%.

Annual publication output increased over the study period, although year-to-year fluctuations were observed. The highest annual output was recorded in 2016, with 41 publications (Fig. 1). Polynomial fitting was consistent with the observed temporal pattern ($R^2 = 0.8742$). The mean total citations per year per article (MeanTCperYear) showed year-to-year variation across the study period, with the highest value observed in 2005 (MeanTCperYear = 9.00).

3.2 Country/region contributions and international collaboration

The United States was the leading contributor to MSCC research, with 267 publications, followed by Germany and England (Fig. 2a). It also ranked first in total citations and had the highest h-index (Fig. 2b). In the international collaboration network, the United States served as the principal hub, with its strongest links to Germany (81 co-authored publications), the Netherlands (44), Canada (20), and Spain (20). Although China ranked among the leading countries by publication output, its international collaboration appeared less extensive in this dataset, with only two co-authored publications involving the United States (Fig. 2a). Citation burst analysis showed changes over time in the research activity of

different countries and regions (Fig. 2c). Early citation bursts were observed for the United States and Denmark. China showed the strongest recent burst.

3.3 Productivity and citation impact of leading authors and journals

Among the 10 most productive authors, Rades D ranked first in publications, total citations, and h-index, whereas Schild SE ranked second across all three indicators (Fig. 3a–c). Among the 10 most productive journals, the *International Journal of Radiation Oncology Biology Physics* ranked first in publications, total citations, and h-index (Fig. 3d–f).

3.4 Highly cited documents and knowledge base

The most frequently cited documents in the MSCC dataset are summarized in Table 1. The main clinical or methodological contributions of these documents were summarized from the original publications[16–25]. The most cited document was the 2005 randomized trial by Patchell et al. published in *Lancet*, which reported better preservation and recovery of ambulation after direct decompressive surgery followed by radiotherapy than after radiotherapy alone. Other highly cited documents mainly addressed radiotherapy fractionation, prognostic factors, baseline neurological status, corticosteroid use, and the role of timely diagnosis and treatment. Together, these documents indicate that the knowledge base of MSCC research has been shaped largely by studies on ambulatory preservation, radiotherapy strategy, patient selection, and functional prognosis.

Table 1
Top 10 highly cited documents in MSCC research

First author	Study type	Total citations	Key findings
Patchell RA[16]	randomized trial	335	Direct decompressive surgery followed by radiotherapy improved ambulatory outcomes compared with radiotherapy alone in selected patients with MSCC.
Maranzano E[17]	prospective study	107	Early diagnosis, radiotherapy, and corticosteroid treatment were associated with preservation of neurological function and walking ability.
Rades D[18]	retrospective analysis	94	Long-course radiotherapy was associated with improved local control, while survival was influenced by prognostic factors and baseline motor function.
Rades D[19]	retrospective analysis	92	Short- and long-course radiotherapy produced similar functional outcomes, whereas long-course treatment was associated with lower recurrence rates.
Rades D[20]	prospective study	78	Long-course radiotherapy improved local control, but survival and motor outcomes were similar to short-course treatment; baseline ambulation remained important.
Helweg-Larsen S[21]	prospective study	77	Pretreatment ambulation predicted post-treatment gait, and recovery of walking ability in initially nonambulatory patients was associated with longer survival.
Cole JS[22]	review	72	The review emphasized early diagnosis, neurological assessment, and selective use of surgery plus radiotherapy to preserve function.
Rades D[23]	review	64	Radiotherapy remained a central treatment modality, with treatment selection guided by prognosis, recurrence risk, and neurological status.
Byrne TN[24]	review	61	The review highlighted prompt corticosteroid therapy and selective surgery to reduce the risk of irreversible neurological deficits.
Bach F[25]	retrospective analysis	53	Pretreatment neurological status, particularly ambulatory ability, was identified as a major predictor of outcome, supporting early diagnosis and timely treatment.

3.5 Keyword analysis and research trends

Keyword analysis was conducted using all available keywords, including both author keywords and Keywords Plus. In the co-occurrence network, key terms such as metastatic spinal cord compression, radiotherapy, surgery, survival, prognostic factors, and quality of life were centrally positioned,

suggesting that these topics form the core conceptual framework of MSCC research (Fig. 4a). Timeline clustering indicated that major thematic domains comprised spinal metastases, spinal cord compression, prognostic factors, separation surgery, and spine oncology (Fig. 4b). Newly emerging clusters reflected a gradual shift toward more specialized, multidisciplinary management strategies.

Keyword burst analysis revealed temporal shifts in research focus (Fig. 5). Earlier burst terms primarily involved epidural metastases, dexamethasone, myelography, and spinal cord compression. More recent bursts included separation surgery, spinal metastases, body radiotherapy, surgical resection, and outcome assessment. These bursts indicate rapid increases in scholarly attention during specific periods.

4 Discussion

Population ageing, improved cancer diagnosis, and advances in systemic treatment have prolonged survival for many patients with malignancies, thereby increasing attention to metastatic complications of the spine[26, 27]. MSCC remains a clinically important oncologic emergency because neurological function, spinal stability, tumor control, life expectancy, and quality of life must often be considered simultaneously. This study mapped the publication and thematic development of MSCC research from 1990 to 2025. The main findings were an overall increase in publication output, a concentration of research influence in a limited number of countries, authors, and journals, and a thematic transition from conventional diagnosis and treatment toward advanced local therapies and structured outcome assessment.

The knowledge base of MSCC research has changed substantially over time. Earlier influential studies mainly addressed clinical recognition, neurological deterioration, corticosteroid use, conventional radiotherapy, prognostic evaluation, and decompressive surgery. Among these, the randomized trial by Patchell et al. remains a landmark study, as it provided evidence that direct decompressive surgery combined with radiotherapy could improve functional outcomes in selected patients compared with radiotherapy alone[16]. This work helped establish the importance of patient selection and functional preservation in MSCC management.

Studies on separation surgery, stereotactic radiosurgery, and stereotactic body radiotherapy have refined the therapeutic framework for selected patients with spinal metastases and MSCC[28, 29]. In this approach, surgery is not only used for decompression but also to restore or maintain spinal stability and create a safer distance between the tumor and spinal cord[30]. High-precision radiotherapy can then be delivered with the aim of improving local tumor control. This evolution suggests that the field has moved beyond simple comparisons between surgery and radiotherapy. Current research increasingly emphasizes individualized treatment planning based on neurological status, mechanical stability, systemic disease burden, tumor radiosensitivity, performance status, and expected prognosis.

The collaborative network analysis showed clear geographic differences in research contribution and influence. The United States remained the leading contributor in publication output, total citations, and h-

index, and it occupied a central position in the international collaboration network. This pattern may reflect stronger research infrastructure, greater clinical specialization, and more established multidisciplinary cancer care systems.

Journal analysis further confirmed the multidisciplinary nature of this field. The most productive and influential journals were concentrated in radiation oncology, spine surgery, and neurosurgery. This distribution reflects the clinical reality of MSCC management, which requires coordination among oncologists, spine surgeons, neurosurgeons, radiation oncologists, neurologists, rehabilitation teams, and supportive care specialists. Progress in MSCC care has therefore depended on interaction across several overlapping clinical and academic communities rather than on a single discipline.

Recent keyword bursts involving separation surgery, stereotactic body radiotherapy, surgical resection, and outcome assessment indicate a shift in publication attention toward more specialized local treatment strategies and more structured evaluation of treatment outcomes. This thematic change is consistent with the increasing complexity of decision-making in spinal oncology. However, bibliometric prominence reflects research activity rather than treatment efficacy. The present findings therefore cannot establish whether one treatment strategy is superior to another or identify which patients derive the greatest benefit. Such questions require comparative clinical studies and evidence synthesis.

The increasing prominence of outcome assessment highlights the need for greater consistency in the reporting of neurological function, ambulatory status, pain, local control, survival, adverse events, and patient-reported quality of life. Future studies should use clearly defined and clinically meaningful endpoints, standardized follow-up periods, and transparent patient-selection criteria. Bibliometric findings may help identify areas of rapid research growth, but they should be integrated with systematic reviews, evidence grading, and prospective comparative studies before informing clinical recommendations.

5 Limitations

This study has several limitations that warrant consideration. First, the analysis relied solely on the WoSCC and included only articles and reviews published in English. While this approach enhances the consistency and comparability of bibliographic and citation data, it may have omitted relevant studies indexed in other databases or published in languages other than English, potentially underrepresenting research from non-English-speaking regions. Second, bibliometric indicators are affected by factors such as publication age, citation practices, and database indexing conventions. Therefore, citation-based metrics should not be interpreted as direct measures of methodological quality or clinical effectiveness. Finally, as with all bibliometric studies, this analysis describes patterns of scholarly output, influence, and thematic trends rather than directly assessing clinical effectiveness. Accordingly, the findings should be interpreted as reflecting the indexed knowledge landscape of MSCC research, rather than the full scope of global evidence in this field.

6 Conclusions

MSCC research published between 1990 and 2025 showed an overall increase in output and an increasingly multidisciplinary thematic structure. The historical literature was strongly shaped by research on neurological preservation, radiotherapy, surgical decompression, and prognostic assessment, whereas more recent publications have increasingly addressed separation surgery, stereotactic body radiotherapy, surgical resection, and structured outcome evaluation. Research influence and international collaboration remained concentrated among a limited number of countries, authors, and journals. These findings characterize the indexed knowledge landscape of MSCC research but do not establish the comparative effectiveness of individual treatments. Future work would benefit from broader international collaboration, standardized outcome definitions, transparent patient-selection criteria, and higher-quality comparative clinical evidence.

Declarations

Funding Declaration

This work was supported by the General Program of the Hebei Natural Science Foundation (H2020406027), the Medical Science and Technology Youth Cultivation Project of the Chinese People's Liberation Army (16QNP074), and the Science and Technology Plan Project of Chengde (202503A065).

Ethics approval

Not applicable.

Clinical trial number

not applicable.

Competing interests

The authors declare no competing interests.

Author Contribution

T.Y.W. and L.Y. conceived and designed the study. M.Z., Z.J.W., and T.Y.W. developed the methodology. M.Z. and F.W. performed the literature search, and F.W. screened the retrieved records. M.Z., F.W., X.C.W., and X.W. curated the data. M.Z. and F.W. standardized author names, journal titles, countries, and keywords. M.Z., X.C.W., X.W., X.L.S., X.L.W., and L.H.Z. performed the formal analysis. M.Z. prepared the visualizations and wrote the original draft of the manuscript. T.Y.W. and L.Y. reviewed and edited the

manuscript. L.Q.R., Z.J.W., T.Y.W., and L.Y. supervised the study. F.W., Z.J.W., and T.Y.W. acquired funding. All authors read and approved the final manuscript.

Acknowledgments

The authors gratefully acknowledge the colleagues who provided technical support during literature retrieval, data standardization, bibliometric analysis, and manuscript preparation.

Data Availability

The data analyzed in this study were obtained from publicly available bibliographic databases. Processed data supporting the findings of this study are available from the corresponding author upon reasonable request.

References

1. Rispoli R, Reverberi C, Targato G, D'Agostini S, Fasola G, Trovò M, et al. Multidisciplinary Approach to Patients With Metastatic Spinal Cord Compression: A Diagnostic Therapeutic Algorithm to Improve the Neurological Outcome. Frontiers in oncology. 2022;12:902928. doi: 10.3389/fonc.2022.902928.
2. Hershkovich O, Sakhnini M, Gara S, Caspi I, Lotan R. Acute Metastatic Spinal Cord Compression: Urgent Surgery versus Radiotherapy and Treatment Result Prediction versus Actual Results. Current oncology (Toronto, Ont). 2022;29(10):7420–9. doi: 10.3390/curroncol29100583.
3. Singer E, Elsayem A, Nassif T, Rodriguez C, Zoghbi M, Dagher J, et al. Initial management and disposition of metastatic spinal cord compression in the emergency department: a review of the literature. Annals of medicine. 2025;57(1):2568117. doi: 10.1080/07853890.2025.2568117.
4. Pojskić M, Saß B, Bopp MHA, Wilke S, Nimsky C. Determinants of Overall and Readmission-Free Survival in Patients with Metastatic Epidural Spinal Cord Compression. Cancers. 2024;16(24). doi: 10.3390/cancers16244248.
5. Gandham S, Clark S, DeMatas M. Management of malignant spinal cord compression. Surgery (Oxford). 2024;42(8):604–14. doi: https://doi.org/10.1016/j.mpsur.2024.05.011.
6. Fisher CG, DiPaola CP, Ryken TC, Bilsky MH, Shaffrey CI, Berven SH, et al. A novel classification system for spinal instability in neoplastic disease: an evidence-based approach and expert consensus from the Spine Oncology Study Group. Spine. 2010;35(22):E1221-9. doi: 10.1097/BRS.0b013e3181e16ae2.
7. Kishore A, Piccioni A, Fiallos Vinueza IL, Younus Khan AR, Kasab M, Lakshminarasimhan D, et al. Current Advancements in the Diagnosis and Treatment of Metastatic Spinal Cord Compression and Its Postintervention Care: A Comprehensive Review. Cureus. 2025;17(6):e86049. doi: 10.7759/cureus.86049.

8. Chang AY, Skirbekk VF, Tyrovolas S, Kassebaum NJ, Dieleman JL. Measuring population ageing: an analysis of the Global Burden of Disease Study 2017. The Lancet Public health. 2019;4(3):e159-e67. doi: 10.1016/s2468-2667(19)30019-2.
9. Brodowicz T, Hadji P, Niepel D, Diel I. Early identification and intervention matters: A comprehensive review of current evidence and recommendations for the monitoring of bone health in patients with cancer. Cancer treatment reviews. 2017;61:23–34. doi: 10.1016/j.ctrv.2017.09.008.
10. Kuah T, Vellayappan BA, Makmur A, Nair S, Song J, Tan JH, et al. State-of-the-Art Imaging Techniques in Metastatic Spinal Cord Compression. Cancers. 2022;14(13). doi: 10.3390/cancers14133289.
11. Hallinan J, Zhu L, Zhang W, Lim DSW, Baskar S, Low XZ, et al. Deep Learning Model for Classifying Metastatic Epidural Spinal Cord Compression on MRI. Frontiers in oncology. 2022;12:849447. doi: 10.3389/fonc.2022.849447.
12. Donthu N, Kumar S, Mukherjee D, Pandey N, Lim WM. How to conduct a bibliometric analysis: An overview and guidelines. Journal of Business Research. 2021;133:285–96. doi: https://doi.org/10.1016/j.jbusres.2021.04.070.
13. Mejia C, Wu M, Zhang Y, Kajikawa Y. Exploring Topics in Bibliometric Research Through Citation Networks and Semantic Analysis. Frontiers in research metrics and analytics. 2021;6:742311. doi: 10.3389/frma.2021.742311.
14. Aria M, Cuccurullo C. bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of Informetrics. 2017;11(4):959–75. doi: https://doi.org/10.1016/j.joi.2017.08.007.
15. Synnestvedt MB, Chen C, Holmes JH. CiteSpace II: visualization and knowledge discovery in bibliographic databases. AMIA Annual Symposium proceedings AMIA Symposium. 2005;2005:724-8.
16. Patchell RA, Tibbs PA, Regine WF, Payne R, Saris S, Kryscio RJ, et al. Direct decompressive surgical resection in the treatment of spinal cord compression caused by metastatic cancer: a randomised trial. Lancet (London, England). 2005;366(9486):643–8. doi: 10.1016/s0140-6736(05)66954-1.
17. Maranzano E, Latini P. Effectiveness of radiation therapy without surgery in metastatic spinal cord compression: final results from a prospective trial. Int J Radiat Oncol Biol Phys. 1995;32(4):959–67. doi: 10.1016/0360-3016(95)00572-g.
18. Rades D, Fehlauer F, Schulte R, Veninga T, Stalpers LJ, Basic H, et al. Prognostic factors for local control and survival after radiotherapy of metastatic spinal cord compression. Journal of clinical oncology: official journal of the American Society of Clinical Oncology. 2006;24(21):3388–93. doi: 10.1200/jco.2005.05.0542.
19. Rades D, Stalpers LJ, Veninga T, Schulte R, Hoskin PJ, Obralic N, et al. Evaluation of five radiation schedules and prognostic factors for metastatic spinal cord compression. Journal of clinical oncology: official journal of the American Society of Clinical Oncology. 2005;23(15):3366–75. doi: 10.1200/jco.2005.04.754.

20. Rades D, Lange M, Veninga T, Stalpers LJ, Bajrovic A, Adamietz IA, et al. Final results of a prospective study comparing the local control of short-course and long-course radiotherapy for metastatic spinal cord compression. Int J Radiat Oncol Biol Phys. 2011;79(2):524–30. doi: 10.1016/j.ijrobp.2009.10.073.
21. Helweg-Larsen S, Sørensen PS, Kreiner S. Prognostic factors in metastatic spinal cord compression: a prospective study using multivariate analysis of variables influencing survival and gait function in 153 patients. Int J Radiat Oncol Biol Phys. 2000;46(5):1163–9. doi: 10.1016/s0360-3016(99)00333-8.
22. Cole JS, Patchell RA. Metastatic epidural spinal cord compression. The Lancet Neurology. 2008;7(5):459–66. doi: 10.1016/s1474-4422(08)70089-9.
23. Rades D, Abrahm JL. The role of radiotherapy for metastatic epidural spinal cord compression. Nature reviews Clinical oncology. 2010;7(10):590–8. doi: 10.1038/nrclinonc.2010.137.
24. Byrne TN. Spinal cord compression from epidural metastases. The New England journal of medicine. 1992;327(9):614–9. doi: 10.1056/nejm199208273270907.
25. Bach F, Larsen BH, Rohde K, Børgesen SE, Gjerris F, Bøge-Rasmussen T, et al. Metastatic spinal cord compression. Occurrence, symptoms, clinical presentations and prognosis in 398 patients with spinal cord compression. Acta neurochirurgica. 1990;107(1–2):37–43. doi: 10.1007/bf01402610.
26. Kai J, Liu X, Wu M, Liu P, Lin M, Yang H, et al. Technological advances in clinical individualized medication for cancer therapy: from genes to whole organism. Personalized medicine. 2025;22(1):45–58. doi: 10.1080/17410541.2024.2447224.
27. Cao W, Chen HD, Yu YW, Li N, Chen WQ. Changing profiles of cancer burden worldwide and in China: a secondary analysis of the global cancer statistics 2020. Chinese medical journal. 2021;134(7):783–91. doi: 10.1097/cm9.0000000000001474.
28. Zhang HR, Li JK, Yang XG, Qiao RQ, Hu YC. Conventional Radiotherapy and Stereotactic Radiosurgery in the Management of Metastatic Spine Disease. Technology in cancer research & treatment. 2020;19:1533033820945798. doi: 10.1177/1533033820945798.
29. Laufer I, Iorgulescu JB, Chapman T, Lis E, Shi W, Zhang Z, et al. Local disease control for spinal metastases following "separation surgery" and adjuvant hypofractionated or high-dose single-fraction stereotactic radiosurgery: outcome analysis in 186 patients. Journal of neurosurgery Spine. 2013;18(3):207–14. doi: 10.3171/2012.11.Spine12111.
30. Lo WY, Yang SH. Metastatic spinal cord compression (MSCC) treated with palliative decompression: Surgical timing and survival rate. PloS one. 2017;12(12):e0190342. doi: 10.1371/journal.pone.0190342.

Figures

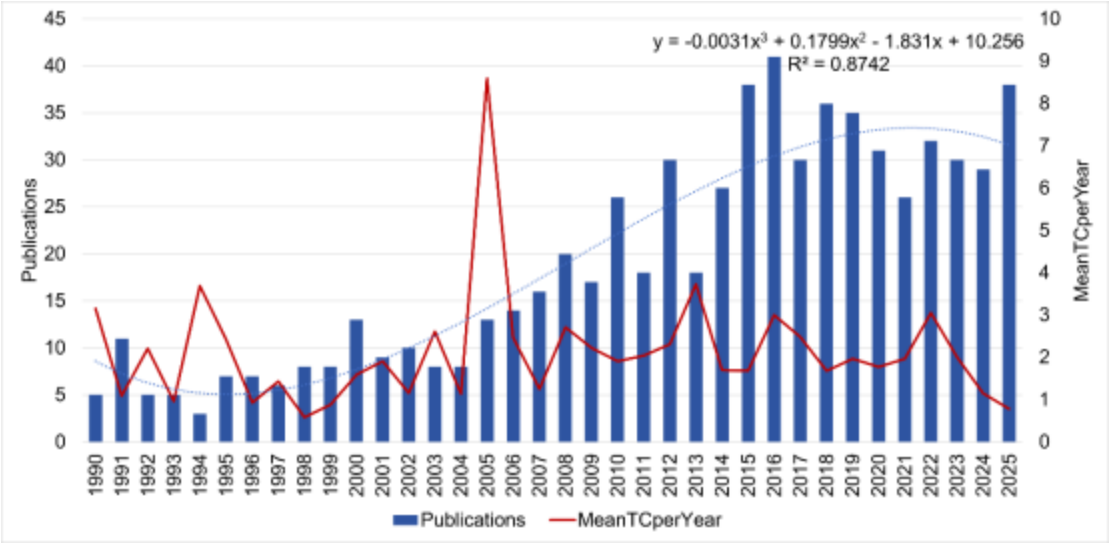


Figure 1

Temporal trends in publication output and citation impact in metastatic spinal cord compression research from 1990 to 2025. Blue bars indicate annual publication output, the red line indicates the mean total citations per year per article (MeanTCperYear), and the dotted blue curve indicates the polynomial trendline

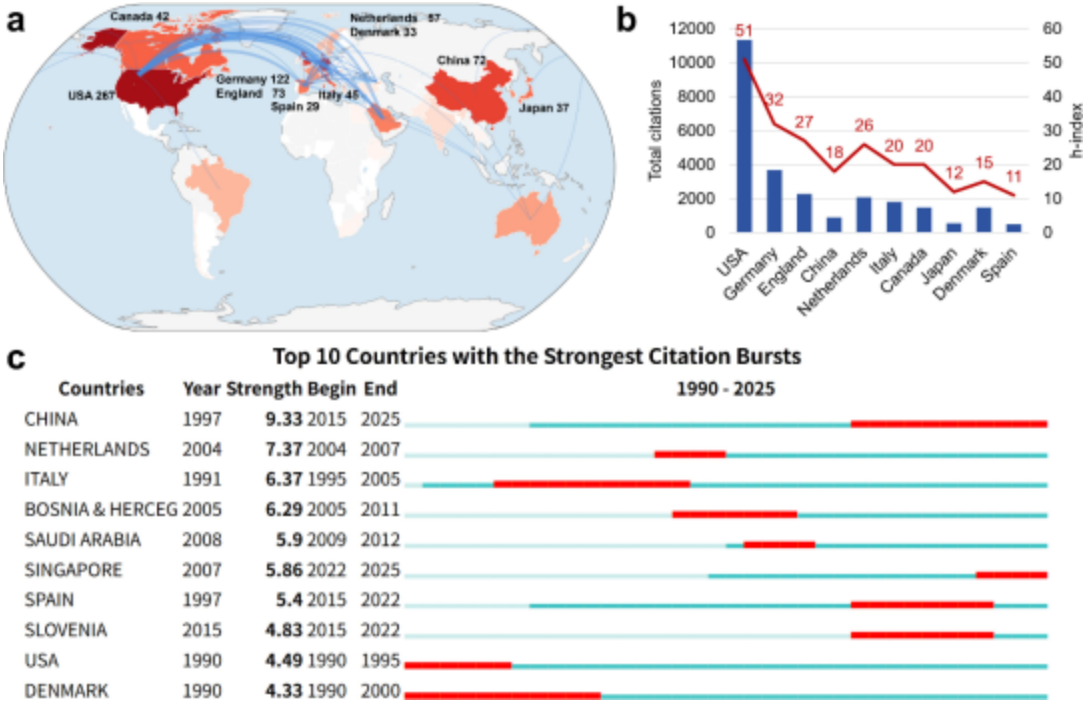


Figure 2

Country/region contributions and international collaboration. **a** Global map of international collaboration among countries and regions. The color intensity represents publication output, the labels indicate the numbers of publications from the 10 most productive countries or regions, and the connecting lines represent international co-authorship links. **b** Total citations and h-index of the 10 leading countries or

regions. Blue bars represent total citations according to the left y-axis, whereas the red line represents the h-index according to the right y-axis. **c** The 10 countries or regions with the strongest citation bursts. Red segments indicate the periods during which citation bursts occurred, whereas “Strength,” “Begin,” and “End” denote burst intensity and the starting and ending years, respectively

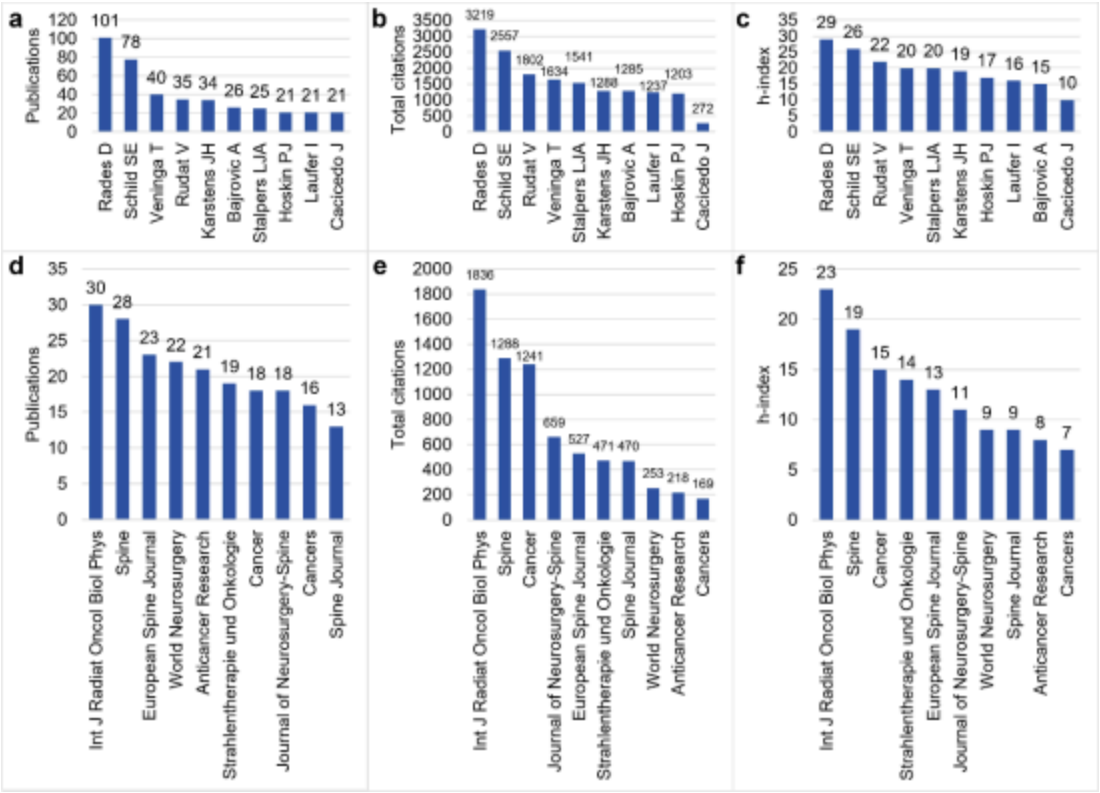


Figure 3

Productivity and citation impact of the most productive authors and journals. **a–c** Publications, total citations, and h-index, respectively, of the 10 most productive authors. **d–f**Publications, total citations, and h-index, respectively, of the 10 most productive journals. Authors and journals were ranked according to publication output

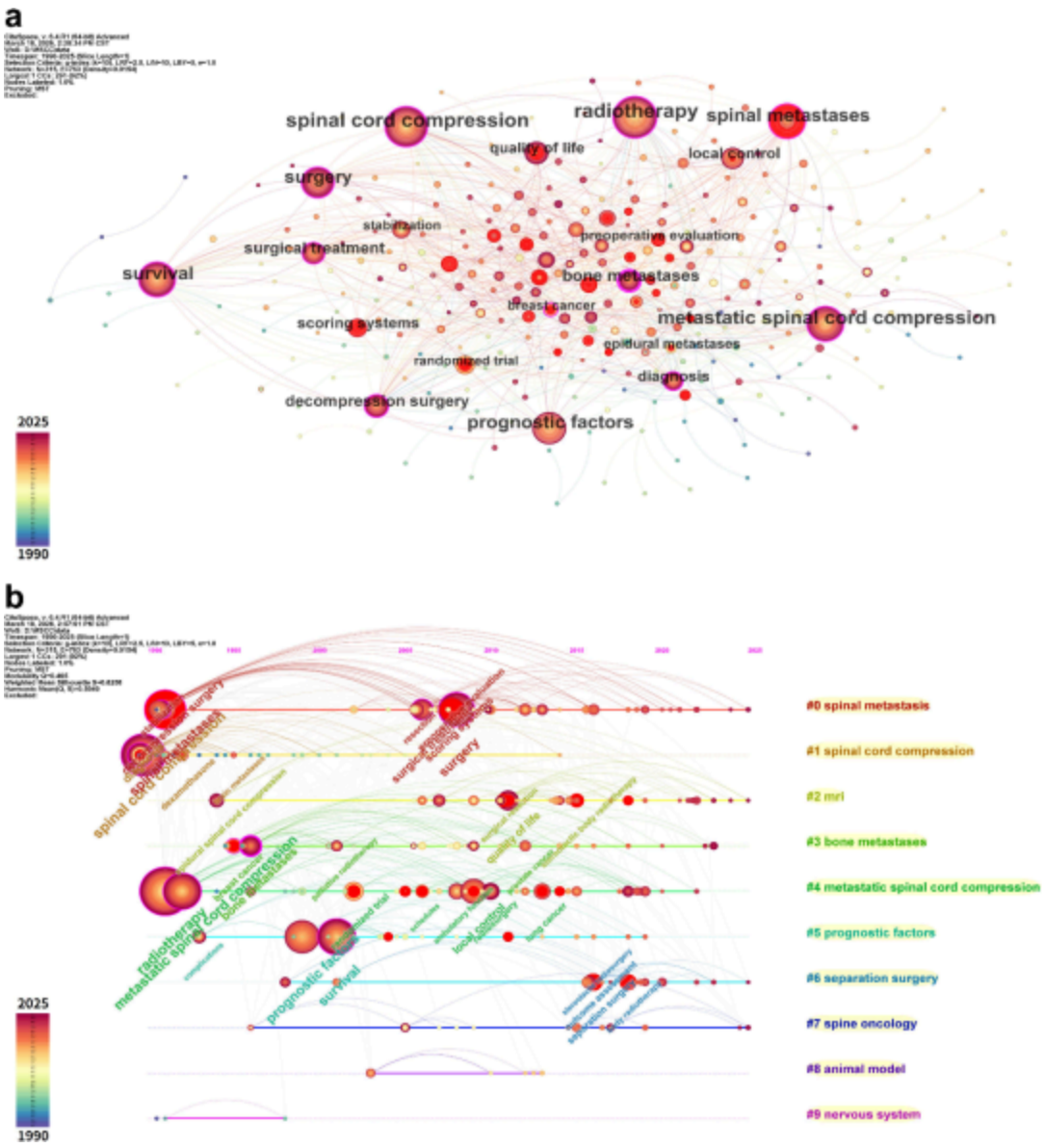


Figure 4

CiteSpace-based keyword analysis and thematic evolution in metastatic spinal cord compression research. **a**Keyword co-occurrence network. Node size indicates keyword frequency, links indicate co-occurrence relationships, node colors represent the temporal distribution of keywords from 1990 to 2025, and purple rings indicate keywords with higher centrality. **b** Timeline view of keyword clusters, showing the temporal evolution of major research themes

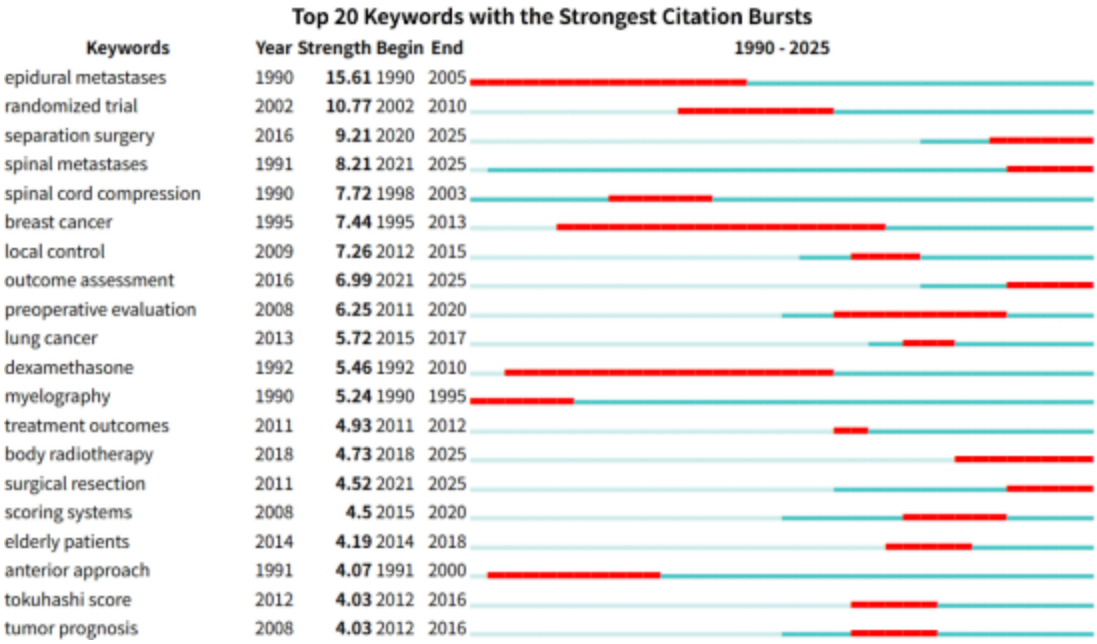


Figure 5

Keywords with the strongest citation bursts. Red segments indicate the periods during which bursts occurred, whereas “Strength,” “Begin,” and “End” denote burst intensity and the starting and ending years, respectively