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Original Article

# Surgical Treatment in the Management of Spinal Metastasis: A Single-center Retrospective Observational Study

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## Abstract

**Background:** Advances in cancer therapies have significantly prolonged patient survival, resulting in a growing number of individuals living with advanced disease. Consequently, the incidence of spinal metastasis has increased, posing a growing clinical challenge regarding diminished quality of life. This study aimed to evaluate survival outcomes in patients with spinal metastasis with or without surgery, and the correlations with Tomita or Tokuhashi scores. **Materials and Methods:** This retrospective observational study included 188 patients who received radiotherapy for spinal metastasis between December 2019 and February 2024 at a single tertiary center. Survival outcomes, including overall survival (OS) and post-spinal metastasis survival (PSMS), were analyzed. Correlations between survival and Tomita or Tokuhashi scores and the impact of treatment aligned with Tomita score recommendations were evaluated. **Results:** Among the included patients, 29.3% underwent a surgical intervention. Patients who received surgery had a trend toward longer PSMS (median: 14.8 vs. 6.5 months, $P = 0.078$). Tomita score was inversely correlated with PSMS but not with OS. In contrast, the Tokuhashi score was not significantly correlated with either outcome. Treatment plans were consistent with Tomita score recommendations in 28.3% of cases. However, no survival benefit was observed for patients receiving Tomita-aligned strategies. **Conclusion:** Surgical intervention was associated with improved 1-year survival among patients with spinal metastasis receiving radiotherapy. Tomita score demonstrated limited prognostic value, and adherence to treatment recommendations did not improve survival. These findings highlight the limitations of existing scoring systems and the need for individualized strategies in managing spinal metastasis.

**Keywords:** Spinal metastasis, surgical intervention, Tokuhashi score, Tomita score

## Introduction

According to the World Health Organization, the global incidence of cancer is expected to increase substantially, with an estimated 29.4 million new cases by the year 2040.[1] Improvements in cancer therapies have significantly prolonged patient survival, leading to a growing population of individuals living with advanced malignancies. Among these, the spine remains a common site of metastasis, particularly in patients with primary malignancies such as

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lung, esophageal, and prostate cancers in men, and breast cancer in women.[2]

Spinal metastasis is a major contributor to cancer-related morbidity, often manifesting as pain and, in more advanced cases, leading to pathological vertebral compression fractures or metastatic epidural spinal cord compression (MESCC).[3,4] MESCC can result in severe neurological deficits, including gait disturbance and incontinence, profoundly diminishing the quality of life and increasing healthcare costs and mortality risk.[5]

Conventional treatment strategies for spinal metastasis are largely palliative, with the primary objectives being pain relief, preservation of neurological function, and maintaining spinal stability.[6] Historically, clinical decision-making has been informed by prognostic scoring systems such as the Tomita and Tokuhashi scores,[7-9] which estimate patient survival and guide the choice of therapy. The Tomita score incorporates the primary site of malignancy, the presence of treatable visceral metastasis, and whether the metastatic disease is solitary or multiple. In addition to these factors, the Tokuhashi score further considers the patient's performance and neurological status related to spinal metastasis. More recently, the Neurologic, Oncologic, Mechanical, and Systemic decision-making framework has increasingly been used in multidisciplinary clinical settings.[10] Despite these tools, adherence to guideline-based decision-making remains variable, especially in local hospital settings where treatment approaches may be influenced by the preferences and judgments of radiologists, oncologists, and spine surgeons.

This retrospective single-center observational study was undertaken to evaluate survival outcomes in patients with spinal metastasis who underwent radiotherapy, with or without surgical intervention. We further analyzed the extent to which the treatment strategies aligned with Tomita and Tokuhashi scoring system recommendations and whether such alignment correlated with survival outcomes. These findings were intended to inform the development of a standardized, evidence-based treatment algorithm at our institution.

## Materials and Methods

This retrospective study was conducted at a single tertiary care center. The inclusion criteria were patients who received radiotherapy for spinal metastasis between December 2019 and February 2024. The exclusion criteria were patients with concurrent double primary malignancies or unclear oncological diagnoses.

Baseline clinical data were collected, including demographic variables (age, sex), primary cancer site, extent and distribution of spinal metastasis (single, oligo, or multiple levels), presence of neurological symptoms (pain, weakness, and incontinence), Eastern Cooperative Oncology Group (ECOG) performance status, history of systemic therapy (chemotherapy, immunotherapy), and prior spinal interventions (surgery or radiotherapy). Single-level spinal metastasis was defined as metastasis with one vertebral body, oligo-level as two or three vertebral bodies, and multiple-level as more than three vertebral bodies.

The primary outcome was overall survival (OS) and post-spinal metastasis survival (PSMS). OS was defined as the time from initial cancer diagnosis to death or last follow-up. PBMS was defined as the time from spinal metastasis diagnosis to death or last follow-up. The secondary outcomes were: (1) correlations between survival and prognostic scores (Tomita and Tokuhashi); (2) correlations between clinical treatment decisions and the recommendations based on these scores; and (3) survival differences between patients whose treatments were or were not aligned with these scoring systems.

Group comparisons were conducted using the Mann–Whitney *U*-test and Pearson's Chi-square test, with a $P < 0.05$ considered statistically significant.

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Chang Gung Medical Foundation (IRB No. 202400353B0, Approved Date: March 17, 2024). Informed consent was waived due to the retrospective nature of the study.

## Results

A total of 188 patients were included in this study, of whom 62.2% were male, and the mean age was 61.40 ± 12.02 years. The most common primary tumor types were lung (35.1%), breast (12.2%), and colorectal (10.6%). Regarding the extent of spinal involvement, 18.1% of the patients presented with single-level metastasis, 28.7% with oligo-level involvement, and 53.2% with multiple spinal metastases.

The most frequent indication for radiotherapy was pain (71.3%), followed by motor weakness (26.6%). A total of 55 patients (29.3%) underwent a surgical intervention, of whom 76.4% underwent laminectomy, 16.4% vertebroplasty, and 7.2% corpectomy. Most patients had an ECOG performance status of either 1 (56.4%) or 2 (32.4%). The mean total radiotherapy dose was 3122.76 ± 778.92 cGy, with an average dose per session of 296.27 ± 58.48 cGy.

No statistically significant differences were observed between the surgical and non-surgical groups with respect to age, sex, primary tumor site, level of spinal metastasis, ECOG performance status, radiotherapy dosage, or the use of chemotherapy and immunotherapy. However, motor weakness was significantly more prevalent in the surgical group ($P < 0.001$), indicating that neurological compromise was a major factor influencing surgical decision-making [Table 1].

In terms of survival outcomes, the median OS was 22.16 months (95% confidence interval [CI]: 15.86–28.47) in the surgery group and 21.3 months (95% CI: 17.43–25.2) in the radiotherapy-only group [Figure 1; $P = 0.611$]. The PSMS was 14.83 (95% CI: 7.52–22.15) months in the surgery group, compared to 6.53 months (95% CI: 4.4–8.65) in the

**Table 1: General characteristics**

| Characteristics | Total (*n*=188), *n* (%) | With operative (*n*=55), *n* (%) | Without operative (*n*=133), *n* (%) | *P* |
|---|---|---|---|---|
| Age - year | 61.40±12.02 | 61.58±11.53 | 61.32±12.26 | 0.894 |
| Male sex | 117 (62.2) | 31 (56.4) | 86 (64.7) | 0.367 |
| Primary tumor (*n*) | | | | |
| Bile duct | 7 | 0 | 7 | 0.062* |
| Bladder | 3 | 2 | 1 | |
| Breast | 23 | 10 | 13 | |
| Colorectal | 20 | 4 | 16 | |
| Endometrium | 2 | 0 | 2 | |
| Esophagus | 8 | 2 | 6 | |
| Gastric | 5 | 2 | 3 | |
| Head and neck | 11 | 1 | 10 | |
| Hepatic | 14 | 3 | 11 | |
| Kidney | 6 | 1 | 5 | |
| Lung | 66 | 19 | 47 | |
| Lymphoma | 4 | 3 | 1 | |
| Pancreas | 2 | 1 | 1 | |
| Pleura | 1 | 0 | 1 | |
| Prostate | 11 | 4 | 7 | |
| Sarcoma | 3 | 3 | 0 | |
| Thyroid | 2 | 0 | 2 | |
| Metastasis site | | | | |
| Single | 34 (18.1) | 9 (16.4) | 25 (18.8) | 0.077* |
| Oligo | 55 (29.3) | 10 (18.3) | 44 (33.1) | |
| Multiple | 100 (53.2) | 36 (65.5) | 64 (48.1) | |
| Reason for treatment | | | | |
| Pain | 134 (71.3) | 31 (56.4) | 103 (77.4) | 0.783 |
| Weakness | 50 (26.6) | 21 (38.2) | 29 (21.8) | 0.001** |
| Incontinence | 3 (1.6) | 2 (3.6) | 1 (1.8) | 0.288 |
| No symptom | 2 (1.1) | 2 (3.6) | 19 (14.3) | 0.167 |
| ECOG | | | | |
| 0 | 6 (3.2) | 2 (3.6) | 4 (3) | 0.126 |
| 1 | 106 (56.4) | 27 (49.1) | 79 (59.4) | |
| 2 | 61 (32.4) | 21 (38.2) | 40 (30.1) | |
| 3 | 11 (5.9) | 3 (5.5) | 8 (6) | |
| 4 | 4 (2.1) | 2 (3.6) | 2 (1.5) | |
| Operation for spine metastasis | 55 (29.3) | 55 (29.3) | N/A | |
| Vertebroplasty - (operative patients) | 9 (16.4) | 9 (16.4) | N/A | |
| Laminectomy - (operative patients) | 42 (76.4) | 42 (76.4) | N/A | |
| Corpectomy - (operative patients) | 4 (7.2) | 4 (7.2) | N/A | |
| Total radiotherapy dose – cGy | 3122.76±778.92 | 3019.82±822.97 | 3166.36±747.68 | 0.311 |
| Radiotherapy dose per time - cGy | 296.27±58.48 | 301.03±61.71 | 294.18±57.21 | 0.469 |
| Chemotherapy | 149 (79.3) | 42 (76.4) | 107 (80.5) | 0.666 |
| Immunotherapy/target therapy | 108 (57.4) | 34 (61.8) | 74 (55.6) | 0.537 |

*$P$=0.05–0.1, **$P$<0.05. $P$ value refers to the two sub-groups of with OP and without OP. ECOG: Eastern Cooperative Oncology Group, NA: Not available

radiotherapy-only group [Figure 2; $P = 0.078$]. No significant differences were observed in either survival endpoint between the two treatment groups.

There was a trend of better OS in the patients who received immunotherapy [Figure 3; $P = 0.082$]. In the patients who received immunotherapy, the median OS was 28.5 months (95% CI: 17.19–39.8), compared to 14.83 months (95% CI: 11.49–18.18) in the patients not receiving immunotherapy.

A significant inverse correlation was observed between Tomita score and PSMS [Figure 4; Spearman $r = -0.151$; $P = 0.046$], indicating that a higher Tomita score was associated with shorter survival. However, the correlation between Tomita score and OS did not reach statistical significance [Figure 5; $r = -0.122$; $P = 0.11$]. Of the 187 patients for whom scoring data were available, 53 (28.3%) received treatment that was consistent with their Tomita score recommendations. The compatibility was higher in those with a higher Tomita score [Figure 6]. No significant difference in survival was observed

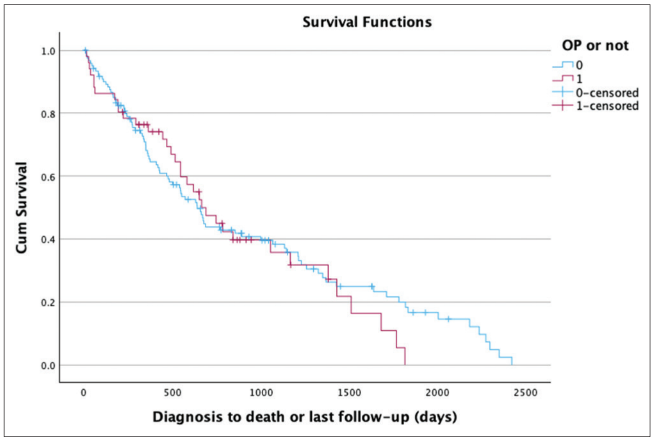


**Figure 1:** Overall survival of the surgery group (red line) and the radiotherapy-only group (blue line). $P = 0.611$

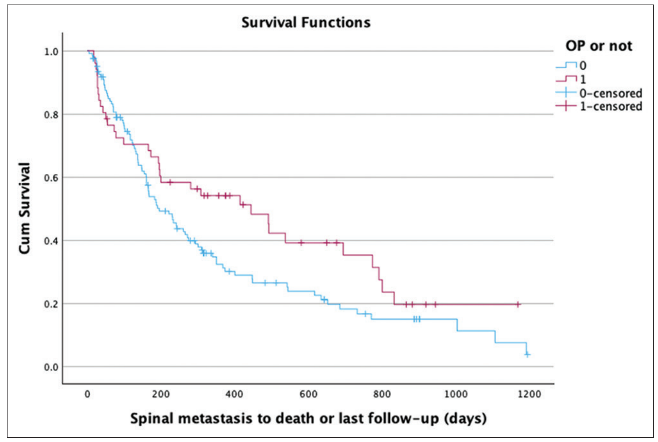


**Figure 2:** Postspinal metastasis survival of the surgery group (red line) and the radiotherapy-only group (blue line). $P = 0.078$

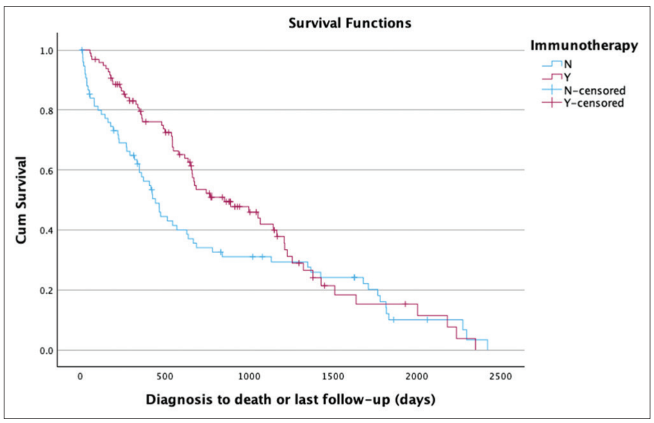


**Figure 3:** Overall survival of the patients treated with (red line) and without (blue line) immunotherapy. $P = 0.082$

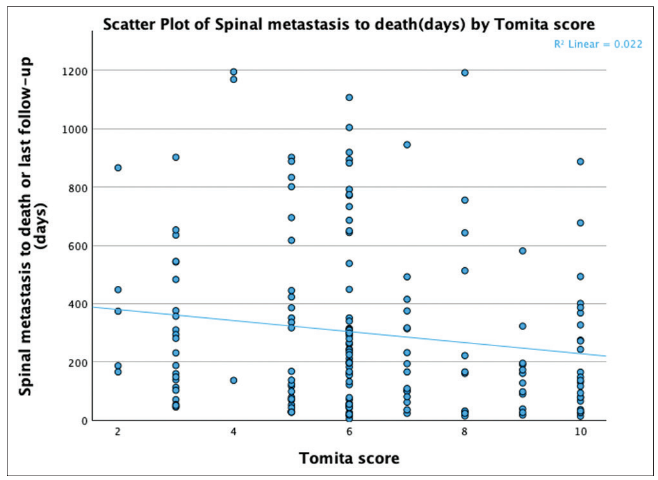


**Figure 4:** Distribution of observed follow-up time from spinal metastasis among patients with diGerent Tomita scores. This analysis is descriptive in nature and does not represent survival probability estimation

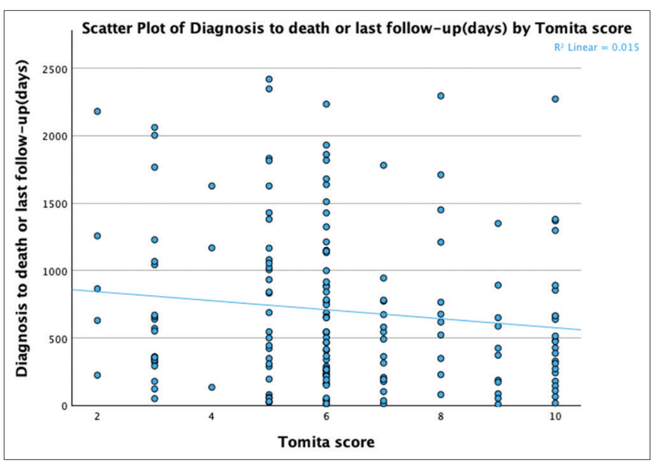


**Figure 5:** Distribution of observed follow-up time from cancer diagnosis among patients with diGerent Tomita scores. This analysis is descriptive in nature and does not represent survival probability estimation

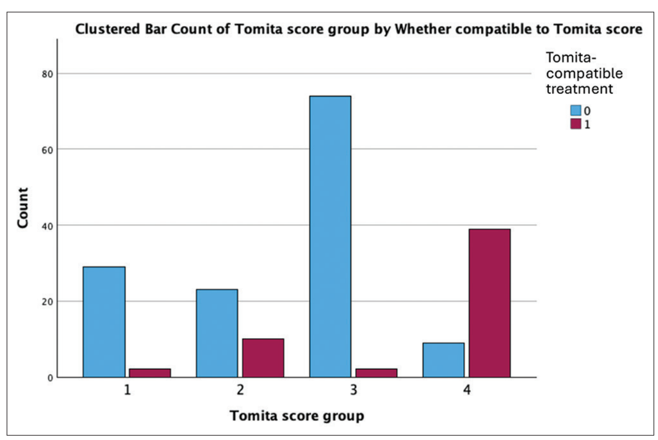


**Figure 6:** Tomita-compatible treatment (blue bar = not compatible, red bar = compatible). Tomita score group definition: 1 = Tomita score 2–3, 2 = Tomita score 4–5, 3 = Tomita score 6–7, 4 = Tomita score 8–10

between the patients who received Tomita-aligned treatment and those who did not when analyzing the four Tomita groups apart or together [Figure 7]. In contrast, no significant correlations were found between Tokuhashi score and OS [Figure 8; $r = 0.11$; $P = 0.149$] or PSMS [Figure 9; $r = 0.022$; $P = 0.775$]. These results suggested that the Tokuhashi score

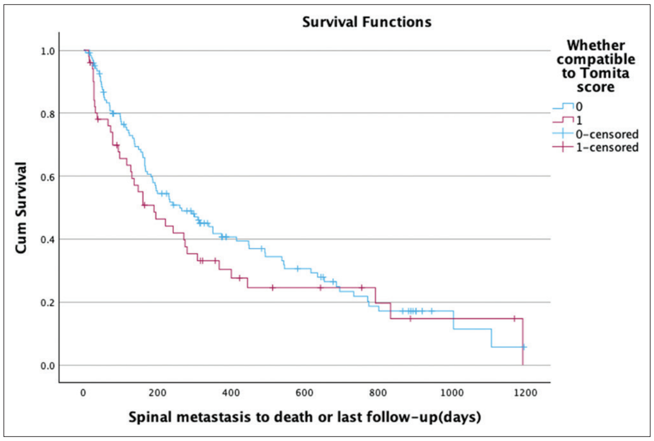


**Figure 7:** Post-spinal metastasis survival of the Tomita score compatible group (red line) and the incompatible group (blue line). $P = 0.078$

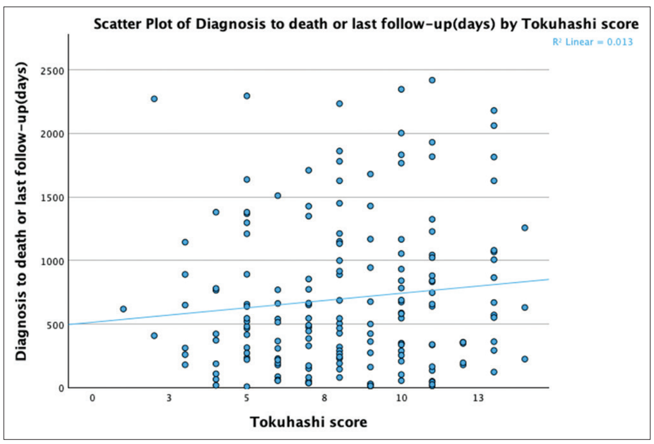


**Figure 8:** Distribution of observed follow-up time from cancer diagnosis among patients with diGerent Tokuhashi scores. This analysis is descriptive in nature and does not represent survival probability estimation

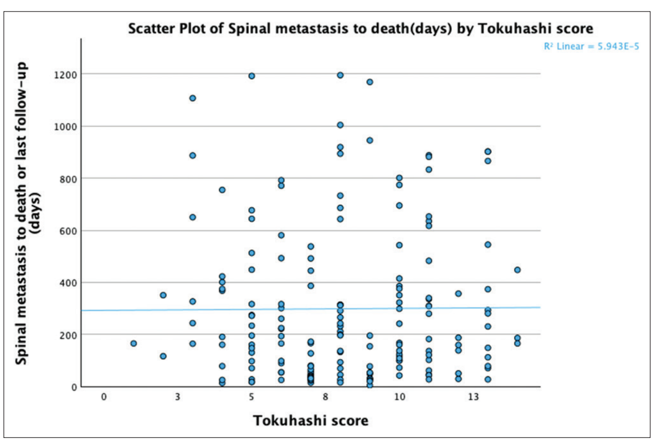


**Figure 9:** Distribution of observed follow-up time from spinal metastasis diagnosis among patients with diGerent Tokuhashi scores. This analysis is descriptive in nature and does not represent survival probability estimation

had limited predictive value for survival in this cohort. Because censored observations cannot be appropriately handled in linear regression models, this analysis was intended as a descriptive illustration rather than a formal survival analysis.

## Discussion

In our cohort, the patients who underwent surgery tended to have better survival outcomes than those who did not. This finding is consistent with previous studies and may also be explained by selection bias, as patients in better clinical condition are more likely to be surgical candidates.[11] A propensity score analysis by Leitner *et al*. suggested that surgery not only improved neurological outcomes in younger patients, those with non-genitourinary malignancies, and those without brain metastasis or new metastatic sites within the last 3 months, but also determined OS.[12] In addition, the prospective observational study of spinal metastasis treatment demonstrated a 28% reduction in the odds of mortality in the operative group.[13]

Considering Tomita and Tokuhashi scores, only the Tomita score demonstrated a significant inverse correlation with survival in our study, suggesting its potential utility in guiding treatment decisions. In contrast, the Tokuhashi score did not correlate with either survival outcome, which may reflect limitations in its applicability across diverse tumor types as in our study. The results of previous studies regarding the predictive value of Tokuhashi and Tomita scores have been inconsistent.[14] Aoude and Amiot reported that both scores were accurate in differentiating patients with a poor prognosis from other patients, while it was not clear whether a treatment choice based on the scores alone was beneficial in patients with scores corresponding to a moderate or good prognosis.[15] A Korean study that included 641 spinal metastasis patients compared the effectiveness of eight scoring system in identifying patients with a poor prognosis, and found that most scoring systems had low discriminative power, with only the Skeletal Oncology Research Group nomogram having moderate power.[16] This emphasizes the importance of the individualized nature of clinical decision-making, where multidisciplinary teams can balance neurological status, tumor control, and patient preference beyond the scope of scoring systems.

A review of the original study by Tomita *et al*.[9] revealed that the proposed surgical strategy was developed based on an analysis of 68 patients enrolled between 1987 and 1991. Given the three-decade interval since the original study and its limited sample size, temporal and contextual differences may limit the applicability of its findings to contemporary clinical practice. Moreover, over the past three decades, numerous immune biomarkers have been identified, and corresponding targeted and immunotherapeutic agents have been developed. In our study, the patients who received immunotherapy tended to have improved survival outcomes, underscoring the importance of incorporating immune markers and immunotherapy into prognostic scoring systems in the current era.

In our cohort, approximately 30% of the patients received treatment strategies consistent with the Tomita score. However, no significant difference in survival was observed between the patients whose treatment adhered to the Tomita score and those whose treatment did not. Interestingly, adherence to the recommended surgical strategy was more frequently observed among the patients with a higher Tomita score, which may reflect a tendency toward more conservative treatment approaches at our institution.

This study has several limitations that warrant consideration. First, the relatively small sample size and heterogeneity of primary tumor types may limit the generalizability of the findings. While all cancer types were included to better reflect real-world clinical practice, this approach introduces variability that may obscure cancer-specific prognostic trends. However, this inclusive strategy aligns with the study's goal of informing a pragmatic treatment algorithm tailored to institutional practice.

Second, we did not assess the patients' quality of life, which is an important outcome in the management of spinal metastasis. Due to the retrospective nature of the analysis, reliable quality-of-life data could not be obtained from existing medical records. Future prospective studies are needed to incorporate patient-reported outcomes to better evaluate functional and symptomatic improvement.

Finally, the study cohort was restricted to patients who received radiotherapy. This inclusion criterion may have introduced selection bias by excluding patients with spinal metastasis who were not considered eligible for radiotherapy, thereby limiting the applicability of the results to the broader metastatic spinal population.

## Conclusion

This retrospective observational study offers valuable insights into real-world treatment strategies for spinal metastasis. Among the patients who received radiotherapy, surgical intervention was associated with a significant improvement in 1-year OS and showed a trend toward improved PSMS. The Tomita score appeared to be more predictive of OS than the Tokuhashi score; however, adherence to its recommended surgical strategy did not correlate with improved outcomes. Future research should focus on developing individualized treatment approaches tailored to specific cancer types.

### Author contributions

Ying-Yun Chen: Conceptualization, Methodology, Data curation, Formal analysis, Investigation, and Writing – original draft. Jiun-Lin Yan: Supervision, Conceptualization, Methodology, and Writing – review & editing. All authors have read and agreed to the final version of the manuscript.

### Data availability statement

The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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