

# Life Expectancy and Metastatic Spine Scoring Systems

## *An Academic Institutional Experience*

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**Study Design:** A retrospective data collection study with application of metastatic spine scoring systems.

**Objectives:** To apply the Tomita and revised Tokunashi scoring systems to a surgical cohort at a single academic institution and analyze spine-related surgical morbidity and mortality rates.

**Summary of Background Data:** Surgical management of metastatic spine patients requires tools that can accurately predict patient survival, as well as knowledge of morbidity and mortality rates.

**Methods:** An Oregon Health & Science University (OHSU) Spine Center surgical database was queried (years 2002–2010) to identify patients with an ICD-9 code indicative of metastatic spine disease. Patients whose only surgical treatment was vertebral augmentation were not included. Scatter plots of survival versus the Tomita and revised Tokunashi metastatic spine scoring systems were statistically analyzed. Spine-related morbidity and mortality rates were calculated.

**Results:** Sixty-eight patients were identified: 45 patients' (30 male patients, mean age 45 y) medical records included operative, morbidity, and mortality statistic data and 38 (26 male patients, mean age 54 y) contained complete metastatic spine scoring system data. Of the 38 deceased spine metastatic patients, 8 had renal cell, 7 lung, 4 breast, 2 chondrosarcoma, 2 prostate, 11 other, and 4 unknown primary cancers. Linear regression analysis revealed  $R^2$  values of 0.2570 and 0.2009 for the revised Tokunashi and Tomita scoring systems, respectively. Overall transfusion, infection, morbidity, and mortality rates were 33% and 9%, and 42% and 9%, respectively.

**Conclusions:** Application of metastatic prognostic scoring systems to a retrospective surgical cohort revealed an overall poor correlation with the Tomita and revised Tokunashi predictive survival models. Morbidity and mortality rates concur with those in the medical literature. This study underscores the difficulty in utilizing metastatic spine scoring systems to predict patient survival. We believe a scoring system based on cancer type is needed to account for changes in treatment paradigms with improved patient survival over time.

**Key Words:** metastatic spine disease, metastatic spine scoring systems, Tomita, revised Tokunashi, metastatic cancer

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Cancer is diagnosed in approximately 1.2 million new patients in the United States each year. Spinal metastasis occurs in 5%–30% of cancer patients over disease course, with more than 20,000 new cases occurring in the United States per year.<sup>1,2</sup> Up to 66% of patients with breast, prostate, lung, and hematopoietic cancers will develop spine metastases.<sup>1</sup> In those patients with metastatic spine cancer, approximately 20% present with symptoms of back pain or motor weakness. In patients presenting with paraplegia, surgery to restore of the ability to walk improves overall survival.<sup>3–5</sup> In 2005, a prospective trial by Patchell et al,<sup>3</sup> showed that circumferential spinal cord decompression for symptomatic metastatic epidural spinal cord compression (MESCC) improved patient survival and quality of life (median survival time 126 d vs. 100 d). Further in 2005, a meta-analysis by Klimo and colleagues found that circumferential decompressive surgery showed improved ability to ambulate (1.3 times more likely) and greater likelihood of improvement in pain (90% vs. 70%) compared with radiotherapy alone. Surgical morbidity, however, can be as high as 50%.<sup>5</sup>

When faced with a patient with metastatic spine disease, surgeons must weigh surgical morbidity, mortality, and recovery time with the chances of improving neurologic function, decreasing pain, and restoring spine stability.<sup>3–5</sup> Surgical decision-making is in the context of a patient who may not survive surgery or whose life expectancy may be shorter than the expected recovery time.

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Surgery for metastatic disease involves circumferential spinal cord decompression and spine stabilization, potentially with an associated high blood loss, long hospital stay, and up to 8 weeks recovery from surgery-related pain.<sup>5</sup> The revised Tokuhashi and Tomita scoring systems were designed to predict life expectancy in patients with metastatic spine disease.<sup>6–8</sup>

We applied the revised Tokuhashi and Tomita scoring systems to patients who underwent surgery for metastatic spine disease at Oregon Health & Science University (OHSU) to alleviate pain and/or prevent or restore neurologic deficit. Patient demographics, surgical morbidity and mortality, and linear regression analysis of metastatic spine scoring system versus survival were accomplished. We reflect on our institutional experience, with the goal of better serving the needs of metastatic spine patients and making surgical decisions based upon experience.

## METHODS

The OHSU Spine Center maintains an Institutional Review Board-approved patient database of all patients treated by 4 spine surgeons in the Departments of Neurological Surgery and Orthopaedics. This surgical database was queried to identify patients treated for metastatic spine diseases from 2002 to 2010. Three International Classification of Disease (ICD-9) Ninth Edition codes were used to identify patients (198.5: secondary malignancy neoplasm of bone and bone marrow, 733.13: pathologic fracture of vertebrae, and 238: neoplasm of uncertain behavior of other and unspecified sites and tissues). Retrospective review of patient records was undertaken and age, sex, cancer type, cancer burden, surgery performed, surgical data, operative complications, postoperative complications, and date of death recorded. Dates of death were crosschecked with an institutional patient outcomes database. Patients who underwent kyphoplasty or vertebroplasty for metastatic spine disease were excluded. These minimally invasive procedures were excluded because they are usually performed in patients without neural compression and uncontrolled back pain. In this patient subset, the risk of surgery is low and life expectancy is less of a consideration. Thus, a life expectancy scoring system is not a useful tool in decision-making.

## Revised Tokuhashi and Tomita Metastatic Spine Scoring Systems

The revised Tokuhashi and Tomita metastatic spine scoring systems were applied to identified patients by evaluating the data recorded in electronic medical records and the appropriate computed tomography (CT) and/or magnetic resonance imaging (MRI) of the involved metastatic vertebral bodies. The Tomita score rates patients based on the primary tumor grade, the presence of visceral metastases, and the bony metastases quantity. The Tomita score offers treatment goals and surgical strategies for terminal, short-term, medium-term, and long-term care. The revised Tokuhashi scores a patient's general condition, number of extraspinal metastases, number of metastases in the vertebral body, ability to remove metastases of the

major internal organs, palsy grade, and primary site of the cancer. On the basis of the score, the survival categories are < 6 months, ≥ 6 months, or ≥ 1 year.<sup>6–8</sup>

## Statistics: Survival Proportions and Regression Analysis

Survival proportions for the revised Tokuhashi metastatic spine scores were created by grouping scores as 3 groups: ≤ 8, 9–11, and ≥ 12 (Prism 6; GraphPad Software Inc., La Jolla, CA). Survival proportions for the Tomita metastatic spine scores were created by grouping scores into 4 groups; 2–3, 4–5, 6–7, and 8–10 (Prism 6; GraphPad Software Inc.). Scatter plot graphs of the revised Tokuhashi and Tomita metastatic spine scores versus patient survival were analyzed using linear regression analysis (Prism 6; GraphPad Software Inc.) with 95% confidence intervals.

## RESULTS

### Demographics

A total of 91 patients met the ICD-9 inclusion criteria; 23 who underwent only kyphoplasty/vertebroplasty were excluded. Of the remaining 68 patients; 45 (38 were deceased) had complete medical records that included operative statistics and date-of-death records for scoring system analysis. There were 7 survivors at the time of analysis.

### Operative Data

Forty-five patients had complete medical records for operative statistics, morbidity, and mortality. There were 30 male and 15 female patients with an average age of 45 years (range, 31–74 y). Eleven patients had primary renal cell carcinoma, 7 had lung cancer, 4 had breast cancer, 4 had chondrosarcoma, 2 had prostate cancer, 13 had other types of cancers, and 4 had metastatic cancer of unknown primary origin (Table 1). Average surgical time was 5.6 hours (range, 1–14 h) and estimated blood loss was 1.9 L (range, 0.01–12 L) and 15 (33%) patients received blood products (ie. packed red blood cells, platelets, and/or fresh frozen plasma) (Table 1). There were 32 complications (morbidity) in 19 patients (42%), 15 were intraoperative and 17 postoperative. Intraoperative complications included 4 vessel or large organ injuries, 3 bleeding cases of < 4 L, 5 excessive bleeding cases of > 4 L, 2 vertebral body fractures, and 1 cerebrospinal fluid leak (CSF). Postoperative complications included 3 deep infections requiring incision and drainage, 1 superficial infection, 3 unplanned returns to the operating room (2 wound washouts for hematoma and 1 CSF leak), 3 excessive bleeding and anemia, 1 new bowel or bladder deficit, 1 visual blindness, 1 myocardial infarction, 1 reintubation, 1 stroke, 1 pulmonary embolus, and 1 acute renal failure. No intraoperative mortalities occurred. Four (9%), 6 (13%), 9 (20%), and 16 (35.5%) patients had died within 1, 2, 3, and 6 months of surgery, respectively. Therefore, overall mortality at 6 months was 35% (16/45), (Table 2).

**TABLE 1.** Characteristics and Surgical Parameters of 45 Patients Undergoing Surgery for Metastatic Spine Disease

Median age, years (range)	45 (31–74)
Sex, M:F (n)	30: 15
Primary cancer (n)	
Renal cell carcinoma	11
Lung	7
Breast	4
Chondrosarcoma	4
Prostate	2
Hematopoietic	1
Leiomyosarcoma	1
Esophageal	1
Ewing sarcoma	1
Colon cancer	1
Adenocarcinoma	1
Sarcoma	1
Melanoma	1
Thyroid	1
Hepatocellular	1
Gastric carcinoid	1
Parotid	1
Cervical	1
Unknown	4
Surgical parameters	
Time, hours (range)	5.6 (1–14)
Estimated blood loss (range) (L)	1.9 (0.01–12)
Transfusion rate*	33% (15/45)

\*Transfusion rate = percentage of patients receiving blood products, that is, packed red blood cells, fresh frozen plasma, or cryoprecipitate.

### Revised Tokuhashi and Tomita Scoring Systems

Thirty-eight deceased patients had complete records for metastatic spine scoring system analysis as of the study date. There were 26 male and 12 female patients

**TABLE 2.** Morbidity and Mortality in 45 Patients Undergoing Metastatic Spine Surgery

Complications (n = 32 in 19 patients; 42%)	n
Intraoperative (n = 15)	4
Vessel/organ injury	
Excessive bleeding < 4L	3
Excessive bleeding > 4L	5
Vertebral fracture	2
Cerebrospinal fluid leak	1
Postoperative (n = 17)	
Bowel/bladder deficit	1
Infection deep*	3
Infection superficial	1
Visual deficit	1
Myocardial infarction	1
Reintubation	1
Stroke	1
Unplanned return to OR	3
Excessive bleeding and anemia	3
Pulmonary embolus	1
Acute renal failure	1
Mortality (n = 45) (mo) [n (%)]	
at 1	4 (9)
at 2	6 (13)
at 3	9 (20)
at 6	16 (36)

\*Infection deep required return to operating room for wound wash out.

**TABLE 3.** Mean Survival Times of 38 Patients Undergoing Metastatic Spine Surgery Based on Primary Cancer and Revised Tokuhashi and Tomita Scores

Primary Cancer	n	Mean Survival, (range) (mo)
Kidney	8	28.8 (3.3–65.2)
Lung	7	5.0 (0.3–9.3)
Breast	4	20.5 (2.3–51.6)
Prostate	2	8.6 (3.2–14.0)
Liver	2	5.0 (0.5–9.6)
Gastrointestinal	2	13.6 (1.7–25.5)
Other	13	13.0 (0.7–39.8)
Revised Tokuhashi score		
≤ 8	22	6.8 (0.3–25.5)
9–11	8	28.7 (2.4–65.2)
≥ 12	8	22.3 (2.3–51.6)
Tomita score		
2–3	13	21.9 (2.3–51.6)
4–5	15	14.5 (2.4–65.2)
6–7	2	10.7 (9.4–12.1)
8–10	8	4.3 (0.3–25.5)

There were 26 male and 12 female patients with an average age of 54 years (31–69 y).

with an average age of 54 years (range, 31–69 y). Of these 38 patients, 8 had renal cell primary cancer, 7 had lung cancer, 4 had breast cancer, 2 had chondrosarcoma, 2 had prostate cancer, 11 had other primary cancers, and 4 had metastatic spine cancer of unknown primary origin. Mean survival time was 4.6 months for patients with metastatic diseases of unknown primary origin and 15–28.8 months for patients with renal cell cancer (Table 3). As of the study date, there were 7 surviving patients.

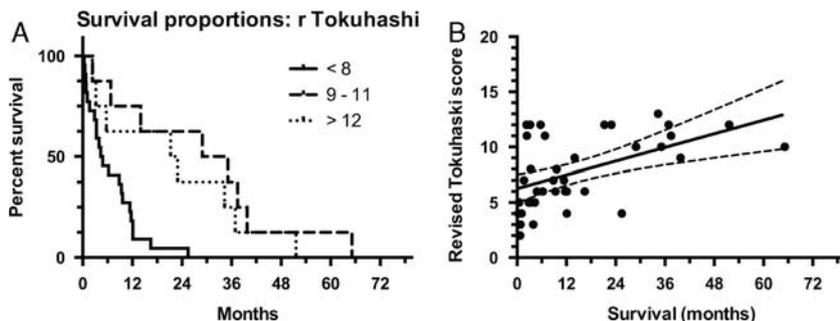
### Statistical Analysis

Proportional survival analysis for the revised Tokuhashi scoring system revealed mean survivals of 6.8, 28.7, and 22.3 months for scores ≤8, 9–11, and ≥12, respectively (Table 3, Fig. 1A). Proportional survival analysis for the Tomita scoring system revealed mean survivals of 21.9, 14.5, 10.7, and 4.3 months for scores 2–3, 4–5, 6–7, and 8–10, respectively (Table 3, Fig. 2A). Linear regression analysis revealed  $R^2$  values of 0.2570 and 0.2009 for the revised Tokuhashi and Tomita scoring systems, respectively (Fig. 1A and Fig. 2B).

### DISCUSSION

Surgeons treating metastatic spine disease patients require tools that can help accurately predict patient survival and help interpret institutional morbidity and mortality rates. Metastatic spine scoring systems are examples of easy-to-administer, reliable, and reproducible tools.

Eight prognostic scoring systems for the patient with metastasis to the spine have been proposed for predicting surgical management and survival: the Tokuhashi score,<sup>6</sup> Tokuhashi revised score,<sup>7</sup> Tomita score,<sup>8</sup> Van der Linden score,<sup>9</sup> Sioutos system,<sup>10</sup> Bauer score,<sup>11</sup> Bauer Modified score,<sup>12</sup> and (most recently) the Oswestry Risk Index.<sup>13</sup> We applied the revised Tokuhashi and Tomita metastatic spine scoring systems to institutional data because this has been the most widely used scoring system



**FIGURE 1.** Revised Tokuhashi scores of 38 patients with metastatic spine disease. A, Survival proportions plot of revised Tokuhashi scores of  $\leq 8$  (predicted survival  $<6$  mo), 9–11 (predicted survival  $>6$  mo, 30%  $>1$  y), and  $\geq 12$  (predicted survival  $>1$  y in 95%).<sup>6,7</sup> B, Scatter plot of the revised Tokuhashi score versus survival. Linear regression analysis (solid line) with 95% confidence intervals (dotted lines),  $R^2=0.2570$ .

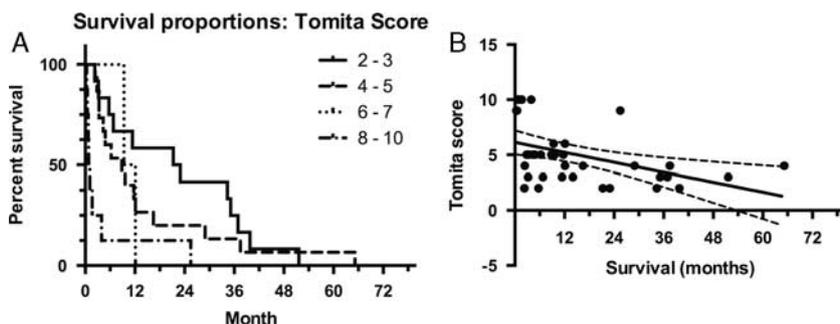
reported in the literature. Poor survival correlation was shown with linear regression analysis  $R^2$  values of 0.2570 and 0.2009 for the revised Tokuhashi and Tomita scoring systems, respectively (Fig. 1B and Fig. 2B).

### Morbidity and Mortality After Metastatic Spine Surgery

Among 45 patients, surgical time averaged 5.6 hours with an average estimated blood loss of 1.9 L and 33% of patients received transfusions. Operative times, estimated blood loss, and transfusion rates are similar to those reported in other studies, where average surgical times ranging from 3.1 to 4.5 hours, median blood loss was 1.4–2.5 L, and transfusion rates were 26%, respectively (Table 4).<sup>15,18,19</sup> Morbidity, infection, and 30-day mortality rates of 42%, 9%, and 9%, respectively (Tables 1, 2), were also comparable with those in other metastatic spine series and likely reflect operative risk for patients with systemic cancer, a high number of renal cell carcinoma patients in our series (ie, vascular tumors with high blood loss), multiple medical comorbidities, and often previously irradiated tissue (Table 4).<sup>20–22</sup>

### Metastatic Spine Scoring Systems for Predicting Patient Survival

Application of the revised Tokuhashi and Tomita scores to our operative data revealed a poor correlation with overall survival, underscoring the difficulty in predicting survival in patients with metastatic spine cancer. We propose that the time from diagnosis of the primary cancer and first spinal metastasis is more helpful in predicting survival. For example, current spine metastasis prognostic scoring systems may score a newly diagnosed prostate cancer patient with metastatic spine disease (prostate cancer with distant metastasis) and a lung cancer patient with a new spinal metastasis at 1 year similarly. The prostate cancer patient has an approximately 28% 5-year survival rate (prostate cancer with distant metastasis) and the lung cancer patient has a 4% 5-year survival rate (National Cancer Institute, Surveillance Epidemiology and End Result, <http://www.seer.cancer.gov>), however. We suggest that predictive survival models should be developed that analyze each primary cancer individually. This would account for the variability between primary cancer survivals as well as take into consideration treatment advancements (eg, antibody therapies, small molecular inhibitors) that effect patient survival over time.



**FIGURE 2.** Tomita scores of 38 patients with metastatic spine disease. A, Survival proportions plot of patients with Tomita scores of 2–3, 4–5, 6–7, and 8–10. The mean reported survival by Tomita for 2–3, 4–5, 6–7, and 8–10 are 50, 23.5, 15, and 6 months, respectively.<sup>8</sup> B, Scatter plot of the Tomita score versus survival. Linear regression analysis (solid line) with 95% confidence intervals (dotted lines),  $R^2=0.2009$ .

**TABLE 4. Literature Review of Operative Parameters, Morbidity, and Mortality**

References	Study Description	Operative Time (Range) (mo)	EBL (Range) (mo)	Transfusion Rate [n (%)]	Infection [n (%)]	Morbidity [n (%)]	Mortality
Eleraky et al <sup>14</sup>	Comparison review of 32 patients with surgery for metastatic spine disease	NA	1165 ± 900	NA	5/35 (15.6)	7/35 (21.9)	Mean survival 17 mo (median 16; range 13–27 mo)
Shehadi et al <sup>15</sup>	Review of 87 patients; surgery for spinal metastases from breast cancer	NA	2500 (500–5500)	23/87 (26)	18/87 (21)	39/87 (44) complications	Median survival of 80 mo post surgery (6.6 y; 95% CI, 5.4–7.7 y). Survival rate after the date of primary breast cancer diagnosis 96% at 1 y, 81% at 3 y, and 69% at 5 y
Pascal-Moussellard et al <sup>16</sup>	Retrospective review of 145 patients; surgery for metastatic disease of the spine	NA	Not given	NA	Wound dehiscence and infection (11%)	37/145 (25.5) postoperative complication	Only early death listed (within 1 mo of surgery)
Quraishi et al <sup>17</sup>	Surgical review of 25 patients with metastatic renal cell carcinoma	276 (90–696)	1696 (400–5000)	Average 2.3 (0–7) units transfused	8/25 (32)	17/101 (16)	3/145 (2.06%) 1 y survival rates (48%), 6 mo survival (59%)

CI indicates confidence interval; EBL, estimated blood loss.

Several studies have also evaluated these scoring systems with mixed results, with correlations ranging from “significantly correlated to survivability” ( $R^2 = 0.57$ ) to “borderline significant” ( $R^2 = 0.394$ ) to “poor correlation” (Table 5).<sup>24,25,27</sup> Although a literature review of the revised Tokuhashi system tends to be more favorable than reviews of the earlier Tokuhashi system, reviews still demonstrate significant variance. In a 2008 a study of 38 patients by Putz and colleagues, calculated an  $R^2$  value of 0.330, which is similar to our calculated  $R^2$  value of 0.2570; however, Zeng et al,<sup>28</sup> found “reliable estimation of life expectancy” with the revised Tokuhashi score ( $R^2 = 0.693$ ) in a 2007 study of 477 patients.

Podalcker and Tow,<sup>24</sup> retrospectively analyzed 102 operative metastatic spine patients and found that a revised Tokuhashi score of  $\geq 7$  and a Tomita score of  $\leq 6$  indicated a  $> 50\%$  chance of surviving 6 months postoperatively. Papastefanou and colleagues prospectively collected data on 52 consecutive patients who underwent surgery. The Tokuhashi score was statistically significant ( $r = 0.574$ ,  $P = 0.01$ ), and the Tomita score was borderline significant ( $r = -0.394$ ,  $P = 0.05$ ) at predicting survival. This finding agrees with our study, with the prognostic value of the revised Tokuhashi score appearing to be more reliable ( $R^2 = 0.2570$ , Fig. 1A) than the Tomita score ( $R^2 = 0.2009$ , Fig. 2B).<sup>25</sup> Liang et al,<sup>27</sup> retrospectively analyzed 104 operative metastatic spine cases and found that the Tokuhashi, revised Tokuhashi and Tomita scores were closely related to survival time. These authors concluded that the combination of Tokuhashi score and Tomita score may be applied to better predict postoperative survival and guide the surgical options for patients with spinal metastasis.<sup>27</sup>

Although Tomita and Tokuhashi/revised Tokuhashi remain among the most widely utilized and studied, several multisystem evaluations suggest that other, simpler preoperative scores might have more predictive power. Leithner et al,<sup>23</sup> assessed the predictive value of 7 of these systems and found that the Bauer and Bauer Modified scores had the best association with survival in a cohort of 69 patients, followed by Tokuhashi revised and Van der Linden scores. In a larger study of 254 patients, Wibmer et al,<sup>29</sup> also found that the Bauer and Bauer modified systems had the most predictive power for patient mortality. We attribute poor correlation with Tomita and revised Tokuhashi scoring systems to several possible factors: (1) scoring systems were designed in the 1990s and may not apply to current cancer treatment paradigms; (2) national differences in treatment paradigms and patient populations, and (3) nature of a United States tertiary center with trend toward difficult cases. Future studies will focus on the Bauer and modified Bauer scoring systems.

**Limitations**

The study is limited by the weaknesses inherent to retrospective studies. Specifically, sample size was small: 38 metastatic spine patients and surgical preference varied between the 4 surgeons. The percentages of patients with

**TABLE 5.** Literature Review of Metastatic Scoring Systems: Linear Regression Comparing Scoring System With Survival ( $R^2$  Values)

References	Study Description	Overview	Tokuhashi	Revised Tokuhashi	Tomita	Conclusions
Tomita <sup>8</sup>	Prospective cohort of 61 patients with metastatic spine disease treated either conservatively or palliative surgery based on Tomita scoring system	The mean reported survival by Tomita for 2–3, 4–5, 6–7, and 8–10 are 50, 23.5, 15, and 6 mo, respectively	NA	NA	Number of patients/treatment/mean survival 13 patients/intralesional excision/21.5 mo 11 patients/palliative surgery and stabilization/10.1 mo 37 patients/terminal care/5.3 mo	Prognostic scoring system to guide surgical strategy
Tokuhashi et al <sup>6</sup>	Prospective cohort of 183 patients metastatic spine patients with either conservative or palliative surgical treatment	2–3, mean survival 50 mo 4–5, middle-term local control (mean survival 23.5 mo) $\geq$ marginal or intralesional excision 6–7, palliation (mean survival 15 mo) $\geq$ palliative surgery 8–10, terminal care (mean survival 6 mo) $\geq$ supportive care, no surgery	NA	<i>r</i> Tokuhashi score: 0–8 9–11 12–15 87.9% in the 183 patients	NA	Survival period of patients affected the functional prognosis; therefore, may be appropriate to select treatment by giving first priority to life expectancy
Wibmer et al <sup>29</sup>	Retrospective review of 254 patients with spine metastasis	Seven prognostic scoring systems (Tomita, Tokuhashi, Revised Tokuhashi, Sioutus, Van der Linden, Bauer, Modified Bauer) were applied retrospectively to the patient group, with the greatest correlation to survivability found in the Bauer and Bauer modified scores	Our analysis showed that both the original and revised Tokuhashi are reasonably reliable, except that the distinction between good and moderate prognosis shows no significance ( $P = 0.17$ in the original score and $P = 0.07$ in the revised version)		The Tomita score had a statistically significant difference in survival between the group with the poorest prognosis and the group with a good prognosis, but not in the group with middle-term prognosis compared with the group with a good prognosis	Bauer and Bauer modified scores most reliable for predicting survival
Leithner et al <sup>23</sup>	Retrospective review 69 operative patients with spinal metastases	Seven prognostic scoring systems (Tomita, Tokuhashi, Revised Tokuhashi, Sioutus, Van der Linden, Bauer, Modified Bauer) were applied retrospectively to the patient group, with the greatest correlation to survivability found in the Bauer and Bauer modified scores	The original Tokuhashi score had a significant prognostic value in the group including multiple myeloma patients only	Mean survivals of 11, 18, and 80 mo for revised Tokuhashi scores of >8, 9–11, and 12–15, respectively	Mean survivals of 46, 20, 9, 10 mo for Tomita scores of 2–3, 4–5, 6–7, and 8–10 points, respectively	Bauer and Bauer modified scores most reliable for predicting survival
Padalkar and Tow <sup>24</sup>	Retrospective review of the postoperative survival pattern of 102 patients with spinal metastases	The Revised Tokuhashi and Tomita score were applied retrospectively to the patient cohort to determine correlation with survival	NA	Revised Tokuhashi scores were found to correlate strongly with survival. Scores of 0–3, 4–6, 7–9, 10–12, 13–15 yielded median survivals of 1, 4, 7, 13, and 15 mo, respectively	Bone metastases, visceral metastases, and tumor activity had correlation scores of $P = 0.0450$ , $0.0003$ , and $0.003$ , respectively	Both the revised Tokuhashi score and the Tomita score were significantly correlated with survival. A revised Tokuhashi score of 7 or more and a Tomita score of 6 or less indicated > 50% chance of surviving 6 mo postoperatively

Papastefanou et al <sup>25</sup>	Prospective and retrospective cohort of 52 operative patients	Prospectively applied Tokuhashi and retrospectively applied Tomita. Survival by score not reported	For predicting survival: statistically significant ( $r = 0.574$ , $P = 0.01$ ) Overall survival: borderline significant for survival ( $r = 0.380$ , $P = 0.05$ )	NA	Survival time: borderline significant ( $r = -0.394$ , $P = 0.05$ ) Overall survival: not significant	The prognostic Tokuhashi score appears to be more valuable for surgical indications than the Tomita score in patients with spinal metastases.
Grainger et al <sup>26</sup>	Retrospective review of 169 patients with metastatic disease of the spine	Each prognostic parameter was significantly related to survival for both systems. There was no difference in survival within the better prognostic groups in relation to surgical strategy. Tomita's system was less sensitive to early mortality	Patients with Tokuhashi scores of 9–12 had 50% survival of 23 mo compared with 5 mo and 2 mo for scores of 5–8 and 1–4, respectively ( $P < 0.05$ )	50% survivals of 15 and 5 mo for predicted long-term and medium-term groups ( $P < 0.05$ )	50% survivals of 15 and 5 mo for predicted long-term and medium-term groups ( $P < 0.05$ )	Both systems are potentially useful in deciding the suitability for surgery in patients with metastatic spinal disease

complete data sets, 45/68 (66%) and 38/68 (56%) are relatively low. This is because of inability to decipher operative complications as well as patients lost to follow-up. In addition, our study period spans a number of years during which both the surgical indications for MESCC and the medical management of metastatic cancer changed dramatically. The combination of the evolving literature demonstrating the effectiveness of surgery for MESCC and the development of new chemotherapy agents that have changed the life expectancy in several cancers limits whether these results reflect “current care” or historical management. Nevertheless, we believe that this study underscores the limitations of metastatic spine scoring systems. Our 42% per patient complication rate and 9% infection rate agree with those reported by other authors and again underscores the difficulty in managing these patients.

### CONCLUSIONS

Application of metastatic prognostic scoring systems to a retrospective surgical cohort revealed an overall poor correlation with the Tomita and revised Tokuhashi predictive survival models. Future work will focus on devising a prognostic system to compare patients within specific primary cancer cohorts. We believe this will help account for the variability between cancer survival and account for increases in survival of patients as newer therapies continue to emerge and improve cancer survival.

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