Original Article

Surgically treated spinal metastases: Do prognostic scores have a role?

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Abstract

Background: The outcome for patients with metastatic disease in spine is difficult to predict. Multiple scoring systems were utilized in this study to determine their effectiveness in predicting long-term prognoses.

Methods: A retrospective analysis of surgically treated patients of spinal metastasis was performed between 2005 and 2016. Data were collected prospectively during which 8 patients were lost to follow-up. Ultimately, data from 63 patients were reviewed. Treatment and prognoses were analyzed utilizing various scoring systems including the SINS, the Tomita, the modified Tokouhashi and Bauer scores.

Results: Records of 63 patients, averaging 54 years of age, were analyzed. The Tomita score was applied in 44 patients, a modified Bauer score was studied in 49 patients, while SINS and modified Tokouhashi scores were calculated in all 63 patients. The hazard ratios for the Tomita score were 1, 0.030, 0.622, and 0.272, respectively. The hazard ratios for the modified Bauer scores were 1, 4.663, and 1.622, respectively. The Tokouhashi ratios were 1, 1.656, and 0.501, respectively. Of interest, the Tomita scores provided the highest statistical significance ($P = 0.000$) followed by the Bauer ($P = 0.002$) and Tokuhashi scores ($P = 0.003$). Notably, the SINS score showed no significant correlation in predicting patient survival.

Conclusion: For evaluating the metastatic spine disease, this study evaluated the prognostic efficacy of four widely used scores: the Tomita, score, the modified Tokouhashi and Bauer scores, and the SINS scores. The Tomita scores provided the highest statistical significance, followed by the Bauer, and Tokuhashi scores, while the SINS score showed no significant correlation in predicting patient survival.

Key Words: Bauer, metastases of spine, prognosis, scoring system, Tokouhashi, Tomita

INTRODUCTION

Spine is the most common site of bone metastases. Knowledge of survival of the individual can help predict the subsequent disease course. Patients with a predicted survival of 3 to 6 months may not be suitable candidates for surgical intervention.[2] There are multiple scoring systems that have been devised to help determine patient

survival in order to guide treatment options.[2] This study attempted to determine the effectiveness of the modified Bauer [Table 1], Tomita [Table 2], modified Tokouhashi [Table 3], Spinal Instability Neoplastic Score (SINS) [Table 4] scoring systems for predicting prognosis in patients with metastases of spine.

MATERIALS AND METHODS

Database of 63 patients

We prospectively collected data and outcomes for 63 patients with spinal metastasis who underwent surgery between 2005 and 2016. Patients, averaging 53.73 years of age, were followed for an average of 18 months (range 1–72 months), with a minimum follow-up of 6 months. Spinal metastasis were located in the cervical spine (8 patients), dorsal spine (30 patients), lumbar spine (20 patients), and sacrum (two patients). Multiple regions were involved in three patients. The most common types of primary malignancy were breast (13 patients) and lung cancers (11 patients). In 14 patients, the primary site was unidentified, of which 6 were labeled as adenocarcinomas [Table 5]. There were 38 patients who underwent palliative excision, while others were treated with complete excision and decompression for attempted cure. Notably, 38 patients expired during the course of this study. Common symptoms and their frequency is elicited in Figure 1.

Preoperative radiographic assessment

All patients were evaluated pre operatively with plain radiographs, computed tomography (CT), and magnetic

resonance imaging of the spine. Bone scintigraphy and a CT of the chest and abdomen were also performed to evaluate the extent of systemic metastases. Patients were selected for surgery based on: (i) expected survival of more than 6 months, (ii) exacerbating pain, (iii) presence
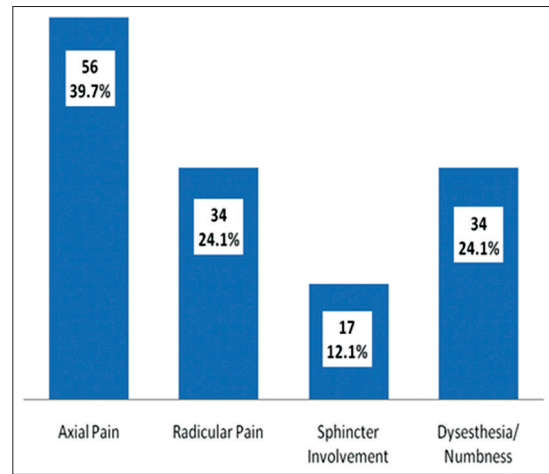
Figure 1: Patients presenting with symptoms and its frequency

Figure 2: Estimated survival curves of Tokouhashi score
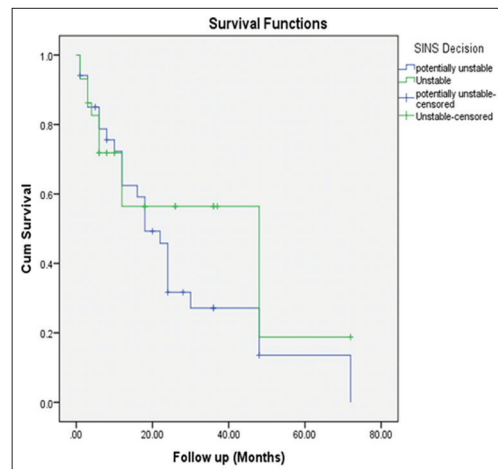
Figure 3: Estimated survival curve of SINS score

Table 1: Bauer modified score Positive prognostic factor points

Positive prognostic factors	Points
No visceral metastases	1
No lung cancer	1
Primary tumor (breast, kidney, lymphoma, multiple myeloma)	1
Solitary skeletal metastases	1

Table 2: Tomita scoring system

	Prognosis parameter score
Primary site	
Slow growth (breast, thyroid, etc.)	1
Moderate growth (kidneys, uterus, etc)	2
Rapid growth (lungs, stomach, etc.)	4
Visceral metastases	
None	0
Treatable	2
Not treatable	4
Bone metastases	
Solitary	1
Multiple	2

of neurological deficits, and (iv) instability. The authors studied multiple preoperative variables: age, gender, the type of primary malignancy, symptoms and their duration, the involved spinal level, neurological status, and the type of surgical procedure offered.

Table 3: Modified Tokouhashi Scoring System

Characteristics	Points
1- General Condition	
Poor	0
Medium	1
Good	2
2- Metastases outside vertebra	
Three or more	0
One or two	1
None	2
3- Metastases to vertebra	
Three or more	0
One or two	1
None	2
4- Metastases in viscera	
Non removable	0
Removable	1
None	2
5- Site	
Lungs, stomach, osteosarcoma, bladder, esophagus, pancreas	0
Liver, gallbladder and unknown	1
Others	2
Kidney and uterus	3
Rectum, thyroid and breast	4
Prostate and carcinoid	5
6- Neurological state	
Frankel A and B	0
Frankel B and C	1
Frankel D and E	2

Staging of disease utilizing multiple systems

Treatment and prognosis were analyzed utilizing the SINS, Tomita, modified Tokouhashi, and modified Bauer scores. We then compared these scores with the actual documented survival (i.e., documented death or last documented hospital visit).

Statistical analysis

Data was examined using survival analysis. As the survival data was not uniformly distributed, the median duration of survival and its 95% confidence interval (CI) were used. Survival curves were estimated by means of the Kaplan–Meier methods. The predictive value of each scoring system was evaluated by using log-rank test. A P value of <0.050 was considered statistically significant. The log-rank test and Cox proportional hazards model were utilized to determine factor-influenced progression.

RESULTS

Survival analysis of each preoperative factor utilized the log rank test [Table 6]. Age ($P = 0.008$) and pre-operative neurological status ($P = 0.016$) depicted a statistically significant relationship to survival. Younger age and good neurological status (Frankel grade C-E) were associated with prolonged survival. While variables like gender, spinal region, and type of surgical approach did not affect survival rates.

The Tokuhashi, Tomita, and Bauer scores provided statistically significant results, while those for SINS were not significant. The Tomita Score provided the highest statistical significance ($P = 0.000$) followed by the Bauer ($P = 0.002$) and Tokuhashi ($P = 0.003$) scores [Tables 7, 8 and Figures 2-5]. Since the numbers of individual neoplasms in each category of scores were
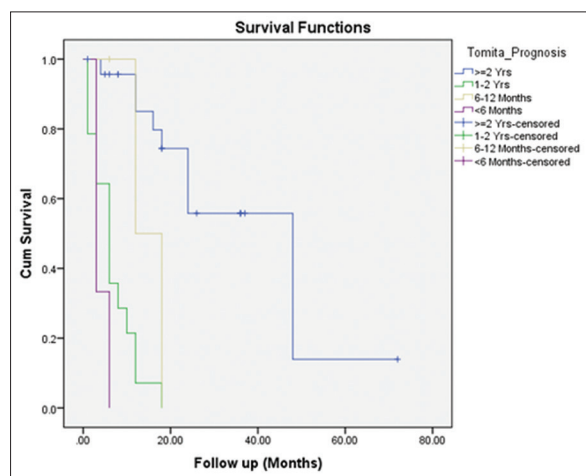

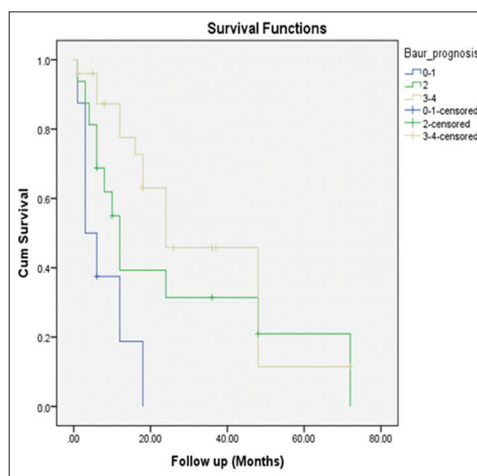**Figure 4: Estimated survival curves of Tomita score**

Figure 5: Estimated survival curves of Bauer score

Table 4: Spinal Instability Neoplastic Score

SINS Component	Score
Location	
Junctional (occiput-C2, C7-T1, T11-L1, L5-S1)	3
Mobile Spine (C3-6, L2-4)	2
Semirigid (t3-T10)	1
Rigid (s2-5)	0
Pain	
Yes	3
Occasional pain but not mechanical	2
Pain-free lesion	0
Bone Lesion	
Lytic	2
Mixed (lytic/blastic)	1
Blastic	0
Spinal alignment	
Subluxation/translation present	4
De novo deformity (kyphosis/scoliosis)	2
Normal alignment	0
Vertebral Body collapse	
>50% collapse	3
< 50% collapse	2
No collapse with >50% body involved	1
None of the above	0
Posterolateral involvement of the spinal elements	
Bilateral	3
Unilateral	1
None of the above	0

Figure 6: Case 1: A 60-year-old female presented with back pain and bilateral leg radiation for 8–9 months and unable to walk for 1 week. MRI lumbosacral spine showed a leftrenal mass involving whole of L4 vertebra. She underwent left kidney nephrectomy and L4 corpectomy, followed by L3-5 pedicle screw fixation with cage placement and anterior interbody screws. She had a Modified Tokouhashi score of 10, Modified Bauer 4, Tomita score 3 and SINS score of 14. All the scales estimated an overall survival of around 12 months for this patient, hence was surgically treated with good results. (a) MRI lumbosacral spine (sagittal view) showing contrast enhancing lesion involving L4 vertebra. (b) Axial view of the same patient showing the diseased level. (c) Postoperative X-rays lumbosacral spine (AP and lateral views) showing L3-5 pedicle and anterior interbody screws. (d) Postoperative coronal CT scan showing the same

Table 5: Demographic data of the study population

Primary Site	Age		Gender		Spine Region					Total
	≤50	>50	Male	Female	Cervical	Dorsal	Lumbar	Sacral	Multiple	
Breast	10	3	1	12	2	6	4	0	1	13
Bladder Ca	0	2	2	0	1	1	0	0	0	2
Liver	0	3	3	0	0	1	2	0	0	3
Lymphoma	1	0	1	0	0	0	0	1	0	1
Multiple Myeloma	0	1	0	1	0	1	0	0	0	1
Parotid	1	0	0	1	0	1	0	0	0	1
Plasmacytoma	1	0	1	0	0	1	0	0	0	1
Prostate	0	4	4	0	1	0	2	0	1	4
Renal Cell Ca	0	5	2	3	1	2	2	0	0	5
Seminoma	1	0	1	0	0	0	1	0	0	1
Skin Lesions	1	0	1	0	0	0	1	0	0	1
Thyroid	0	2	1	1	0	1	1	0	0	2
Unidentified	5	9	11	3	3	8	3	0	0	14
Upper Git	0	2	2	0	0	0	1	0	1	2
Urothelial	0	1	0	1	0	0	1	0	0	1
Lung	1	10	10	1	0	8	2	1	0	11
Total	21	42	40	23	8	30	20	2	3	63

Multiple: Lumbar and dosral

Table 6: Survival analysis of each preoperative factor

Preoperative factor	N	Median (95% CI)	Mean (95% CI)	P
Age Group				
≤50 years	21	48 (30.38-65.61)	39.51 (26.66-52.35)	<0.05
>50 years	42	12 (4.30-19.69)	19.22 (13.21-25.24)	
Gender				
Male	40	12 (1.458-22.54)	25.43 (15.06-35.81)	0.085
Female	23	24 (21.37-26.62)	31.90 (22.41-41.39)	
Region				
Cervical	8	18 (10.79-25.20)	23.33 (15.78-30.87)	0.205
Dosral	30	12 (6.02-17.97)	19.63 (12.11-27.16)	
Dosral and Lumbar	3	48(N/A)	34 (2.31-65.68)	
Lumbar	20	24 (1.59-46.40)	33.78 (20.02-47.54)	
Sacral	2	3(N/A)	3(N/A)	
Anterior/Posterior				
Anterior with fusion	16	12 (5.45-18.55)	19.79 (10.30-29.27)	0.727
Anterior without fusion	6	24 (7.40-40.59)	21.06 (10.51-31.61)	
Posterior with fusion	21	30 (0.00-60.09)	35.19 (18.05-52.34)	
posterior without fusion	20	18 (10.17-25.83)	30.58 (19.04-42.11)	

P-value obtained by log-rank test; P<0.050 denotes statistical significance (Sig); N/A shows estimation data not available due to the lack of uncensored cases.

Table 7: Survival analysis of each prognosis score

Score Prognosis	Scores	N	Median (95% CI)	Mean (95% CI)	P
Tokuhashi					
<6 Months	0-8	39	12 (7.80-16.19)	18.60 (10.49-26.72)	<0.05
6-11 Months	9-11	19	48 (29.71-66.29)	42.02 (30.17-53.86)	
1 year or More	12-15	5	12 (0.00-25.72)	20.75 (10.16-31.33)	
Overall	-	63	18 (10.17-25.83)	27.26 (20.12-34.40)	
SINS					
Potentially unstable	7-12	34	18 (14.70-21.29)	24.31 (16.10-32.52)	0.269
Unstable	13-18	29	48 (24.88-71.11)	32.99 (20.58-45.40)	
Overall	-	63	18 (10.17-25.83)	27.26 (20.12-34.40)	
Tomita					
≥2 Yrs	2-3	23	48 (34.04-61.95)	39.09 (28.53-49.65)	<0.05
1-2 yrs	4-5	7	6 (2.48-9.51)	5.85 (1.99-9.71)	
6-12 Months	6-7	11	12 (8.35-15.65)	10.15 (6.70-13.59)	
<6 Months	8-10	3	3(N/A)	4 (2.04-5.96)	
Overall	-	44	16 (10.96-21.03)	23.43 (16.18-30.69)	
Bauer					
4.8 months	0-1	8	3 (0.00-6.46)	7.62 (2.93-12.31)	<0.05
18.2 Months	2	16	12 (8.74-15.25)	26.37 (11.54-41.20)	
28.4 Months	3-4	25	24 (11.02-36.98)	33.12 (23.27-42.98)	
Overall	-	49	18 (9.57-26.42)	27.29 (19.53-35.04)	

P-value obtained by log-rank test; P<0.050 denotes statistical significance (Sig); N/A shows estimation data not available due to the lack of uncensored cases.

small, individual calculation of *P* value for the same was not possible.

Survival

The mean survival period was recorded according to the primary malignancy; breast correlated with a mean survival of 38.6 months, followed by prostate (26.33 months), and thyroid (21 months). Lung primaries were reported to have the worst prognosis, with a mean survival rate of only 5.81 months. [Tables 9 and 10].

DISCUSSION

Estimating life expectancy in patients afflicted with spinal metastases is important. Management requires

Table 8: Hazard analysis of prognostic scores

Prognosis Scores	Scores	Prognosis	Frequency	Hazard Ratio	P	95% CI*
Tokuhashi						
	0-8	<6 Months®	39	1	-	-
	9-11	6-11 Months	19	1.656	0.412	0.496-5.528
	12-15	1 year or More	5	0.501	0.306	0.133-1.885
SINS						
	7-12	Potentially Unstable®	34	1	-	-
	13-18	Unstable	29	1.421	0.305	0.726-2.783
Tomita						
	2-3	> 2 Yrs®	23	1	-	-
	4-5	1-2 yrs	7	0.030	<0.05	0.006-0.159
	6-7	6-12 Months	11	0.622	0.506	0.153-2.528
	8-10	<6 Months	3	0.272	0.071	0.066-1.120
Bauer						
	0-1	4.8 Months®	8	1	-	-
	2	18.2 Months	16	4.663	<0.05	1.774-12.256
	3-4	28.4 Months	25	1.622	0.223	0.745-3.532

P-value obtained by Cox regression *P*<0.050 denotes statistical significance (Sig) Dash means no value for parameter ®Reference Group
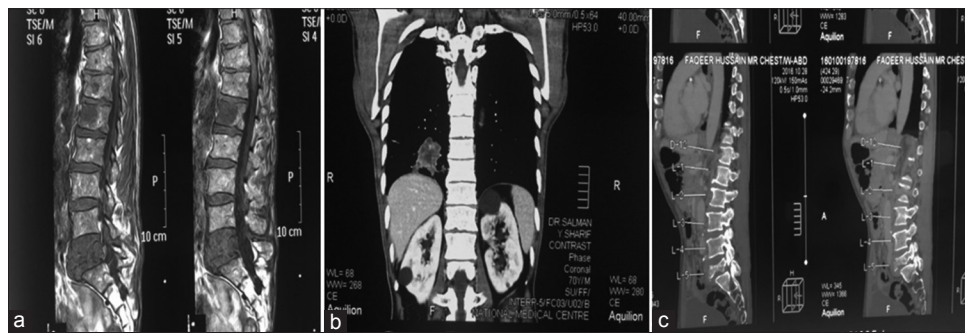

Figure 7: Case 2: A 60-year-old male with back pain and sciatica for 1 month. He had diffuse metastatic disease with Lung lesion and liver and bone metastases. He had a stable posterior column and L5 compression. This patient was managed conservatively. His Modified Tokouhashi score- 4, Tomita-10, Modified Bauer-1 and SINS score 14. The prognostic scores estimated his survival to be less than 6 months; hence this patient was managed conservatively. (a) MRI dorsolumbar spine (sagittal view) showing spinal metastases at L5 and L1. (b) Coronal CT chest showing the primary lesion involving lower zone of right lung. (c) Sagittally reconstructed CT of lumbosacral spine showing compression of L5 vertebra

a multidisciplinary approach utilizing multimodality treatments options to address spinal metastases. It is important to evaluate these patients based upon universally accepted scientific criteria that can be replicable. Various prognostic scoring systems have been recommended[12] and used by the Global Spinal Tumor Study Group [Tables 1-4].[6,10]

Various surgical procedures can be performed in patients with spinal metastasis. Surgery should be reserved for patients with good or moderate prognosis, but not for prognoses of less than 3–6 months.[5,11] The metastatic potential, invasive ability, rate of recurrence, and sensitivity to adjuvant treatment varies with different types of cancers. The primary tumor site is the most important prognostic factor for survival.[7-10] This major factor is well reflected by the allotment of maximum

scoring points in the Tokouhashi revised score (0–5),[8] as well as Tomita and Bauer.[7,9] In Bauer's score, of the four parameters, two are based on the primary tumor site.[7]

Metastases of the spine can cause significant instability, resulting in severe pain, progressive deformity and/or neurological compromise. SINS classification identifies patients with impending or existing spinal instability, for whom surgical intervention may be beneficial;[4] 60% of our study population were 'potentially stable' indicating the marked extent of involvement of vertebral column with metastatic disease.

Tokuhashi *et al.* designed a scoring system based on 6 prognostic factors, whereas the Tomita system was based on three simple factors: the grade of the primary malignancy, the presence of visceral metastases, and the

Table 9: Mean Survival according to different sub categories of the scoring systems for various tumors

Prognosis score	Breast	Bladder Ca	Liver	Lymphoma	Multiple Myeloma	Parotid	Plasmacytoma	Prostate	Renal Cell Ca	Seminoma	Skin Lesions	Thyroid	Unidentified	Upper Git	Urothelial	Lung
Tokuhashi																
0-8																
Total	2	2	3	0	1	1	1	0	1	1	0	0	14	2	0	11
Mean	15	17	8	-	-	-	-	-	-	-	-	-	10.28	3.5	-	5.81
Range (Max-Min)	6 (18-12)	14 (24-10)	6 (12-6)	-	-	-	-	-	-	-	-	-	35 (36-1)	5 (6-1)	-	17 (18-1)
9-11																
Total	7	0	0	1	0	0	0	3	4	0	1	2	0	0	1	0
Mean	41.14	-	-	-	-	-	-	15.33	19.5	-	-	21	-	-	-	-
Range (Max-Min)	60 (12-72)	-	-	-	-	-	-	32 (36-4)	10 (26-16)	-	-	30 (36-6)	-	-	-	-
12-15																
Total	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Mean	13.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Range (Max-Min)	16 (24-8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SINS																
0-6																
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Range (Max-Min)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7-12																
Total	7	1	3	1	1	1	0	0	3	1	1	0	8	0	1	6
Mean	24.57	-	8	-	-	-	-	-	14	-	-	-	13.25	-	-	7.5
Range (Max-Min)	38 (48-10)	-	6 (12-6)	-	-	-	-	-	10 (18-8)	-	-	-	35 (36-1)	-	-	17 (18-1)
13-18																
Total	6	1	0	0	0	0	1	4	2	0	0	2	6	2	0	5
Mean (SD)	33.33	-	-	-	-	-	-	20.75	22	-	-	21	6.33	3.5	-	3.8
Range (Max-Min)	64 (72-8)	-	-	-	-	-	-	33 (37-4)	8 (26-18)	-	-	30 (36-6)	9 (12-3)	5 (6-1)	-	5 (6-1)
Tomita																
2-3																
Total	10	0	0	1	1	0	1	4	4	0	0	1	0	0	1	0
Mean (SD)	33.2	-	-	-	-	-	-	20.75	17.5	-	-	-	-	-	-	-
Range (Max-Min)	64 (72-8)	-	-	-	-	-	-	33 (37-4)	18 (26-8)	-	-	-	-	-	-	-
4-5																
Total	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	4
Mean (SD)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5
Range (Max-Min)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7 (8-1)
6-7																
Total	3	0	2	0	0	0	0	0	0	0	0	1	0	1	0	4
Mean (SD)	13.33	-	9	-	-	-	-	-	-	-	-	-	-	-	-	8.5
Range (Max-Min)	8 (18-10)	-	6 (12-6)	-	-	-	-	-	-	-	-	-	-	-	-	17 (18-1)
8-10																
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Mean (SD)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Range (Max-Min)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3 (6-3)
Bauer																
0-1																
Total	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	7
Mean (SD)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.57
Range (Max-Min)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17 (18-1)
2																
Total	2	2	2	0	0	1	0	2	0	1	1	1	0	0	0	4
Mean (SD)	11.00	17.00	9.00	-	-	-	-	5.00	-	-	-	-	-	-	-	4.5
Range (Max-Min)	2 (12-10)	14 (24-10)	6 (12-6)	-	-	-	-	2 (6-4)	-	-	-	-	-	-	-	7 (8-1)
3-4																
Total	11	0	1	1	1	0	1	2	5	0	0	0	0	2	1	0
Mean (SD)	31.81	-	-	-	-	-	-	36.5	17.2	-	-	-	-	3.5	-	-
Range (Max-Min)	6 (72-8)	-	-	-	-	-	-	1 (37-36)	18 (26-8)	-	-	-	-	5 (6-1)	-	-

Table 10: Survival according to primary tumor site

Primary Site	(n)	Deaths				Survival			
		(n)	(%)	Mean (months)	Range (Max-Min)	(n)	(%)	Mean (months)	Range (Max-Min)
Breast	13	10	76.9	25.60	38 (48-10)	3	23.1	38.66	64 (72-8)
Bladder Ca	2	1	50.0	-	-	1	50.0	-	-
Liver	3	3	100.0	8.00	6 (12-6)	0	0.0	-	-
Lymphoma	1	0	0.0	-	-	1	100.0	-	-
Multiple Myeloma	1	0	0.0	-	-	1	100.0	-	-
Parotid	1	1	100.0	-	-	0	0.0	-	-
Plasmacytoma	1	0	0.0	-	-	1	100.0	-	-
Prostate	4	1	25.0	-	-	3	75.0	26.33	31 (37-6)
Renal Cell Ca	5	2	40.0	17.00	2 (18-16)	3	60.0	17.33	18 (26-8)
Seminoma	1	1	100.0	-	-	0	0.0	-	-
Skin Lesions	1	0	0.0	-	-	1	100.0	-	-
Thyroid	2	0	0.0	-	-	2	100.0	21.00	30 (36-6)
Unidentified	14	5	35.7	13.60	29 (30-1)	9	64.3	8.44	33 (36-3)
Upper Git	2	2	100.0	3.50	5 (6-1)	0	0.0	-	-
Urothelial	1	1	100.0	-	-	0	0.0	-	-
Lung	11	11	100.0	5.81	17 (18-1)	0	0.0	-	-
Total	63	38	60.3	16.44	71 (72-1)	25	39.7	17.88	71 (72-1)

- No statistics calculated

presence of bone metastases. In both scoring systems, the type or grade of the primary malignancy is the most important factor affecting survival.[6,8] The Bauer original and modified scores were the most independent scoring systems, showing significant distinction between the proposed prognostic groups, and the strongest impact on predicting the remaining survival in patients with spinal metastases.[3]

In our study, four prognostic scoring systems were compared in patients with spinal metastases. The Bauer and Tomita scoring systems have showed statistical significance in predicting survival vs. the other scores.[1] Notably, the Tokuhashi score is more complicated and includes many other variables, and thus results in decreased predictive reliability.[4] The simpler scores (Tomita and modified Bauer) have more reliable results.[1] Our study showed that Tomita had the least *P* value (*P* value = 0.00), and the modified Bauer (*P* value = 0.002) was a simple and universally applicable prognostic system. SINS had a minimal role in predicting the overall survival and was considered as an add-on support in providing insights to the need of fusion [Figures 6 and 7].

Analysis of our study showed that breast lesions were most common followed by lung. Like many other series, lung cancer showed the worst prognosis.[5] Age and preoperative neurology showed correlation with survival. Independent preoperative variables including gender, region, symptom duration, pain severity, and surgical approach did not have an effect on the post-operative survival.

CONCLUSION

Of the four widely used scores to assess the extent of metastatic disease to the spine, the Tomita, the modified Tokuhashi and the Bauer, demonstrated statistically significant predictive results. Alternatively, the SINS scoring system, though a good indicator for choosing patients for surgery, lacked statistical significance in predicting survival.

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Conflicts of interest
There are no conflicts of interest.

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