Check for updates

Original Article

AO SPINE

Global Spine Journal
2025, Vol. 15(1) 136–142
© The Author(s) 2024
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/21925682241262691
journals.sagepub.com/home/gsj
Sage

Can Survival Scoring Systems for Spinal Metastases be Used to Predict Postoperative Neurologic Recovery? A Retrospective Study on 204 Patients With Thoracolumbar Metastases Treated at a Tertiary Center

Michael G. Kontakis, MD[1,2] and Panagiotis Tsagkozis, MD, PhD[1]

Abstract

Study Design: Retrospective Cohort Study.

Objective: Scoring systems for metastatic disease of the spine are used to select patients for surgical treatment based on survival estimation, but it is unknown whether they can be used to predict the outcome of surgery. This study aims to investigate the association between two widely used prognostic scores and the neurologic function after surgery.

Methods: Retrospective analysis of 204 patients with thoracolumbar metastases treated with decompressive surgery at Karolinska University Hospital (2001-2020). Modified Bauer and Tokuhashi scores were categorized based on surgical indication, and post-operative neurological function was assessed using the Frankel scale at two different post-surgery intervals.

Results: Modified Bauer scores ≥2 yielded higher late follow-up Frankel scores (3.9 ± 1.1) than scores <2 (3.5 ± 1.1), $P = .03$. Modified Tokuhashi scores ≥9 correlated with higher Frankel scores (4.5 ± .9) than scores <9 (3.5 ± 1.1), $P < .0001$. Both scoring systems positively predicted neurological outcomes at late follow-up, with odds ratios of 1.6 ($P = .03$) for Bauer and 9.2 ($P < .0001$) for Tokuhashi. However, only Tokuhashi predicted ambulatory function at late follow-up ($P < .0001$), demonstrating its utility in prognosticating post-surgical mobility.

Conclusion: Higher modified Bauer and Tokuhashi scores were associated with better neurologic function at last follow-up, as well as greater likelihood of being able to walk again. The Tokuhashi score was found to be more accurate than the modified Bauer score in predicting the neurological outcome after surgery.

Keywords

neurologic compromise, spinal metastasis survival scores, tumor

Introduction

Approximately one third of the patients with malignant neoplasms will develop spinal metastasis at some point with risk for complications such as vertebral fractures, debilitating pain and neurologic compromise.[1,2] Treatment relies on surgery and radiotherapy, and although there is extensive debate on the most proper treatment, surgery is generally reserved for patients with better survival.[3-5] Commonly used point-based scoring systems such as the modified Bauer and

[1] Department of Molecular Medicine and Surgery, Karolinska Institute and Karolinska University Hospital, Stockholm, Sweden
[2] Department of Surgical Sciences, Orthopaedics, Uppsala University, Uppsala, Sweden

Corresponding Author:
Michael G. Kontakis, Department of Molecular Medicine and Surgery, Karolinska Institute and Karolinska University Hospital, Solna, Stockholm 17176, Sweden.
Email: mikael.kontakis@gmail.com

Creative Commons Non Commercial No Derivs CC BY-NC-ND: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs 4.0 License (https://creativecommons.org/licenses/by-nc-nd/4.0/) which permits non-commercial use, reproduction and distribution of the work as published without adaptation or alteration, without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (https://us.sagepub.com/en-us/nam/open-access-at-sage).

Table 1. The Modified Tokuhashi (a) and Modified Bauer (b) Scores, Adapted From [10] and [7] Accordingly.

a.

Modified Tokuhashi score	
Points	**Predictive factors**
0-2	General condition (poor, medium, good).
0-2	Number of metastases outside of vertebra (three or more, one or two, none).
0-2	Number of metastases in vertebra (three or more, one or two, none).
0-2	Visceral metastases (not removable, removable, none).
0-5	Primary cancer (Liver/gallbladder/unknown, others, Kindey/uterus, rectum/thyroid/breast, prostate/carcinoid).
0-2	Neurologic status - Frankel (E/C-D/A-B)

Score	Treatment objective
0-8	Conservative treatment / palliative surgery
9-11	Palliative surgery
12-15	Excisional surgery

b.

Modified Bauer score	
Points	**Positive predictive factors**
1	No visceral metastases
1	No lung cancer
1	Primary tumor = breast, kidney, lymphoma, multiple myeloma
1	Solitary metastasis

Score	Treatment objective	Surgical strategy
0-1	Supportive care	No surgery
2	Short palliation	Posterior surgery
3-4	Local control	Anterior-posterior

the modified Tokuhashi scores (Table 1), allow for survival prediction and optimal treatment selection, both in terms of patient eligibility for surgical intervention, as well as how extensive or radical the surgery should be.[6-9] The primary outcome of the aforementioned scores is patient survival.[7] and patients with a modified Tokuhashi score of <9 and a modified Bauer score of <2 are traditionally seen as candidates for conservative treatment.[7,10] The primary outcome of interest regarding treatment is the preservation or improvement of neurological function, thus, the use of prognostic scores to guide treatment decisions entails an indirect relationship to the outcome of treatment, which has not been investigated whether it holds true.

In the current retrospective study, our objective was to determine the feasibility of using two common prognostic scores as predictive indicators for neurologic outcome following decompressive surgery, in patients with spine metastasis leading to neurologic impairment.

Methods

This study was approved by the Stockholm County health care region with the ethical approval reference number 2012/272-31, amendment 2019-06189. Individual consent for participation was not required since this was a retrospective study. A total of 220 patients with spinal metastases of the thoracolumbar region, who received treatment at Karolinska University Hospital between August 2001 and October 2020, were initially included. All patients underwent posterior decompressive surgery, either with or without fusion, due to neurological compromise (epidural compression). The patients with sarcomas or cancers of unknown origin were not included, thus a subgroup of 204 individuals remained for further analysis. The distribution of primary cancer types within this subgroup was as follows: 64 had prostate cancer, 31 hematological disease (lymphoma or myeloma), 24 lung cancer, 19 breast cancer, 19 kidney cancer, 13 colorectal cancer, 10 genitourinary cancer, 5 thyroid cancer, 3 head and neck cancer, 3 melanoma, 1 neuroendocrine cancer and 12 patients had other types of cancer. The demographic and clinical parameters of the study can be seen in Table 2.

Data on the survival of these patients were collected. The severity of the disease was assessed using the modified Bauer score (0-4), and the Tokuhashi score (1-15). The Frankel scale, converted to a numeric scale (1-5), was used to evaluate the patients' neurological status preoperatively, as well as an early (median of 6 weeks) and late (median of 6 months) postoperative follow-up.

We subdivided the modified Bauer/Tokuhashi scores in two groups based on the recommendation for surgery or conservative treatment provided by the scores. For the modified Bauer score, the first group had a score of <2 and the second ≥2; for the modified Tokuhashi score, the groups were <9 and ≥9 respectively. Survival plots and graphs were created using the survival and the ggplot2 packages. The non-parametric unpaired Mann-Whitney-Wilcoxon test (MASS package) was used to compare the mean scores. The Kruskal Wallis test was used to compare the means of multiple groups; if Kruskal Wallis test came out positive, pairwise comparison was performed with Dunn's test. To determine the predictive value of Bauer and Tokuhashi scores on neurological outcomes, a univariate ordinal (cml) and logistic (logit) regression analysis were performed. Statistical tests (with a level of significance of $P < .05$) were performed and graphs were generated with R.11

Results

Since both prognostic scores give a recommendation regarding treatment (surgical vs non-surgical), with a cut-off

Table 2. The Demographic and Clinical Parameters of the Patients of the Study are Presented Here; Met = Metastasis.

Demographic/Clinical Parameters	
Females: Males	69 : 135
Age (mean±SD)	65.5 ± 12.4
Postoperative radiotherapy	133
Posterior fusions (implant revisions)	87 (19)
Fracture	102
Location of the metastasis	
Thoracic	161
Lumbar	43
Extent of disease	
Generalized	85
Lymph nodes	2
No met	3
Numerous skeletal met	59
Single skeletal met	28

value of 2 for the Bauer and 9 for the Tokuhashi score, we first analyzed whether these scores were associated with the primary outcome of treatment, which is preservation and restoration of the neurological function. We observed that the mean (±SD) numeric Frankel score was higher in the group of patients with a modified Tokuhashi score of ≥9, in comparison to the group that had lower scores at the early [4.1 (±.9) vs 3.7 (±.9)] and at the late follow-up [4.4 (±.9) vs 3.6 (±1.1)], $P < .0001$ (Figure 1A). For the modified Bauer score of ≥2, the neurologic outcome was slightly higher than if the score was <2 at the early follow-up [3.9 (±1.0) vs 3.7 (±.9), $P = .07$], a difference that became statistically significant at the late follow-up [3.9 (±1.1) vs 3.6 (±1.1), $P = .02$] (Figure 1B). Patients that had a preoperative Frankel score of D-E had higher postoperative score at the first follow-up than those that had a preoperative score of A-C [4.3 (±1.0) vs 3.5 (±.7), $P < .0001$] (Figure 1C). Similar trends were seen at the second follow-up, patients with a score of D-E had a postoperative Frankel score of 4.2 (±1.1) and those with an initial score of A-C had 3.5 (±1.1), $P < .0001$. The neurologic outcome was not differentially affected by other demographic and clinical parameters such as age ($P = .48$), sex ($P = .89$), primary tumor type ($P = .49$), and location of metastasis ($P = .19$).

Apart from our review of the neurologic function based on the Frankel scale, we analyzed the results regarding the restoration of the ambulatory capacity, which is often easier to interpret and has a high clinical value. Prior to surgery, 130/201 patients did not have ambulatory capacity, while at the first follow-up that number had decreased to 59/199 (Figure 2A). By the second follow-up, 61/185 patients were non-ambulating, suggesting lasting positive outcomes of treatment. Both the modified Tokuhashi and the modified Bauer scores were shown to be predictors of postoperative neurologic outcome (Figure 2B), with the modified Tokuhashi score exhibiting a stronger predictive capability than the modified Bauer score, as indicated by the OR and CI. At the same time, preoperative ambulatory function (Frankel D or E) was also shown to be a significant predictor of postoperative neurologic outcome (Figure 2B). The OR of modified Tokuhashi was 6.91, higher than that of the preoperative Frankel score, which was 4.62. The univariate logistic regression analysis showed that the modified Tokuhashi score and the preoperative Frankel score of D/E were positive predictors of postoperative ambulatory capacity; the modified Bauer score was however not a predictor (Figure 2C). Table 3 compares the neurological function of the patients prior to surgery with the neurological function that they had at the second follow-up. The majority of the patients that could not ambulate prior to surgery but regained their ambulatory capacity postoperatively, had a preoperative Frankel score of C (84%). Few patients deteriorated in their neurologic function scores after surgery, most of the patients experienced an improvement (supplementary Table).

We lastly wanted to confirm that the categorization of patients we used based on recommendation for surgical treatment or not, was valid regarding their survival. The survival analysis of the different groups is depicted in Figure 3. A modified Tokuhashi score of ≥9 conferred a median survival time of 47 (27 - 83) months vs 7 (6 - 10) months in patients with lower score. The same applied to the modified Bauer score, where patients with a score of ≥2 had a median survival of 15 (11- 23) months than the ones with a lower score which survived for a median of 7 (3 - 10) months.

Discussion

The spinal metastasis scores have been widely adopted, enabling clinicians to quantify the impact of spinal metastasis and facilitate decision-making regarding surgical interventions, radiation therapy, or systemic treatments. Despite the acknowledged limitations, including potential underestimation of survival,[12] our findings align with existing literature, indicating that patients with modified Tokuhashi and Bauer scores of ≥9 and ≥2, respectively, exhibited more favorable survival. Preoperative ambulatory capacity.[13,14] and regaining ambulatory capacity in the postoperative period, are factors that have important implications for patient survival as well. Patients that regain their ambulatory capacity can have a double as much longer median survival in comparison to the patients that remain nonambulatory.[15]

Little is known whether the modified Tokuhashi and Bauer scores can predict the neurological outcome after decompressive surgery. We showed that patients with a modified Tokuhashi score of ≥9 had higher postoperative scores on the Frankel scale at the first and second follow up, while a modified Bauer score of ≥2 entailed higher scores only at the second follow-up.[7] A modified Bauer score of ≥2, a Tokuhashi

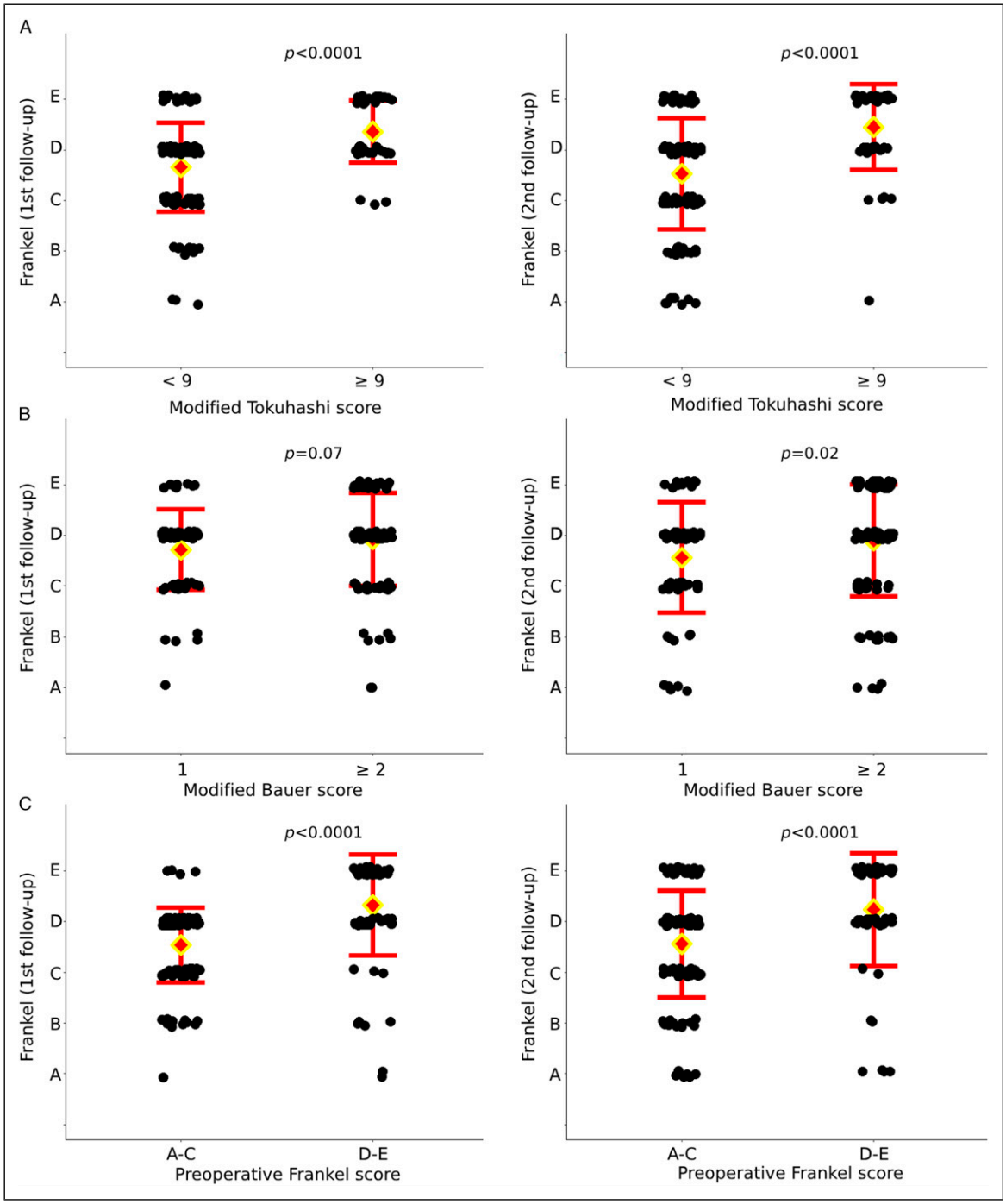
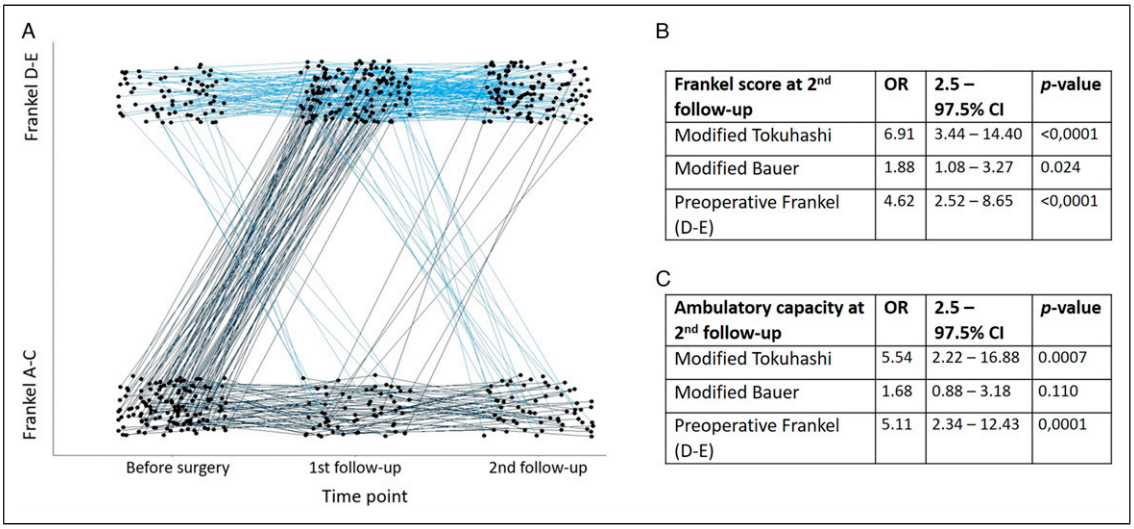


Figure 1. Dot plots of postoperative Frankel scores in relationship to the patients' modified Tokuhashi (A), Bauer (B) and preoperative Frankel (C) scores at first and second follow-up; **a.** Patients with higher Tokuhashi scores had higher Frankel scores at both time points; **b.** Both groups in the modified Bauer scores were equally scattered, at the second follow-up however a stastically significant difference was found; **c.** The preoperative Frankel score is divided on two groups, A-C (nonambulatory) and D-E (ambulatory). The postoperative Frankel scores from both groups were generally higher for the D-E group, in comparison to the A-C group. Red lines = standard deviation; red/yellow rhomboid = mean.

of ≥9 and preoperative Frankel score of D or E were significant predictors of postoperative Frankel scores. It is reasonable to expect that patients with a higher Tokuhashi score will have a higher postoperative neurologic function scores as the Frankel score is included in the modified Tokuhashi score, however the OR for the modified Tokuhashi score to predict Frankel scores at late follow-up was higher than that of preoperative Frankel (6.91 vs 4.62).



B

Frankel score at 2nd follow-up	OR	2.5 – 97.5% CI	p-value
Modified Tokuhashi	6.91	3.44 – 14.40	<0,0001
Modified Bauer	1.88	1.08 – 3.27	0.024
Preoperative Frankel (D-E)	4.62	2.52 – 8.65	<0,0001

C

Ambulatory capacity at 2nd follow-up	OR	2.5 – 97.5% CI	p-value
Modified Tokuhashi	5.54	2.22 – 16.88	0.0007
Modified Bauer	1.68	0.88 – 3.18	0.110
Preoperative Frankel (D-E)	5.11	2.34 – 12.43	0,0001

Figure 2. Paired dot plot of ambulatory (Frankel D-E) and non-ambulatory (Frankel A-C) patients, pre- and post-surgery (A), univariate ordinal regression for postoperative Frankel score (B) and univariate logistic regression for ambulatory capacity (C) at the second follow-up; **a.** (A) significant number of patients regained walking capacity after surgery and the majority of the operated patients retained walking capacity until the second follow up; **b.** The modified Tokuhashi score is a stronger predictor of neurologic outcome than the modified Bauer score; **c.** The modified Tokuhashi score and a preoperative Frankel score of D or E are favorable predictors of postoperative ambulatory function, the modified Bauer score however is not. OR = odds ratio; CI = confidence interval.

Table 3. Preoperative Frankel Score Versus Postoperative Frankel Score at the Second Follow-Up; 59 out of 70 Patients That Regained Their Ambulatory Function Postop had a Frankel Score of C Prior to Surgery.

	Postoperative Frankel score				
Preoperative Frankel score	A	B	C	D	E
A	1	0	2	2	0
B	1	5	2	8	1
C	4	7	31	37	22
D	1	2	2	19	14
E	3	0	0	2	19

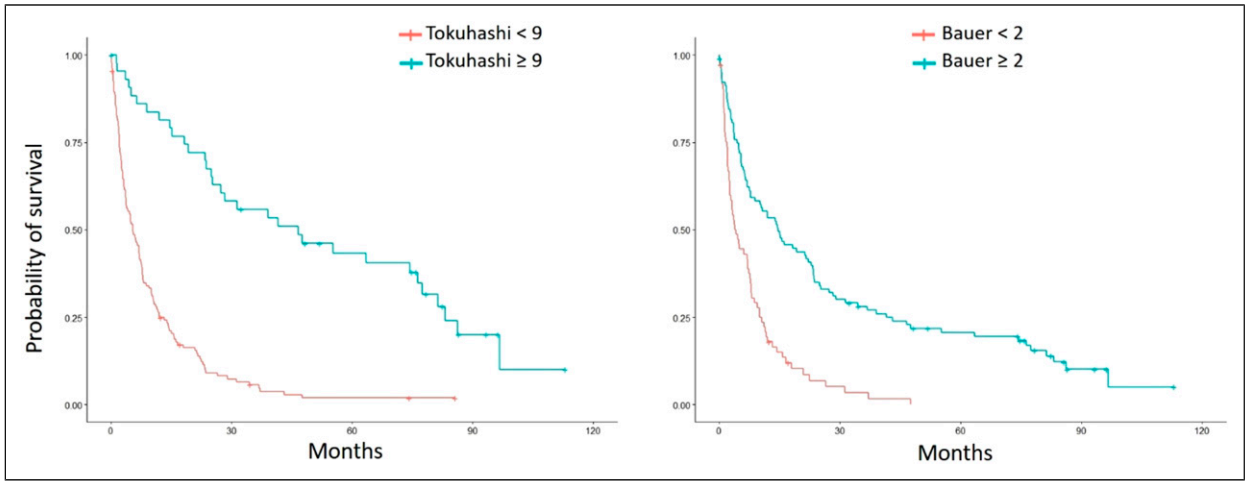


Figure 3. Kaplan Meier survival curves of patients with different modified Tokuhashi and modified Bauer scores. Higher scores entailed longer median survival time (months).

Decompressive surgery is vital in order to alleviate neurologic compromise and to restore motor function, due to medullary cord compression.[16,17] In this study, only 34% of the patients were ambulatory prior to the surgery. Most of the patients that were operated on regained the ability to ambulate (70%) and that was maintained at 6 months (68%). We found that preoperative ambulatory capacity and a modified Tokuhashi score of ≥9 are strong predictors of postoperative ambulatory capacity, the modified Bauer score however was not a predictor. There are limited studies in the literature that explore the prognostic value of the common spinal metastasis scores. In a prospective study of 202 patients by Schoenfeld et al,[18] it was shown that the Tokuhashi score was a good predictor of ambulatory function at 3 and 6 months after operative or non-operative treatment for spinal metastases. The SINS score was a good predictor of ambulatory function only at 3 months of follow-up. Cho et al[19] did not find a correlation between a Tomita score of ≤5 and postoperative neurological recovery in cases of patients with cervical spine metastases.

The present analysis indicated that the modified Tokuhashi and Bauer scores can serve as predictors of the postoperative neurologic outcome. The retrospective design and the fact that there is no equal representation of the patients along the scales of the used metastasis scores constitute weaknesses of this study. The Frankel score is included in the scoring system of the modified Tokuhashi score, which could explain why it performed better than the modified Bauer score at predicting the neurologic outcome. Another limitation of the study is that the low number of patients with low Tokuhashi scores (supplementary Table). Lastly, the fact that all of the patients were treated surgically could constitute a bias.

There is a need for further research into that topic, in order to potentiate the results, either with the inclusion of more patients to increase the power, or to test the validity of other known spine metastasis scores. In 2015, Ghori et al created a scoring system combining the patients' ambulatory status, modified Bauer score and preoperative albumin, the New England Spine Metastasis Score,[20] which was shown to have a similar capacity with the modified Tokuhashi score to predict the postoperative ambulatory status.[18] The advent of machine learning tthas introduced the usage of dynamic scoring systems, with the examples of SORG and PathFx 3.0.[21,22] The use of these scores is however more difficult to interpret, since they do not provide for a treatment recommendation regarding surgery or conservative treatment,

Conclusions

Postoperative ambulatory capacity is a crucial factor influencing patient survival and quality of life. The modified Tokuhashi and Bauer scores were shown to be useful adjuncts for the surgeon, and provided with insights not just on survival, but also on the potential to regain ambulatory function after decompressive surgery. Patients with scores that suggest surgical treatment had higher chances of being ambulatory at follow-up and the Tokuhashi score performed better in this setting.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

ORCID iD

Michael G. Kontakis https://orcid.org/0000-0002-1502-1221

Supplemental Material

Supplemental material for this article is available online.

References

1. Wong DA, Fornasier VL, MacNab I. Spinal metastases: the obvious, the occult, and the impostors. *Spine*. 1990;15(1):1-4.
2. Van den Brande R, Mj Cornips E, Peeters M, Ost P, Billiet C, Van de Kelft E. Epidemiology of spinal metastases, metastatic epidural spinal cord compression and pathologic vertebral compression fractures in patients with solid tumors: a systematic review. *J Bone Oncol*. 2022;35.
3. Harrington KD. The use of methylmethacrylate for vertebral-body replacement and anterior stabilization of pathological fracture-dislocations of the spine due to metastatic malignant disease. *J Bone Jt Surg Am Vol*. 1981;63(1):36-46.
4. Klimo P Jr., Schmidt MH. Surgical management of spinal metastases. *Oncol*. 2004;9(2):188-196. doi:10.1634/theoncologist.9-2-188.
5. Wagner A, Haag E, Joerger AK, et al. Comprehensive surgical treatment strategy for spinal metastases. *Sci Rep*. 2021;11(1). doi:10.1038/s41598-021-87121-1.
6. Bauer HCF, Wedin R. Survival after surgery for spinal and extremity metastases Prognostication in 241 patients. *Acta Orthop Scand*. 1995;66:143-144.
7. Leithner A, Radl R, Gruber G, et al. Predictive value of seven preoperative prognostic scoring systems for spinal metastases. *Eur Spine J*. 2008;17(11):1488-1495. doi:10.1007/s00586-008-0763-1.
8. Tokuhashi Y, Matsuzaki H, Toriyama S, Kawano H, Ohsaka S. Scoring system for the preoperative evaluation of metastatic spine tumor prognosis. *Spine*. 1990;15(11):1110-1113. doi:10.1097/00007632-199011010-00005.
9. Tokuhashi Y, Matsuzaki H, Oda H, Oshima M, Ryu J. A revised scoring system for preoperative evaluation of metastatic spine tumor prognosis. *Spine*. 2005;30(19):2186-2191. doi:10.1097/01.brs.0000180401.06919.a5.

10. Mattana JL, Freitas RR, Mello GJ, et al. Study on the applicability of the modified Tokuhashi score in patients with surgically treated vertebral metastasis. *Rev Bras Ortop*. 2011;46(4): 424-430. doi:10.1016/S2255-4971(15)30257-3.
11. R Core Team. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing; 2021.https://www.R-project.org/
12. Carrwik C, Olerud C, Robinson Y. Predictive scores underestimate survival of patients with metastatic spine disease: a retrospective study of 315 patients in Sweden. *Spine*. 2020; 45(6):414-419. doi:10.1097/BRS.0000000000003289.
13. Luksanapruksa P, Buchowski JM, Hotchkiss W, Tongsai S, Wilartratsami S, Chotivichit A. Prognostic factors in patients with spinal metastasis: a systematic review and meta-analysis. *Spine J*. 2017;17(5):689-708. doi:10.1016/j.spinee.2016.12.003.
14. Wu XG, Zhu BQ, Li AM, Zhang DY. Prognostic factors affecting overall survival in patients with spinal metastasis due to lung cancer: a systematic review and meta-analysis. *Eur Rev Med Pharmacol Sci*. 2022;26(5):1683-1694. doi:10.26355/eurrev_202203_28237.
15. Sugita S, Morita E, Fujiwara M, Okuma T, Hozumi T. Correlation between gait and life expectancy in patients with spinal metastases. *World Neurosurgery*. 2022;163:e156-e161. doi:10.1016/j.wneu.2022.03.079.
16. Zhang C, Han X, Li L, Zhang C, Ma Y, Wang G. Posterior decompression surgery and radiofrequency ablation followed by vertebroplasty in spinal metastases from lung cancer. *Med Sci Mon Int Med J Exp Clin Res*. 2020;26. doi:10.12659/MSM.925169.
17. Yaari LS, Novack L, Shemesh S, et al. Patient outcomes and survival following surgery for spinal metastases. *Journal of Spinal Cord Medicine*. 2021;44(2):204-211. doi:10.1080/10790268.2019.1610602.
18. Schoenfeld AJ, Losina E, Ferrone ML, et al. Ambulatory status after surgical and nonsurgical treatment for spinal metastasis. *Cancer*. 2019;125(15):2631-2637. doi:10.1002/cncr.32140.
19. Cho W, Chang UK. Neurological and survival outcomes after surgical management of subaxial cervical spine metastases. *Spine*. 2012;37(16). doi:10.1097/BRS.0b013e31824ee1c2.
20. Goodwin CR, Schoenfeld AJ, Abu-Bonsrah NA, et al. Reliability of a spinal metastasis prognostic score to model 1-year survival. *Spine J*. 2016;16(9):1102-1108. doi:10.1016/j.spinee.2016.04.008.
21. Paulino Pereira NR, McLaughlin L, Janssen SJ, et al. The SORG nomogram accurately predicts 3- and 12-months survival for operable spine metastatic disease: external validation. *J Surg Oncol*. 2017;115(8):1019-1027. doi:10.1002/jso.24620.
22. Carrwik C, Tsagkozis P, Wedin R, Robinson Y. Predicting survival of patients with spinal metastatic disease using PathFx 3.0 – a validation study of 668 patients in Sweden. *Brain and Spine*. 2022;2. doi:10.1016/j.bas.2022.101669.