PathFx vs modified Tokuhashi score for survival prediction in metastatic bone disease of the spine

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Significance and Hypothesis: Treatment strategies for patients with metastatic bone disease (MBD) are in part determined by the patient's prognosis and life expectancy. Therefore, being able to accurately predict life expectancy after diagnosis is important in planning care and ensuring the best possible outcome. There are many prediction systems available for patients with spinal MBD, arguably the most widely used of which is the Tokuhashi scoring system. PathFx is a newer survival prediction tool developed and tested on extremity and spine MBD to inform decision making with regards to surgical intervention. Our aim is to compare the accuracy of both methods in patients with spine MBD to test our hypothesis that PathFx provides better accuracy of survival prediction for patients with spinal MBD.

Innovation: To our knowledge, this is the first comparison between the predictions made by the modified Tokuhashi system and the PathFx system.

Approach: A cohort of patients was retrospectively identified using the SlicerDicer tool for EPIC. Initial criteria identified 282 patients with “Secondary malignant neoplasm of bone” and CT/MR imaging of the cervical, thoracic, or lumbar spine between January 1, 2012, and December 31, 2019. Patient records were then reviewed for inclusion. Inclusion criteria were presence of one or more metastases to the spine and either a documented death or at least two years of follow up. Patients with primary boney neoplasms, non-solid tumors, and/or insufficient documentation or follow-up were excluded. After review 137 were included in the final analysis. Patients had a range of primary neoplasm (Fig. 1) with an average age at the time of diagnosis of 62 (range 27-86). Modified Tokuhashi scores and PathFX survival curves were generated for each patient. In order to compare Tokuhashi score survival prediction to PathFx survival curves, the point at which the survival curve dropped below 50% was used as the predicted survival time, which was then grouped according to survival time less than six months, between six and twelve months, and greater than twelve months. Actual patient survival time was then compared to both predictions, and the percentage of correct estimates by each method was calculated as well as the sensitivity, specificity, and accuracy of each method at each of the three time ranges (Fig. 2). McNemar’s test was used to calculate the difference in accuracy between each method.

Results: PathFx was able to correctly predict patient life expectancy in 67.2% of patients. The modified Tokuhashi scale was able to correctly predict patient life expectancy in 53.3% of patients. McNemar’s test found a 13.9% difference between the prediction methods (95% CI 5.0% - 22.7%, p = 0.0043).

Discussion and Impact: As treatment modalities continue to evolve, developing accurate methods of predicting patient survival has become increasingly important. PathFx is unique from many other systems in that it can be regularly updated as treatment and diagnostic methods change. Our results indicate that it may be more accurate than the widely used Tokuhashi scale, and it may be beneficial to include results from PathFx when considering predicted patient outcomes.

Fig. 1: Primary neoplasm type

Lung	Breast	Prostate	Urinary Tract	Head and Neck	GI tract	Female Reproductive Tract	Skin	Endocrine	Unknown origin
56	22	13	17	7	6	3	3	2	9

Fig. 2: Sensitivity/specificity/accuracy

	<6 mo		6 - 12 mo		>12 mo	
	PathFx	Tokuhashi	PathFx	Tokuhashi	PathFx	Tokuhashi
Sensitivity (95% CI)	85.9% (75.0 - 93.4%)	89.0% (78.8% - 95.5%)	29.4% (10.3% - 56.0%)	17.7% (3.8% - 43.4%)	57.1% (43.2% - 70.3%)	23.2% (13.0% - 36.4%)
Specificity (95% CI)	65.8% (53.7% - 76.5%)	64.4% (52.3% - 75.3%)	88.3% (81.2% - 93.5%)	69.2% (60.1% - 77.3%)	92.6% (84.6% - 97.2%)	98.8% (93.3% - 99.9%)
Accuracy (95% CI)	75.2% (67.1% - 82.2%)	75.9% (67.9% - 82.8%)	81.0% (73.4% - 87.2%)	62.8% (54.1% - 70.9%)	78.1% (70.2% - 84.7%)	67.9% (59.4% - 75.6%)