# Improvement in Survival after Treatment for Metastatic Bone Disease: An International Trend-Analysis

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INTRODUCTION:

Estimating life expectancy in patients with metastatic bone disease (MBD) is important for framing management options to patients. The decision to operate, both if and how, is at least partially related to the individual patient's estimated survival. Various attempts have been made to prospectively predict survival in MBD, including prognostic scoring systems, advanced statistical modeling, as well as simply relying on subjective surgeon predictions. As modern surgical techniques have allowed for an increasing complexity of operative management, it is important for the orthopaedic community to reflect on its current trajectory to ensure that the associated risks and costs of surgery are leading to tangible results. Short-term results have been investigated, indicating that fracture prevention and prophylactic treatment of extremity metastases can reduce metastatic complications and improve survival rates. Although there have been isolated single-institution reports investigating survival rates in MBD, there has yet to be a worldwide analysis on if and how patient survival has changed in this context.

The goal in treating skeletal metastasis is to maximize both function and quality of life for the greatest amount of time; in doing so, we must balance expectations. Falsely optimistic predictions risk unnecessary perioperative morbidity and mortality; falsely pessimistic predictions risk insufficient biomechanical durability and complicated revisions. Considering the medical costs and significant risks associated, providing evidence regarding the true change in survival rates with respect to surgery can provide physicians and patients with more accurate information to make evidence-based decisions.

Our primary aim is to demonstrate current rates and long-term trends in survival rates for patients with surgically-managed MBD. Secondary aims include comparing survival rates across multiple primary oncological diagnoses. We hypothesized that survival for surgically-managed patients treated for symptomatic MBD will increase progressively over the past decades.

METHODS:

Initially, we queried the International Bone Metastasis Registry (IBMR) to identify all patients treated for MBD, regardless of institution. To provide historical context, we also used data that supported the development and validation of the PATHFx survival models, from centers that now contribute data to the IBMR. Inclusion criteria consists of adult patients who underwent treatment, including surgery and/or radiotherapy, for MBD to the axial and appendicular skeleton. We excluded records lacking the oncologic diagnosis, date of surgery, or overall survival. Patients were additionally divided by primary malignancy for the most common diagnoses. For each record, we calculated overall survival in months. For patients who were treated more than once, only the first surgery for metastases was accounted for in the survival analysis.

We grouped records according to three time periods: Period I (2000-2010), Period II (2010-2020), and Period III (2020-Present). Cumulative survival with 95% confidence intervals by diagnosis group were portrayed using Kaplain-Meier curves; a Mantel-Cox log-rank test was applied to test for statistically significant differences between groups. All P-values $\leq 0.05$ were considered significant.

RESULTS: A total of 3,061 patients were included in this study, 1,099 from the IBMR and 1,962 from historical data. No patients were excluded as all had prerequisite data of overall survival. Of these patients with MBD, 20% were due to breast cancer, 15% lung, 13% myeloma, 11% renal, 9% prostate, 4% sarcoma, 3% colorectal, 3% melanoma, 1% thyroid, and 21% other. Using Mantel-Cox log-rank tests applied to Kaplan-Meier curves of cumulative survival rates, patients included in Period II (2010-2020) demonstrated increased survival rates compared to Period I (p-value $<0.0001$) (Figure 1). Median survival had not been reached for Period III, however there was an apparent trend toward increased survival rates compared to both Period II and I (Figure 1). Subgroup analysis demonstrated a significant increase in survival rates over time periods for prostate, thyroid, melanoma, lung, and breast (all p-value $< 0.0001$), but not necessarily for multiple myeloma, or kidney cancer.

DISCUSSION AND CONCLUSION:

Cumulative survival rates for patients after treatment for MBD has improved over time. This was seen in nearly all disease-specific subgroups. Although the changes are likely due to improvements in medical management, orthopaedic decision making should involve methods to estimate life expectancy based on objective information. In doing so, more durable constructs should be strongly considered if applicable.

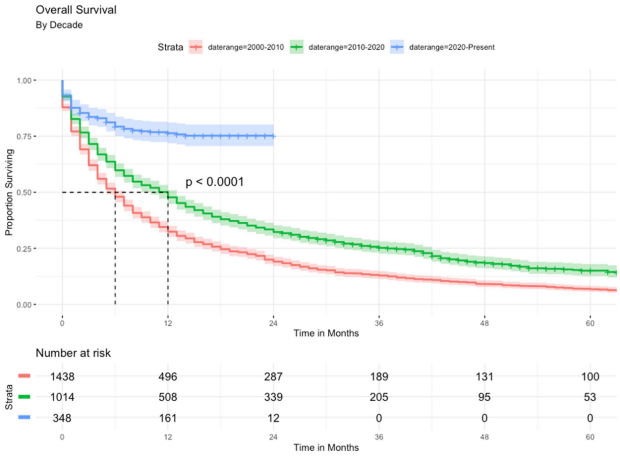


**Figure 1:** Kaplain-Meyer curve of overall survival rates for all patients, separated and compared by time period. Using Mantel-Cox log-rank testing, there was a statistically significant increase in survival rates found in patients during Period II compared to Period I ($p<0.0001$). Median survival has not yet been obtained for Period III.