Treatment of Impending Fractures is More Cost-Effective than Treatment of Completed Pathological Fractures in the Long Bones: A Propensity-Score Matched Study of 399 Patients

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INTRODUCTION:

Metastatic bone disease (MBD) is a significant driver of the cost of cancer treatmentwith an estimated cost of $12.6 billion in the United States. Due to recent advances in cancer biology and treatment in cancer treatment, the prevalence of MBD as well as the accompanying costs are expected to increase.

Cost-effective treatment with the greatest health outcomes is an important goal of cancer treatment due to increasing pressure on our healthcare system. It is therefore useful for physicians and healthcare systems to be aware of relative costs of treatment for prophylactic surgery in patients with an impending fracture versus surgery in patients with a completed pathological fracture in the long bones. For ethical reasons, there is no randomized data on this topic available, and we therefore must rely on observational – mostly retrospective – data. A previous study by Blank et al. reviewed 40 patients and assessed if there was a cost difference between the treatment of completed and impending pathological fractures. While the study suggested that there is an economic value in prophylactic stabilization compared with the fixation of completed pathological fractures, validity of the study was limited due to a small sample size and no correction of confounders. Propensity score matching is a statistical technique that limits the inherent shortcomings of non-experimental study designs by generating comparable distributions of relevant variables to reduce confounding.

The aim of this study was to compare the difference in healthcare costs between propensity score matched patients with long bone metastases who underwent surgery for an impending versus a completed pathologic fracture.

METHODS:

Clinical and financial data was retrospectively collected from two affiliated urban tertiary care referral centers for musculoskeletal oncology between January 2016 to December 2020 in the United States. All patients 18 years of age and older who underwent surgery for an impending or completed pathological fracture of a long bone metastases were included in the study. The choice of treatment is decided by both patient and surgeon, aided by the Mirels' score. In general, patients with a Mirels' score of eight or higher received prophylactic surgery. Propensity score matching was done using a one-to-one nearest-neighbor matching in a random order without replacement and with a caliper fixed at 0.005 on 21 variables including demographics, clinical characteristics, tumor variables, and laboratory values. The primary outcome was healthcare costs per episode of care (the time from admission until 30 days post-discharge). This was assessed by comparing both the median costs using the Mann Whitney U test and mean costs using the independent student t-test.

RESULTS:

In total, 399 patients were included, of which 207 patients (52%) had an impending fracture, and 192 patients (48%) had a pathologic fracture. After matching, 88 patients with pathological fracture were matched to 88 patients with an impending fracture (Table 1). Prior to statistical analysis, financial data was converted to cost-units (CU) which are the actual costs divided by a common denominator. After matching, the median total costs of the prophylactically treated patients (716 CU, IQR; 479 – 940) were lower compared with patients treated for a pathologic fracture (827 CU, IQR; 583 – 1291; $P<0.05$; Table 1). In-hospital costs were significantly lower in the prophylactically treated group than in the pathologic fracture group: 688 CU versus 505 ($p < 0.01$). Thirty-days discharge costs did not differ gravely between the two groups ($p = 0.83$). Patients who were prophylactically treated for a metastatic lesion of the femur had significantly shorter length of stay (4.9 ± 4.7 days) versus those treated for a pathologic fracture (6.8 ± 5.9 days) ($p = 0.03$), which could have led to the observed higher costs (Table 2).

DISCUSSION AND CONCLUSION:

The risk of confounding was minimized through complete propensity score matching on 22 traits, adding to the validity of this study. As such, the findings of the current study suggest that prophylactic treatment of pathological fractures are associated with lower cost of treatment as compared to completed pathologic fractures, indicating that prophylactic surgery may have financial benefits. Regardless of these financial benefits, identifying patients best suited for prophylactic treatment remains of paramount importance to improve clinical oncologic care. It would be helpful to develop an easy to use, precise prediction which can accurately assess the risk of a pathologic fracture.

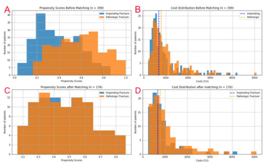

Figure 2. The propensity scores are depicted before (A) and after (C) matching. The overlap between propensity scores after adjusting for 25 confounders indicates adequate matching. The costs distributions are also shown before (B) and after (D) matching. Both cost distributions graphs are right skewed for the costs of patients with a completed fracture. After propensity score matching, the total costs are lower for the prophylactically treated patients (before matching $p = 0.07$; after matching $p = 0.047$).

Table 1. Costs of hospital stay and 30 days post-discharge for all patients before (n = 399) and after matching (n = 176). Costs are presented as cost-units (CU) which are the actual costs divided by a common denominator.

Non-PSM (n=399)	Pathologic (n=192)	Impending (n=207)	p-value*	PSM-Matched (n = 176)	Pathologic (n=88)	Impending (n=88)	p-value*
			Median (IQR) Total Costs (CU)				
Hospital Stay	637 (434 - 1094	490 (354 - 922	**<0.01**	***Hospital stay***	688 (456 – 971)	504 (354 – 804)	**<0.01**
30 days post-discharge	56 (6 – 241)	99 (5 – 227)	0.73	***30 days post-discharge***	147 (10 – 192)	142 (12 – 210)	0.83
Total	723 (515 - 964	644 (461 - 806	0.07	***Total***	827 (583 - 1291	716 (479 – 940)	**0.047**
			Mean ± SD of Total Costs (CU)				
Hospital Stay	824 ± 638	$751 ± 689	**<0.01**	***Hospital stay***	891 ± 729	$726 ± 661	0.11
30 days post-discharge	187 ± 352	186 ± 170	0.75	***30 days post-discharge***	212 ± 353	161 ± 170	0.22
Total	928 ± 655	880 ± 711	0.07	***Total***	$1102 ± 863	887 ± 687	0.07

** Patient with completed pathologic fracture vs prophylactically treated patients; Mann Whitney U test was used for comparison of medians and the independent t-test was used for comparison of means; P<0.05 was considered statistically significant.*

Table 2. Costs of hospital stay and 30 days post-discharge for patients who were treated for a metastatic lesion in the femur after propensity score matching. Costs are presented as cost-units (CU) which are the actual costs divided by a common denominator.

PSM-Matched Femur Patients (n = 142)			
	Pathologic (n=71)	Impending (n=71)	p-value*
Median Total Costs (IQR) in CU			
Hospital stay	704 (496-965)	502 (362-803)	**<0.01**
30 days post-discharge	146 (10-184)	123 (13-223)	0.65
Mean Total Costs ± SD in CU			
Hospital stay	934 ± 778	695 ± 604	**0.04**
30 days post-discharge	190 ± 311	168 ±182	0.60
Length of stay (days)	6.8 ± 5.9	4.9 ± 4.7	**0.03**
PSM-Matched Humerus Patients (n = 34)			
	Pathologic (n=17)	Impending (n=17)	p-value*
Median Total Costs (IQR) in CU			
Hospital stay	643 (406-925)	355 (256 - 527)	**0.036**
30 days post-discharge	156 (13-177)	122 (8-146)	0.28
Mean Total Costs ± SD in CU			
Hospital stay	765 ± 561	436 ±261	0.08
30 days post-discharge	271 ± 452	91 ±76	0.23
Length of stay (days)	5.3 ± 6.8	3.1± 2.6	0.33

** Patient with completed pathologic fracture vs prophylactically treated patients; Mann Whitney U test was used for comparison of medians and the independent t-test was used for comparison of means; P<0.05 was considered statistically significant.*

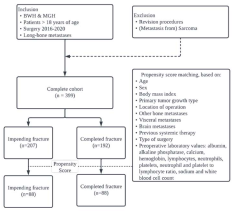

Figure 1. Flowchart representing the methods on patient selection. After propensity score matching on 21 variables, a balanced cohort of 176 patients was created.