Patient-Reported Outcomes after Intramedullary Nailing of Oncologic Impending or Pathologic Fractures with Carbon Fiber or Titanium Implants

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INTRODUCTION:

Intramedullary nailing (IMN) is an effective procedure to prophylactically or therapeutically stabilize the bone and prevent further fracture in oncology patients. In recent years, the mechanical and biocompatible properties of carbon fiber (CF) have led to its increasing utilization in orthopaedic implants. The radiolucent properties of CF nails allow for better visualization of fracture reduction and tumor recurrence after bone stabilization. Despite the clear benefits of this procedure, literature on patient-reported outcomes (PROs) is scarce, and no studies have compared PROs between titanium and CF IMNs. Our study sought to compare postoperative PROs in patients treated with either CF or titanium IMNs.

METHODS:

We conducted a retrospective review of patients treated at our institution with CF or titanium IMN for impending or pathologic fractures from localized or metastatic bone disease between 2016 and 2022 (Figure 1). Postoperative patient-reported outcomes were measured using three Patient-Reported Outcomes Measurement Information System (PROMIS) questionnaires: Global Health Short Form Mental (SF Mental), Global Health Short Form Physical (SF Physical), and Physical Function Short Form 10a (SF 10a). Pain was assessed with visual analog scale (VAS). Both absolute and differential (postoperative minus preoperative) scores were compared between groups at the 1-month, 3-month, 6-month, and 1-year timepoints.

Demographic, clinical, and PROMIS variables were displayed using descriptive characteristics. Differences between groups were compared using Mann Whitney U test for continuous variables and chi-square for categorical variables. Propensity-score matching was performed between groups and was based on age-adjusted Charlson Comorbidity Index (CCI), type of primary tumor, American Society of Anesthesiologists (ASA) class, fracture type, and nail location. A p-value ≤ 0.05 was considered statistically significant.

RESULTS:

A total of 347 patients treated with IMN for pathologic or impending fractures were eligible for inclusion. After propensity score matching, 225 patients were included in the final analysis. Sixty-one patients (27.1%) were treated with CF IMNs and 164 (72.9%) with titanium IMNs. No differences in sex, ASA class, BMI, age adjusted CCI, and primary tumor type were seen between groups (Table 1).

No differences between groups were seen on preoperative PROMIS SF Mental (p=0.41), SF physical (p=0.57), or SF 10a (p=0.48). Patients treated with CF nails had a higher preoperative pain VAS than those treated with titanium nails (p=0.013) (Table 2). One month postoperatively, no differences in PROMIS SF Physical, SF Mental, and SF 10a were seen between groups. Median pain VAS was still higher in patients treated with CF nails (p=0.005). No differences in absolute scores were seen between groups in any scores at the 3-month, 6-month, and 1-year timepoints (Table 3).

No difference in differential scores were seen at the one-month postoperative mark (Table 4). At three-months postoperatively, a higher reduction in pain VAS was seen in the CF group than in the titanium group (p=0.022). At six months postoperatively, both groups displayed higher physical function scores (PROMIS SF Physical and SF 10a) than preoperative scores. One year after surgery, both groups achieved similar levels of pain reduction and physical and mental function.

DISCUSSION AND CONCLUSION:

In our study, the type of implant, carbon fiber or titanium, was not associated with differences in postoperative PROMIS scores. Given the similar PROs after CF IMN and the added benefits of this material, physicians should consider using these implants more frequently. Future studies should focus on prospectively following patients after treatment with titanium or CF IMN and identify risk factors for differences in patient-reported outcomes.

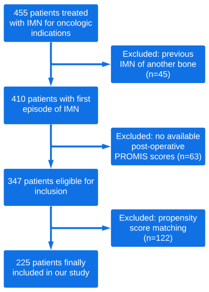

Table 1. Demographic and clinical characteristics of included patients before and after propensity score matching.

	Base cohort (n = 347)			Propensity-score matched cohort (n = 225)		
	Carbon fiber (n=66)	**Titanium (n=281)**	***p***	**Carbon fiber (n=61)**	**Titanium (n=164)**	***p***
Age[+]	68 (56-73)	66 (58-72)	0.78	68 (57-74)	66 (57-72)	0.38
Female sex	38 (57.6%)	146 (52.0%)	0.41	35 (57.4%)	87 (53.0%)	0.56
ASA class			**0.003**			0.24
1	0 (0.0%)	1 (0.4%)		0 (0.0%)	1 (0.6%)	
2	18 (27.3%)	28 (10.1%)		14 (23.0%)	23 (14.0%)	
3	46 (69.7%)	234 (84.2%)		45 (73.8%)	138 (84.1%)	
4	2 (3.0%)	15 (5.4%)		2 (3.3%)	2 (1.2%)	
BMI[+]	25 (23-29)	26 (23-30)	0.73	25 (23-28)	26 (23-30)	0.47
Age-adjusted CCI[+]	8 (7-10)	9 (8-10)	**0.028**	9 (7-10)	9 (8-10)	0.38
Primary tumor			**0.01**			0.21
Breast	11 (16.7%)	67 (23.8%)		11 (18.0%)	38 (23.2%)	
Lung	17 (25.8%)	56 (19.9%)		16 (26.2%)	35 (21.3%)	
Renal	5 (7.6%)	38 (13.5%)		5 (8.2%)	23 (14.0%)	
Multiple myeloma	8 (12.1%)	27 (9.6%)		7 (11.5%)	19 (11.6%)	
Prostate	2 (3.0%)	20 (7.1%)		2 (3.3%)	6 (3.7%)	
Bone and STS	12 (18.2%)	14 (5.0%)		9 (14.8%)	7 (4.3%)	
Other	10 (15.2%)	56 (19.9%)		10 (16.4%)	34 (20.7%)	
Unknown primary	1 (1.5%)	3 (1.1%)		1 (1.6%)	2 (1.2%)	
Fracture type			**<0.001**			0.44
Impending	52 (78.8%)	155 (55.2%)		47 (77.0%)	118 (72.0%)	
Complete	14 (21.2%)	126 (44.8%)		14 (23.0%)	46 (28.0%)	
Nail location			**<0.001**			0.33
Femur	42 (63.6%)	220 (78.3%)		42 (68.9%)	113 (68.9%)	
Humerus	14 (21.2%)	54 (19.2%)		14 (23.0%)	45 (27.4%)	
Tibia	10 (15.2%)	7 (2.5%)		5 (8.2%)	6 (3.7%)	
Length of stay (days)[+]	3 (2-7)	3 (2-6)	0.93	3 (2-6)	3 (2-5)	0.59
Follow-up (months)[+]	17 (4-33)	9 (3.5-25)	0.12	12 (3.8-33)	11 (4.3-33)	0.85

ASA: American Society of Anesthesiologists; *BMI*: Body mass index; *CCI*: Charlson comorbidity index; *STS*: soft tissue sarcoma.

[+] Median values and interquartile ranges between brackets.

Table 2. Pre-operative PROMIS and pain VAS by type of intramedullary nail.

	Carbon fiber (n=61)	**Titanium (n=164)**	***p***
PROMIS Global Health SF Physical[+]	37.4 (32.4, 42.3)	34.9 (32.4, 42.3)	0.57
PROMIS Global Health SF Mental[+]	43.5 (41.1, 50.8)	48.3 (38.8, 50.8)	0.41
PROMIS Physical Function SF 10a[+]	35 (31.2, 40.9)	34.4 (29.4, 38.7)	0.48
Pain VAS[+]	6 (5, 8)	5 (2, 7)	**0.013**

PROMIS: Patient-Reported Outcomes Measurement Information System; *SF:* short form; *VAS*: visual analog scale.

[+] Median values and interquartile ranges between brackets.

Table 3. Absolute PROMIS and pain VAS by type of intramedullary nail.

	1-month post-op			3-month post-op			6-month post-op			1-year post-op		
	Carbon fiber	**Titanium**	***p***	**Carbon fiber**	**Titanium**	***p***	**Carbon fiber**	**Titanium**	***p***	**Carbon fiber**	**Titanium**	***p***
PROMIS Global Health SF Physical[+]	36.15 (29.6, 42.3)	37.4 (32.4, 42.3)	0.27	41.05 (37.4, 44.9)	38.6 (34.9, 46.3)	0.92	42.3 (34.9, 50.8)	39.8 (34.9, 44.9)	0.26	42.3 (37.4, 57.7)	42.3 (34.9, 50.8)	0.3
PROMIS Global Health SF Mental[+]	43.45 (38.8, 53.3)	45.8 (41.1, 50.8)	0.67	44.65 (41.1, 50.8)	49.55 (38.8, 56)	0.43	48.3 (43.5, 56)	45.8 (41.1, 53.3)	0.22	53.3 (43.5, 67.6)	50.8 (45.8, 53.3)	0.14
PROMIS Physical Function SF 10a[+]	31.8 (25, 37.8)	32.5 (27.7, 35.7)	0.73	30.4 (24.1, 39.3)	35.7 (31.2, 37.9)	0.2	38.5 (32.5, 43.5)	40.15 (34.8, 44.4)	0.39	37.9 (34, 45.5)	37.9 (32.7, 45.5)	0.79
Pain VAS[+]	5 (3, 7)	3 (2, 5)	**0.005**	2 (1, 3)	4 (0, 5)	0.56	3 (1, 4)	3 (0, 5)	0.98	2 (0, 4)	1.5 (0, 5)	0.96

PROMIS: Patient-Reported Outcomes Measurement Information System; *SF:* short form; *VAS*: visual analog scale.

[+] Median values and interquartile ranges between brackets.

Table 4. Differential PROMIS and pain VAS by type of intramedullary nail

	Preop to 1-month post-op			Preop to 3-month post-op			Pre-op to 6-month post-op			Preop to 1-year post-op		
	Carbon fiber	**Titanium**	***p***	**Carbon fiber**	**Titanium**	***p***	**Carbon fiber**	**Titanium**	***p***	**Carbon fiber**	**Titanium**	***p***
PROMIS Global Health SF Physical[+]	1.4 (-4.9, 7.5)	0 (-7.8, 2.65)	0.34	3.75 (0, 9.9)	0 (-2.5, 5.1)	0.38	2.8 (0, 5.9)	5.1 (0, 8.5)	0.82	4.55 (-1.8, 13.05)	0 (-2.5, 7.8)	0.49
PROMIS Global Health SF Mental[+]	0 (-2.7, 2.7)	-2.5 (-9.5, 2.5)	0.34	1.25 (-4.7, 5)	0 (-5, 3)	0.47	0 (-5.1, 4.7)	2.5 (1.15, 3.65)	0.44	1.3 (-8.25, 19.2)	9.8 (-5, 15.1)	0.6
PROMIS Physical Function SF 10a[+]	-1.9 (-7.8, 3)	-.4 (-7.3, 4)	0.84	.8 (-4.6, 4.5)	1.8 (-1.5, 5.8)	0.48	6.1 (0, 16.1)	3.4 (-.1, 9.1)	0.46	5.75 (0, 8.3)	3.25 (-3.8, 10.5)	0.72
Pain VAS[+]	-1 (-3, 0)	-1 (-3, 2)	0.73	-5 (-6, -2)	0 (-5, 1)	**0.022**	-3 (-4, -1)	-1 (-2, 0)	0.14	-2.5 (-3.5, -.5)	-3 (-4, 1)	0.84

PROMIS: Patient-Reported Outcomes Measurement Information System; *SF:* short form; *VAS*: visual analog scale.

[+] Median values and interquartile ranges between brackets.