Prophylactic Carbon Fiber Nail Fixation in Patients with Musculoskeletal Lesions Requiring Postoperative Surveillance Imaging

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Background

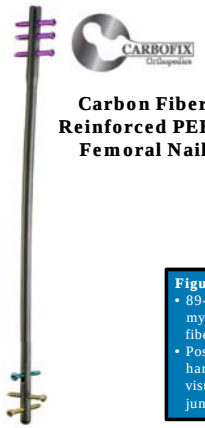
Prophylactic long bone fixation is routinely performed in patients at high risk for pathologic fracture following the resection of bone or soft tissue lesions, especially when local adjuvant therapy is indicated. Traditional fixation constructs made of titanium or stainless steel can obstruct postoperative surveillance imaging secondary to artifact seen on both computed tomography (CT) and magnetic resonance imaging (MR). The advent of carbon fiber reinforced polyetheretherketone (CFR-PEEK) fixation introduced an alternative construct material with equivalent mechanical stability to titanium, but with distinct radiolucent properties. We hypothesized that a carbon fiber intramedullary nail can achieve equally effective prophylactic long bone fixation and minimize the obstructive artifact seen on CT or MR surveillance images required to monitor for recurrent disease.

Table 1: Carbon Fiber Patient Demographics

Age (yrs)	Sex	Histologic Diagnosis	Location	Nail type	XRT?	Surgical Adjuvant
47	F	High grade undifferentiated pleomorphic sarcoma	Vastus lateralis	Femoral	Yes	No
39	F	Adamantinoma/ impending fracture	Tibia	Tibial	No	Cryotherapy
39	F	Sessile osteochondroma	Femur	Femoral	No	No
35	M	Fibrous dysplasia/ impending fracture	Tibia	Tibial	No	No
64	M	High grade myxofibrosarcoma	Vastus intermedius	Femoral	Yes	No
30	F	Intramuscular hemangioma invading adjacent bone	Femur	Femoral	No	Argon beam
89	M	Myxofibrosarcoma	Vastus intermedius	Femoral	Yes	No
44	M	Cortical metastatic thyroid carcinoma metastasis	Femur	Femoral	Yes	Cryotherapy

Patients & Methods

- IRB-approved (WA0552-13) retrospective review from 2012-2014:
  - 8 patients with tibial or femoral prophylactic fixation with a CarboFix™ CFR-PEEK intramedullary nail (CarboFix Orthopedics, Israel).
- All patients had post-op surveillance imaging by MR, CT, or x-ray.
- Median follow-up was 12 months [range 6-19 months].
- Surveillance imaging performed at 3- and 6-month intervals per NCCN Guidelines.
- For image analysis, the control group was comprised of patients with a femoral titanium intramedullary nail and a postoperative MR or CT.
- Image analysis performed by a single MSK-trained radiologist who assessed the percentage of cortex, corticomedullary junction, and bone-muscle interface visualized on axial images using a 5-point scale.



Carbon Fiber Reinforced PEEK Femoral Nail

CT Imaging of Carbon Fiber Nail

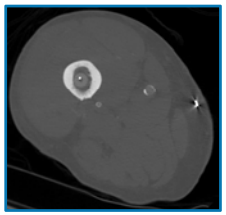


Figure 1.
- 89-year-old male s/p resection thigh myxofibrosarcoma and placement of carbon fiber prophylactic nail.
- Postoperative CT shows decreased beam hardening artifact and near complete visualization of the cortex, corticomedullary junction, and bone-muscle interface.

MR Imaging Comparison

Carbon Fiber Prophylactic Fixation

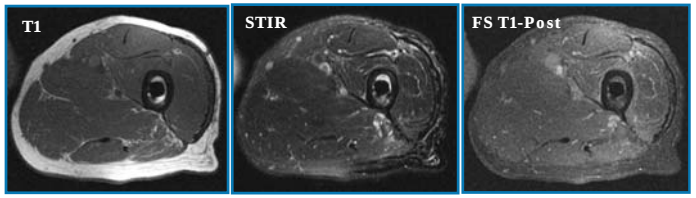


Figure 2.
- 63-year-old male s/p resection thigh myxofibrosarcoma and placement of carbon fiber prophylactic nail.
- Exam scored 5 in visualization of the cortex, corticomedullary junction, and muscle-bone interface.
- Fat suppression was considered good.

Titanium Prophylactic Fixation

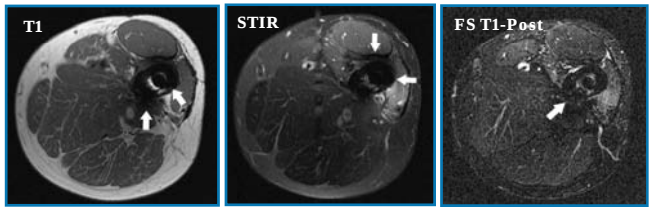


Figure 3.
- 44-year-old male s/p resection thigh myxoid liposarcoma and placement of titanium prophylactic nail.
- In T1-weighted sequence, the study scored 3 in visualization of the cortex, 2 in the corticomedullary junction, 3 in the muscle-bone interface.
- In STIR, the study scored 3 in visualization of the cortex, corticomedullary junction, and muscle-bone interface.
- In post contrast T1-weighted fat saturated sequence, the study scored 2 in visualization of the cortex, and corticomedullary junction, and 3 in visualization of the muscle-bone interface.
- Fat suppression was considered fair in STIR and poor in post contrast T1-weighted fat-saturated sequence.
- Focal susceptibility artifact results in the signal loss (arrows) in and outside of the bone near the nail.

5-Point Scale

1: <10%, **2:** 10-30%, **3:** 30-60%, **4:** 60-90%, and **5:** >90%

Table 2: MR Image Analysis Results

	T1-weighted		STIR		T1 post-contrast fat sat	
	Control	Carbon fiber nail	Control	Carbon fiber nail	Control	Carbon fiber nail
Cortex	2.8	3.8	2.9	3.9	2.7	2.9
Corticomedullary junction	2.3	3.6	2.4	3.7	2.4	3.5
Bone-muscle interface	2.8	4.2	2.9	4.2	3	4.3
Degree of fat saturation	-	-	2.1	2.8	1.8	2.8

Results

- **CFR-PEEK nails have significantly less MR and CT artifact, allowing for greater visualization of the cortex, corticomedullary junction, and bone-muscle interface on T1, STIR, and T1 post-contrast fat saturated MR sequences.**
- On CT images of CFR-PEEK nails, the beam hardening artifact was substantially less than that seen with titanium nails, allowing for near complete visualization of the cortex, corticomedullary junction, and bone-muscle interface.
- At last follow-up [mean 12 months, range 6-19 months], no patient developed a pathologic fracture, infection, or other complication related to the CFR-PEEK intramedullary nail.
- All patients had Good or Excellent MSTS functional assessment scores.

Conclusion

Carbon fiber reinforced PEEK intramedullary nail fixation is a novel and superior alternative to titanium for patients requiring prophylactic fixation and future surveillance MR or CT imaging of bone and soft tissue pathologic lesions.

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The Authors Have No Financial Conflicts of Interest.