Prereferral MRI Use in Patients with Musculoskeletal Tumors Is Not Excessive

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Abstract

Background Inappropriate MRI use has been targeted as a particular area of concern in orthopaedics, but it is unclear whether and to what extent its use is inappropriate in musculoskeletal oncology.

Questions/Purposes We therefore evaluated the incidence and cost of inappropriate prereferral MRI among patients with musculoskeletal tumors.

Methods We retrospectively identified 920 patients treated in a musculoskeletal oncology clinic between 2009 and 2010. We accepted as necessary any MRI for a primary bone sarcoma, for biopsy-proven soft tissue sarcomas, for soft tissue masses greater than 5 cm in diameter, for soft tissue masses deep to the fascia, for painful soft tissue masses, and for growing soft tissue masses. Patients without these criteria were reviewed by a team of musculoskeletal oncologists to determine the necessity. The criteria for a repeat MRI were failure to show the tumor, lack of gadolinium contrast, lack of T1 or T2 MRI

sequence, or poor image quality. Cost was determined using 2010 Medicare reimbursement rates.

Results Of 920 patients, 320 (35%) arrived with a prereferral MRI study. Eight of the 320 (3%) studies were unnecessary, and 12 (4%) were necessary but were repeated. The cost was \$11,474, which averages to \$574 per study and \$36 of waste per patient referred with an MRI study.

Conclusions Based on our data, we judged MRI use before referral to our tertiary center as not excessive. This is likely attributable, in part, to the relatively low use of MRI in our referral base. Inappropriate MRI use in patients with tumors may not be as widespread as previously reported.

Level of Evidence Level IV, case series. See Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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Introduction

Healthcare spending in the United States as a percentage of Gross National Product is nearly double that of other developed countries [16, 20]. This expenditure has sparked intense public debate regarding the best way to control costs. Previous investigators have argued that as much as 1/3 of healthcare spending is duplicative, unhelpful, or even potentially harmful and that a reduction in this waste would realize substantial cost savings [8, 9]. Against this backdrop, the cost of advanced imaging increased by 17% per year from 2000 to 2006 [17], and inappropriate imaging studies have been widely criticized as an area of excess [1, 7, 14, 18].

Advanced imaging modalities such as MRI are in widespread use for the diagnosis and staging of musculoskeletal

tumors [3, 6, 11]. Primary care physicians and general orthopaedists in general practice frequently obtain advanced imaging before referring a patient with a tumor to a tertiary center. Because of the rarity of musculoskeletal tumors, there is a possibility that physicians unaware of the appropriate indications for advanced imaging may order unnecessary studies. Aboulafia et al. [1] investigated this issue and reported that 34.2% of MRI studies were not necessary for making the diagnosis or planning therapeutic interventions in patients referred to a musculoskeletal oncologist, and that orthopaedic surgeons were just as likely as primary care physicians to order unnecessary studies.

Even if the indications for obtaining an MRI are sound, technical inadequacy is an additional potential area of waste. Common examples of technical inadequacy include failure to image the correct anatomic site or the entire compartment containing a suspected tumor, or images that lack intravenous contrast to properly evaluate the tumor. Because of these technical inadequacies, the MRI study must be repeated at the receiving institution, thus doubling the cost of the study. The previous study on this topic for patients with musculoskeletal tumors did not report the incidence of repeat MRI studies [1]. Thus, the incidence of repeating technically inadequate or incorrectly ordered MRI studies in patients with musculoskeletal tumors is unclear and the associated costs are unknown.

We therefore determined the incidence and cost of inappropriate MRI studies in patients with musculoskeletal tumors.

Patients and Methods

We retrospectively reviewed all 920 new patients referred to our musculoskeletal oncology clinic between January 1, 2009, and December 31, 2010. Our department maintains an institutional review board-approved prospectively collected electronic database of patient records. Outside radiographic images are loaded into this computer system before review by our staff, and the record is time-stamped. We queried this database to identify patients referred for evaluation of a suspected bone or soft tissue tumor who had MRI studies completed before their first visit. Patients who had an MRI study completed for an indication other than evaluation of a suspected bone or soft tissue tumor (for instance, MRI of the knee to evaluate for ligamentous injury) in which the tumor was discovered incidentally were excluded. Of the 920 patients, 320 were referred for evaluation or treatment of a suspected bone or soft tissue sarcoma with an MRI study completed before referral and were included in our study (Table 1). This study received IRB approval and was HIPAA compliant.

Table 1. Patient characteristics

Characteristic	Number of patients	Percent
Gender		
Male	167	52%
Female	153	48%
Tumor location		
Thigh	48	15%
Lower leg/foot	60	19%
Knee	84	26%
Upper extremity	76	24%
Spine	2	< 1%
Hip/pelvis	40	13%
Other	10	3%
Diagnosis		
Benign	236	74%
Malignant	79	25%
Unknown	5	1%
Tissue involvement		
Soft tissue	147	46%
Bone	172	54%
Both compartments	1	< 1%

For these 320 patients, we performed a detailed chart review to determine which of the MRI studies were necessary for diagnosis or surgical planning. To determine the necessity of MRI, we used the referral guidelines for patients with cancer, which have been published elsewhere [5, 12, 19]. Specifically, an MRI was considered necessary for all patients with primary bone sarcomas, biopsy-proven soft tissue sarcomas, soft tissue masses greater than 5 cm in diameter, soft tissue masses deep to the fascia, painful soft tissue masses, and soft tissue masses that reportedly had been growing. Patients who did not have these explicit indications were independently reviewed by a fellowship-trained musculoskeletal oncologist (BJM) not involved in the initial care of the patient. His opinion then was compared with that of the original treating surgeon (JAB or JM). Each of the two oncologists had to agree on the appropriateness or inappropriateness of the study. Any differences of opinion were discussed and resolved so there was agreement between the investigators in all cases.

After categorizing each of the studies as either necessary or unnecessary, we determined the incidence of repeated studies. For each of the patients who arrived with a necessary MRI study, we queried our database to identify which of them had repeat MRI studies ordered within 30 days of their first visit. Any studies that were obtained after 30 days were more likely to have been needed for reassessment or monitoring of the lesion and were not counted as repeats. The repeated MRI studies were divided

into two categories: repeats resulting from technical inadequacy and repeats that were clinically indicated. Examples of technical inadequacy include inadequate observation of the tumor, lack of gadolinium contrast, lack of T1 or T2 MRI sequence, or poor image quality. We considered studies that were repeated within 30 days specifically to document progression of the tumor as clinically necessary repeats.

For our cost analysis, we used the global 2010 Medicare reimbursement rates [22], which include the physician and hospital fees paid by Medicare. The total Medicare cost (physician and hospital fees) of the inappropriate MRI studies was determined. We then determined an average Medicare cost per patient who arrived with an MRI study completed before referral by dividing the total number of patients into the total cost.

Results

Of the 320 patients, 312 (97%) met the definition of having a necessary study as specified in the Methods section. Eight (3%) of the MRI studies were unnecessary for

Table 2. Unnecessary and inappropriate repeated studies by diagnosis

Diagnosis	Number of unnecessary studies	Number of repeat studies
Benign		
Enchondroma	3	
Nonossifying fibroma	3	
Unicameral bone cyst	1	
Nerve sheath tumor		2
Avascular necrosis		1
Lipoma		1
Hemangioma		1
Thrombosis		1
Benign lesion, not otherwise specified	1	
Total benign	8	6
Malignant		
Liposarcoma		1
Malignant peripheral nerve sheath tumor		1
Chondrosarcoma		1
Synovial sarcoma		1
T-cell lymphoma		1
Myxoid sarcoma		1
Total malignant	0	6

either diagnosis or surgical planning (Table 2). Of the 312 patients with necessary MRI studies, 17 (5%) had repeat MRI within 30 days of their initial clinic visit. Five of these repeats were indicated to document progression of the disease. Twelve of the 312 (4%) necessary studies were repeated as a result of technical inadequacy. Specifically, eight of these 12 MRI studies were repeated because of a lack of contrast sequences in the initial study and four of the MRI studies did not show the full extent of the tumor.

In total, 20 MRI studies (eight unnecessary and 12 repeated) of the initial 320 (6%) ultimately were categorized as inappropriate imaging studies and identified as a potential area of cost savings. The Medicare cost of the unnecessary studies was \$4206 (Table 3), and the Medicare cost of the repeated studies was \$7268 (Table 4). Thus, the total combined Medicare cost of these inappropriate studies was \$11,474 during the 2-year study period. This amounts to an average of \$574 per inappropriate imaging study ($11,474/20 = 574$) and \$36 per patient who

Table 3. Types and costs of unnecessary MRI studies

Imaging type	Number unnecessary	2010 Medicare reimbursement*	Cost of unnecessary study*
Pelvis MRI with and without contrast	1	\$610	\$610
Lower extremity joint MRI without contrast	2	\$392	\$784
Lower extremity MRI with and without contrast	4	\$605	\$2420
Upper extremity joint MRI without contrast	1	\$392	\$392
Totals	8		\$4206

* Numbers rounded to whole dollars.

Table 4. Types and costs of repeat MRI studies

Imaging type	Number repeated	2010 Medicare reimbursement*	Cost of repeats*
Upper extremity joint MRI with and without contrast	2	\$604	\$1208
Lower extremity MRI with and without contrast	3	\$605	\$1815
Lower extremity joint MRI with and without contrast	5	\$605	\$3025
Pelvis MRI with and without contrast	2	\$610	\$1220
Totals	12		\$7268

* Numbers rounded to whole dollars.

was referred to our clinic with an MRI study for workup of a suspected bone or soft tissue tumor ($11,474/320 = 36$).

Discussion

Overutilization of healthcare resources is a widely debated issue, with substantial interest to orthopaedic surgeons, and orthopaedic surgery has been criticized specifically as a common source of unnecessary MRI studies [1, 2, 4, 10, 15]. Although the use of MRI is known to have expanded rapidly in multiple orthopaedic subspecialties [2, 4, 10, 15], to the best of our knowledge only one prior study has examined this issue specifically in patients with musculoskeletal tumors [1]. An accurate and technically sound advanced imaging study is imperative to appropriate treatment of musculoskeletal tumors, and the repetition of inadequate imaging is universally required to ensure optimal patient care. Thus, we determined the incidence and cost of unnecessary or repeated images among our patients with tumors.

Our study has several limitations. First, the determination regarding whether a study is necessary or unnecessary is subjective. We identified specific inclusion criteria based on previously suggested indications to obtain MRI [5, 12, 19]. However, when in doubt whether a study was absolutely necessary, we tended to give the benefit of the doubt to the referring physician, because we could not know the circumstances or details of the patient's initial clinical presentation and we labeled the study as necessary. Therefore, it is possible that an occasional study that we defined as necessary would be thought to be superfluous by another. Second, it is possible that a patient's MRI study could have been brought on a CD and viewed by the surgeon without it being loaded into our electronic database. However, loading outside images onto our servers for review by the radiologist has been a requirement at our institution since 2004, and compliance with this requirement has been high. Third, the generalizability of our results is limited by the practice patterns of the referring physicians. In our study, only 35% of patients were referred with an MRI study, in contrast to a similar previous investigation in which 76% of patients were referred with an MRI study [1]. This is a substantial difference and could be attributed to several factors such as availability and convenience of referral, the legal environment, the practice habits of general orthopaedists and primary care physicians, availability of advanced imaging, and reimbursement and insurance issues. It is conceivable that our lower rate of inappropriate studies is primarily reflective of the referring physicians in our area having a tendency to refer patients with suspected bone and soft tissue tumors without ordering an MRI study. This is difficult to quantify

and an interesting topic for further study. Ideally our study would have made use of data from a large population, drawn from around the country, which would have better accounted for regional variations in practice patterns, and would better increase our generalizability. Finally, our study is limited by its retrospective nature. We cannot ask the patients additional clarifying questions, and thus are limited by the completeness and accuracy of the charting at the initial clinic visit. In addition, with a prospective study, the necessity of the imaging is assessed at the same time as the workup and surgical planning are being completed, potentially decreasing the subjectivity of assessing its importance.

Eight of 320 (3%) of the MRI studies in our study were determined to be unnecessary, and all of these were in patients with benign tumors. The only other study on this topic in patients with musculoskeletal tumors found a much higher incidence of 34.2% [1]. Similar to our findings, the majority of the inappropriate studies were of benign lesions. However, Aboulaia et al. did not list specific criteria for what they considered to be a necessary imaging study [1]. In contrast, we have listed specific criteria based on size, clinical characteristics, and patient history, which are consistent with previously published studies on appropriate indications in this patient population [5, 12, 19]. Not all patients with these characteristics will need imaging, but imaging in these patients should be considered reasonable and not excessive. In general, our results indicate primary care physicians and orthopaedists in general practice in our referral area are ordering MRI studies for the appropriate indications in patients with musculoskeletal tumors. Twelve of the 312 necessary MRI studies (4%) were repeated as a result of technical inadequacy. The most common reason for repeating an MRI study in our study was a lack of intravenous contrast. Multiple authors have reported on the advantages of gadolinium contrast MRI over noncontrast imaging for the diagnosis of sarcomas [11, 13, 21]. Despite this widespread acceptance, our results indicate a small percentage of patients with musculoskeletal tumors do not receive gadolinium contrast with their MRI. The second most common reason for repeating an MRI study in our study was inadequate observation of the tumor. Musculoskeletal sarcomas frequently occur around joints. However, a standard joint MRI, for example MRI of the knee, may not show the full extent of a tumor that involves the distal femur or proximal tibia. This information should be fully communicated to the radiology technician performing the MRI to ensure the full extent of the tumor, including the entire bone if there is concern for an osseous sarcoma, is seen.

The cost analysis we conducted was an estimate based on 2010 Medicare reimbursement rates for the imaging

studies. These charges alone were \$11,474. However, other insurance types compensate at a higher rate than Medicare. The rates charged by different insurance carriers vary between institutions and regions, and were not available to us. Thus, we were not able to account for the additional costs experienced by our patients who did not have Medicare insurance. Furthermore, this analysis does not take into account other sources of cost such as blood work, laboratory studies, office visits, patient travel, or other imaging modalities such as CT, bone scan, or mammography. Thus, the total unnecessary costs incurred by patients are greater than what are reported here. Aboulafia et al. evaluated cost inefficiencies in the imaging studies ordered for patients referred to a musculoskeletal oncologist [1]. Twenty-six of 76 (34.2%) MRI scans in their study were deemed unnecessary, which amounted to a waste of \$502 per patient referred with an MRI study. We found a total of \$11,474 was spent during a 2-year period, which amounts to a much more modest \$36 per patient referred with an MRI study despite the fact that we included repeat and unnecessary MRI studies in our cost analysis. The prior study used an estimated MRI cost of \$1467 [1]. The Medicare reimbursement for MRI has decreased substantially since then, and 2010 reimbursement rates for MRI studies in our study averaged \$574. Adjusting for this discrepancy, the Medicare cost of unnecessary imaging in the prior study would have amounted to \$196 per referred patient. Even after this adjustment, the costs of inappropriate imaging in our study are much lower, which indicates that MRI use in patients with musculoskeletal tumors is not as excessive as reported. Our study differed from that of Aboulafia et al. in that we have specific inclusion criteria which we believe decreases the subjectivity of the analysis, and we have a much lower use of MRI among our referral base. With lower overall use likely also comes lower costs associated with unnecessary or repeated imaging. Furthermore, if the trend of decreasing MRI reimbursement continues, it will further diminish the magnitude of monetary loss resulting from unnecessary or repeated studies among patients.

The overall cost of inappropriate prereferral MRI studies among our patients with musculoskeletal tumors was low, and the low use of MRI in our referral base likely contributed to these results. Our observations indicate excessive use of MRI is not universally widespread, as has been suggested. Orthopaedic surgeons reportedly account for 37% of prereferral office visits and 52% of the unnecessary prereferral imaging in patients with musculoskeletal tumors [1], and we believe our study is useful for orthopaedic surgeons who make those referrals. Furthermore, given the intense recent interest in overutilization of healthcare resources, we believe our study can help to educate orthopaedic surgeons regarding this important

issue in patients with musculoskeletal tumors. Overall, the judicious use of MRI by physicians in our referral base for bone and soft tissue tumors is defensible, and attempts to further curtail use beyond our modest recommendations are unlikely to result in substantial cost savings in patients with musculoskeletal tumors.

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