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# Magnetic resonance imaging for elbow pathology: overused by both orthopedic surgeons and primary care providers

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**Background:** Magnetic resonance imaging (MRI) use by both orthopedic surgeons and primary care providers (PCP) for analysis of elbow pathology is expensive and growing in frequency. In light of this, scrutiny regarding the appropriate utilization of this technology is increasing. Currently, there is no literature investigating the appropriateness of MRI use for complex elbow pathology from either orthopedic surgeons or PCPs.

**Methods:** A retrospective chart review was performed on consecutive elbow MRIs performed at a tertiary care center between January 1, 2012, and December 31, 2015. A total of 225 patients were included. Patients meeting the inclusion criteria were divided into two cohorts, determined by whether the ordering provider was an orthopedic surgeon or a PCP. MRI referrals were made by orthopedic surgeons in 94 patients and by nonorthopedic surgery providers in 131 patients. MRI diagnoses of no pathology, muscle/tendon tear, neuritis/nerve injury, tendinosis, ligament injury/instability, osteoarthritis/degenerative joint disease/decreased range of motion/contracture, or fracture/osteochondral injury were analyzed, as were the interventions of no intervention, nonprocedural treatment (therapy, orthosis, or nonoperative modality), nonsurgical procedure/referral for procedure, referral to surgeon, surgery, additional imaging/electrodiagnostic nerve testing, or other.

**Results:** 1. Orthopedic surgeons are more accurate in their diagnoses after MRI, while PCPs order more MRI scans for 'routine' diagnoses typically made without MRI. 2. When the MRI did not validate an orthopedic surgeon's preimaging diagnosis, rates of surgery decreased. The same discrepancy in diagnosis leads to an increase in orthopedic surgeon referrals within the PCP cohort. 3. An MRI was ordered for "pain" by orthopedic surgeons and PCPs in approximately 30% of the patients in both groups with a similarly low rate of pathology discovery.

**Conclusions:** The unexpected result of this study is that there is still a large quantity of MRI exams being conducted by orthopedic surgeons for the preMRI diagnosis of "pain." In both groups, there was a similar rate of negative imaging. We expected orthopedic surgeons who have advanced knowledge in musculoskeletal pathology would be less likely to order an MRI for pain and would also less likely order an MRI that resulted in no pathology. This places an increased and unnecessary burden on the financial aspect of the health care system.



The elbow is a complex hinge joint consisting of multiple bony articulations, ligamentous stabilizers, muscles, and a joint capsule. Pathology in the elbow can present a challenge for the physician to diagnose and manage, as patients with diverse pathologies may present with vague symptoms including pain, weakness, instability, stiffness, or numbness. Patients with elbow dysfunction may initially be evaluated by their primary care provider or may be referred to an orthopedic surgeon for specialist evaluation. While a thorough history and physical examination may often be diagnostic, additional studies may be necessary in some cases to further elucidate the etiology of elbow dysfunction.

Advanced imaging including ultrasound, computerized tomography (CT), and magnetic resonance imaging (MRI) can aid in diagnosis of elbow pathology when physical examination and plain radiographs are not definitive. Due to its ability to evaluate both soft tissue and bony injuries, MRI is frequently utilized. Ultrasound also has utility in identifying soft tissue injury, but it is limited in its scope to identify nondisplaced fractures or boney edema. MRI may

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detect osteochondral defects, ligament injuries, tendon ruptures, tendinosis, bursitis, occult fractures, nerve entrapment, and loose bodies that may not be evident using other imaging modalities.[5,15]

While MRI has excellent diagnostic utility, it is expensive compared to other imaging modalities.[16] In addition, utilization of MRI is increasing. Between 1996 and 2002 inpatient MRI usage more than doubled, resulting in an associated 151% increase in imaging costs.[3] With the cost of healthcare expected to reach 5.4 trillion USD per year by 2024, it is likely that the appropriate utilization of advanced imaging studies such as MRI will face greater scrutiny.[9] The aim of this study is to analyze differences in MRI utilization in the diagnosis of elbow symptomology between orthopedic surgeons and primary care providers (PCPs). Identification of differences between the two cohorts may help target areas of health care resource improvement. We predict that the accuracy of preMRI diagnosis, the treatment recommendations following MRI, and the rate of less specific indications for advanced imaging—such as "elbow pain," will differ between orthopedic surgeons and PCPs.

## Methods

After institutional review board approval at our institution, a retrospective chart review was performed on consecutive elbow MRIs performed at a tertiary care center between January 1, 2012, and December 31, 2015. The MRIs reviewed were cataloged in a database maintained by the radiology department at our institution utilizing billing information for the study. Inclusion criteria consisted of patients obtaining an imaging study coded as MRI of the elbow at our institution with a documented radiologist analysis of the study (n = 239). Patients were excluded if the MRI was obtained without any clinical documentation preMRI or postMRI (n = 10) or if the imaging study did not include the elbow joint in its entirety (n = 4). A total of 225 patients were included in the study. Patients meeting the inclusion criteria were divided into two cohorts, determined by whether the ordering provider was an orthopedic surgeon or a PCP.

Patient demographics obtained from the electronic medical record included age and gender. Clinical data included preMRI diagnosis/indication for the imaging study, postMRI diagnosis, and postMRI intervention. PreMRI diagnoses/indications were obtained from the indication for the study documented on the MRI order in the electronic medical record. These were categorized as no pathology, muscle/tendon tear, neuritis/nerve injury, tendinosis, ligament injury/instability, osteoarthritis (OA)/degenerative joint disease (DJD)/decreased range of motion (ROM)/contracture, fracture/osteochondral injury, or pain. PostMRI diagnoses were obtained from the MRI report submitted by board-certified radiologists. These were categorized as no pathology, muscle/tendon tear, neuritis/nerve injury, tendinosis, ligament injury/instability, OA/DJD/decreased ROM/contracture, or fracture/osteochondral injury. Interventions were obtained from the electronic medical record and were categorized as no intervention, nonprocedural treatment (therapy, orthosis, or nonoperative modality), nonsurgical procedure/referral for procedure, referral to surgeon, surgery, additional imaging/electrodiagnostic nerve testing, or other.

A chi-squared test was used to compare the distribution of data among the various preMRI and postMRI diagnoses between orthopedic surgeons and PCPs. Whether or not postMRI diagnosis was the same as preMRI diagnosis was also evaluated and compared between orthopedic surgeons and PCPs. When comparing preMRI and postMRI accuracy, the diagnosis of pain was excluded, as this represented a symptom as opposed to a diagnosis that could be confirmed using MRI. PostMRI intervention was also compared between orthopedic surgeons and PCPs. Findings were defined as statistically significant when *P*-value was < .05. No funding was utilized in this study. This study was conducted utilizing the STROBE checklist.[10]

## Results

### *Accuracy of preMRI and postMRI diagnoses*

A total of 225 patients were included in the study. MRI referrals were made by orthopedic surgeons in 94 patients and by nonorthopedic surgery providers in 131 patients. Male and female patients represented 66.2% (n = 149) and 33.8% (n = 76) of the study group, respectively. The mean age was 43.0 ± 16.8 years old (range, 11-84 years old). There were no differences in demographics between the two cohorts (Table I).

PreMRI, tendinosis was the primary diagnosis with greater frequency in patients referred by PCPs compared to patients referred by orthopedic surgeons (17.69% vs. 6.67% $P = .01$, 95% confidence interval [CI] = 0.024-0.196). No differences were noted between cohorts with respect to preMRI diagnoses of muscle/tendon tear, neuritis/nerve injury, ligament injury/instability, OA/DJD/decreased ROM/contracture, or fracture/osteochondral injury (Table II).

MRI findings were consistent with 1 diagnosis in 172 (76.4%) patients, 2 diagnoses in 41(18.2%) patients, and 3 diagnoses in 11 (4.9%) patients. One (0.4%) patient had an MRI consistent with 4 diagnoses. The incidence of normal MRIs was not statistically different between PCPs and orthopedic surgeons (18.3% vs. 12.8%, $P = .26$). Patients evaluated by orthopedic surgeons had a lower prevalence of tendinosis (13.9% vs. 27.4% $P < .01$, 95% CI = 0.035-.0234) and a higher prevalence of degenerative joint disease (18.3% vs. 7.7% $P = .02$, 95% CI = 0.017-0.194) based on MRI compared to patients evaluated by PCPs. PostMRI, there were no differences between the cohorts in the prevalence of no pathology, muscle/tendon tear, neuritis/nerve injury, ligament injury/instability, or fracture/osteochondral injury (Table III).

Overall, orthopedic surgeons were more accurate than PCPs in their preoperative diagnosis with an accuracy of 69% vs. 51% (Table IV). More specifically, confirmation of elbow instability and ligamentous injuries were confirmed in 6/8 cases by orthopedic surgeons compared to 2/9 cases by PCPs. In evaluation of degenerative joint disease or elbow contracture, MRI confirmed the preoperative diagnosis in 5/5 cases in the orthopedic surgeon group compared to 0/4 cases in the PCP group.

### *PostMRI evaluation treatments*

Following MRI, a higher rate of therapy referral (36.0% vs. 21.6 % $P = .02$) was noted in the group of patients evaluated by PCPs regardless of whether the diagnosis was confirmed. Of the patients originally evaluated by PCPs, 23.0% were referred to an orthopedic surgeon. Following the MRI, higher rates of surgery were noted in those patients evaluated by an orthopedic surgeon compared to a PCP (9.2% vs. 0.7% $P < .01$) (Table V).

Within the orthopedic surgeon cohort, surgical intervention decreased when an alternative postMRI diagnosis was made compared to when the preMRI diagnosis was confirmed (17.8% vs. 57.7% $P < .01$). Within the PCP cohort, surgeon referral decreased when an alternative postMRI diagnosis was made compared to when the preMRI diagnosis was confirmed (15.8% vs. 31.8% $P = .044$).

### *Utility of MRI for the indication of 'pain' only*

MRI was ordered for "pain" by orthopedic surgeons and PCPs in approximately 30% of the patients in both groups.

**Table I**
Patient demographics.

| Patient demographics | | | | |
|---|---|---|---|---|
| | Orthopedic surgeon patients | Nonorthopedic surgeon patients | Total | *P* value |
| Age (y) | 41.65 ± 16.57 | 43.92 ± 17.04 | 42.97 ± 16.84 | .32 |
| Male (n) | 64 (68.1%) | 85 (64.9%) | 149 (66.2%) | .62 |
| Female | 30 (31.9%) | 46 (35.1%) | 76 (33.8%) | .33 |

**Table II**
Differences in preMRI diagnosis.

| Differences in preMRI diagnosis | | | | |
|---|---|---|---|---|
| PreMRI diagnosis | Orthopedic surgeon group | Non orthopedic surgeon group | *P* value | 95% CI |
| Muscle/Tendon injury | 35/105 = 33.3% | 35/147 = 23.8% | .13 | |
| Neuritis/Nerve injury | 6/105 = 5.7% | 10/147 = 6.8% | .93 | |
| Tendinosis | 7/105 = 6.7% | 26/147 = 17.7% | .01 | 0.02-0.20 |
| Dislocation/Ligament injury/Instability | 8/105 = 7.6% | 9/147 = 6.1% | .84 | |
| OA/DJD/ROM/Contracture | 6/105 = 5.7% | 4/147 = 2.7% | .41 | |
| Fracture/OCD/Intraarticular body | 13/105 = 12.4% | 17/147 = 11.6% | 1.0 | |
| Pain/Other | 30/105 = 28.6% | 46/147 = 31.3% | .61 | |

*MRI*, magnetic resonance imaging; *CI*, confidence interval; *OA*, osteoarthritis; *DJD*, degenerative joint disease; *OCD*, osteochondral defect; *ROM*, range of motion.

**Table III**
Differences in postMRI diagnosis.

| Differences in MRI diagnosis (% of total MRI diagnosis) | | | | |
|---|---|---|---|---|
| MRI diagnosis | Orthopedic surgeon group | Nonorthopedic surgeon group | *P* value | 95% CI |
| No pathology | 12/115 = 10.4% | 24/168 = 14.3% | .43 | |
| Muscle/Tendon injury | 27/115 = 23.5% | 32/168 = 19.0% | .46 | |
| Neuritis/Nerve injury | 2/115 = 1.7% | 6/168 = 3.6% | .56 | |
| Tendinosis | 16/115 = 13.9% | 46/168 = 27.4% | <.01 | 0.04-0.23 |
| Dislocation/Ligament injury/Instability | 13/115 = 11.3% | 19/168 = 11.3% | 1 | |
| OA/DJD/ROM/Contracture | 21/115 = 18.3% | 13/168 = 7.7% | .02 | 0.02-0.19 |
| Fracture/OCD/Intraarticular body | 20/115 = 17.4% | 17/168 = 10.1% | .12 | |
| Other | 4/115 = 3.5% | 11/168 = 6.5% | .23 | |

*MRI*, magnetic resonance imaging; *CI*, confidence interval; *OA*, osteoarthritis; *DJD*, degenerative joint disease; *OCD*, osteochondral defect; *ROM*, range of motion.

When orthopedic surgeons ordered an MRI for the indication of pain alone, no pathology was found 20.6% of the time, with tendinosis in 29.4% of the cases and ligament injury 14.7% of the time. When PCPs ordered an MRI for the indication of pain alone, no pathology was found 19.2% of the time with tendinosis 38.5% of the time and ligament injury in 13.5% of the time (Table VI).

## Discussion

The findings of this study demonstrated differences in MRI utilization and management between orthopedic surgeons and PCPs when diagnosing elbow pathology. With advanced training in musculoskeletal care, one would expect that when orthopedic surgeons order imaging tests, their preMRI diagnoses would be more accurate overall than their nonorthopedic surgery counterparts. Similarly, it may be expected that orthopedic surgeons may order fewer imaging studies for diagnoses that are routinely identified through a physical exam and treated with nonoperative management, such as tendinosis. One may also expect that PCPs would refer more patients to physical therapy than orthopedic surgeons would after a confirmed MRI finding. As surgeons, advanced imaging modalities may not be ordered for a suspected nonoperative injury until a trial of physical therapy has been completed. This therapy may also have been initiated by the patient's PCP. Additionally, when confronted with an MRI with discordant findings to the preMRI diagnosis, it may be expected that PCPs would more readily refer the patient to a specialist for further assessment while orthopedic surgeons would choose to reevaluate the patient before proceeding with surgery. These findings have been reflected in similar analyses of MRI utilization on other limbs.[2,14,17]

The unexpected finding of this study, however, is that a similar percentage of patients were referred for MRI of the elbow for "pain" in the two groups at about 30%. Moreover, the incidence of negative MRIs with no pathology was similar in the two groups at approximately 20%. Approximately 56% of the time an orthopedic surgeon ordered an MRI for an indication of pain only, and 64% of the time a PCP ordered an MRI for the same indication, no pathology or a diagnosis of tendinosis was found. These results seem consistent with the findings of Hendee et al that 20%-50% of advanced imaging does not provide information that improves patient welfare.[7,8] As health care spending continues to increase, it is critical that appropriate indications for ordering advanced imaging is adhered to.[4] Pain can be attributed to a multitude of different pathologies, as evidenced by the findings in this study (Table V). Pain itself is a symptom, not a diagnosis, and further evaluation of the patient via a thorough history and physical examination should first be obtained. We expected orthopedic surgeons who have advanced knowledge in musculoskeletal pathology would be less likely to order an MRI for pain and would also less likely order an MRI that resulted in no pathology.

Previous studies have evaluated the use of advanced imaging in the primary care setting and found that 26% of studies ordered by primary care clinics did not meet appropriate criteria.[11]

**Table IV**
Accuracy of preMRI diagnosis.

| PreMRI diagnosis | Orthopedic surgeon group | Non orthopedic surgeon group | Chi-squared value | *P* value |
|---|---|---|---|---|
| Muscle/Tendon injury | 22/35 = 63.9% | 22/35 = 63.9% | 0 | 1.00 |
| Neuritis/Nerve injury | 1/6 = 16.7% | 1/10 = 10% | 0.15 | .70 |
| Tendinosis | 5/7 = 71.4% | 16/26 = 61.5% | 0.23 | .63 |
| Dislocation/Ligament injury/Instability | 6/8 = 75.0% | 2/9 = 22.2% | 4.74 | .03 |
| OA/DJD/Decreased ROM/Contracture | 5/5 = 100.0% | 0/4 = 0.0% | 8.0 | <.01 |
| Fracture/OCD/Intraarticular body | 12/13 = 92.3% | 11/17 = 64.7% | 3.14 | .08 |
| Total | 51/74 = 69% | 52/101 = 51% | 5.36 | .02 |

*MRI*, magnetic resonance imaging; *OA*, osteoarthritis; *DJD*, degenerative joint disease; *OCD*, osteochondral defect; *ROM*, range of motion.

**Table V**
Differences in postMRI intervention.

| Differences in postMRI intervention (% of total postMRI intervention) | | | | |
|---|---|---|---|---|
| | Orthopedic surgeon group | Nonorthopedic surgeon group | *P* value | 95% CI |
| No intervention | 28/97 = 28.9% | 33/139 = 23.7% | .47 | |
| Nonprocedural intervention (ie. therapy) | 21/97 = 21.6% | 50/139 = 36.0% | .02 | 0.02-0.27 |
| Procedural intervention | 6/97 = 6.2% | 13/139 = 9.4% | .51 | |
| Surgeon referral | 2/97 = 2.1% | 32/139 = 23.0% | <.01 | 0.13-0.29 |
| Surgery | 38/97 = 39.2% | 1/139 = 0.7% | <.01 | 0.28-0.49 |
| Imaging/Nerve testing | 2/97 = 2.1% | 9/139 = 6.5%% | .16 | |
| Other | 0/97 = 0% | 1/139 = 0.7% | 1.0 | |

*MRI*, magnetic resonance imaging; *CI*, confidence interval.

Lehnert and Bree evaluated the appropriateness of advanced imaging studies ordered by primary care clinics and found that when appropriate criteria for obtaining the imaging study were met, there was a higher incidence of positive findings when compared with the images that were obtained with inadequate clinical suspicion (58% vs. 24%).[11] In our study, approximately 1/3 of patients in both groups were referred for MRIs with a diagnosis of "pain," which is not an appropriate indication for advanced imaging. For patients with nonspecific preMRI diagnosis of "pain," 20% of patients in both groups had negative MRIs with no pathology.

Considering these findings, if neither history nor physical exam reveals a clear diagnosis, providers could consider pursuing additional nonoperative modalities for the treatment of the most encountered pathologies before ordering advanced imaging if the only indication is pain.[1,6,12,13] Resources that have not been utilized extensively in the past, such as the American College of Radiology's Appropriateness Criteria, have been developed and are available for clinical practitioners' use.[17] When faced with a clinical situation in which the PCP or orthopedic surgeon is not sure if any further imaging is warranted, having reference guides such as these reduce the unnecessary utilization of advanced imaging.

Our retrospective study evaluating the utilization of MRI among orthopedic surgeon and PCPs has limitations. One potential criticism of the study is that we utilized the indication from the MRI order within the electronic medical record to stratify patients into preMRI diagnosis groups. Indications for MRI were identified using an ICD code, which can encompass multiple diagnoses. Therefore, we sometimes grouped multiple pathologies under one diagnosis category based on their clinical similarity. Moreover, there may have been a more clear indication for the MRI referral in the clinical evaluation that was not entered in the initial MRI order but was documented in the actual clinical note and evaluation. Also, the postMRI diagnosis was based off of the report of the board-certified radiology team. This was necessary since this study is retrospective and encompasses multiple patients from both orthopedic surgeons and PCPs. However, this can introduce the possibility of misdiagnosis, as radiology interpretations can sometimes be discordant with clinical evaluation.

In addition, the postMRI intervention comparison is biased by the fact that surgeons were compared to a nonsurgeon group. It would be expected that the decision to proceed with surgery would be much higher in the surgeon group compared to the PCP group. We compared PCP's referral of a patient to a surgeon as a surrogate for their decision to perform surgery; however, these decisions are not equivalent, as PCPs may have referred patients to orthopedic surgeons due to orthopedists' greater familiarity with the nonoperative management of specific musculoskeletal complaints.

To our knowledge, no previous investigation has explored the differences in the utilization of MRI in the diagnosis and treatment of elbow pathology. Another strength of the present study is the inclusion of a large number of patients (225) and radiographic exams that were obtained by 90 different surgical and nonsurgical providers. The large number of exams and diverse group of practicing physicians provides a level of generalizability to the present study. This study clearly demonstrated that differences exist regarding indications for obtaining MRIs, the findings on MRI, the accuracy of preMRI diagnoses and the treatment after obtaining MRIs between the two cohorts. But more importantly, this study also highlights why it is important, both clinically and financially, to have a proper indication for obtaining advanced imaging. With continued escalating healthcare expenditures, there will be increased scrutiny on appropriate indications for advanced imaging and use of healthcare resources. This study sets an important foundation for future research on this subject.

## Conclusion

The findings in our study highlight that despite higher levels of training in recognition and treatment of musculoskeletal pathologies, orthopedic surgeons still often order advanced imaging studies without clear indications. When the only indication for ordering advanced imaging was "pain," the resulting studies were usually not diagnostic and provided little to no information to assist

**Table VI**
MRI diagnosis when indicaiton was "pain."

| Differences in MRI diagnosis (% of total MRI diagnosis) | | | |
|---|---|---|---|
| MRI diagnosis | Orthopedic surgeon group | Non orthopedic surgeon group | *P* value |
| No pathology | 7/34 = 20.6% | 10/52 = 19.2% | .69 |
| Muscle/Tendon injury | 3/34 = 8.8% | 6/52 = 11.5% | .34 |
| Neuritis/Nerve injury | 0/34 = 0.0% | 1/52 = 1.9% | .16 |
| Tendinosis | 10/34 = 29.4% | 20/52 = 38.5% | .19 |
| Dislocation/Ligament injury/Instability | 5/34 = 14.7% | 7/52 = 13.5% | .44 |
| OA/DJD/ROM/Contracture | 4/34 = 11.8% | 6/52 = 11.5% | .49 |
| Fracture/OCD/Intraarticular body | 5/34 = 14.7% | 2/52 = 3.9% | .06 |

*MRI*, magnetic resonance imaging; *OA*, osteoarthritis; *DJD*, degenerative joint disease; *ROM*, range of motion; *OCD*, osteochondral defect.

in clinical decision-making. These unnecessary and expensive tests place an undue financial burden on the medical system and further delay patient care.

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