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Use of Shoulder Imaging in the Outpatient Setting: A Pilot Study

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Purpose: Characterize the clinical utility of diagnostic shoulder imaging modalities commonly used in the outpatient workup of shoulder pain.
Materials/Methods: Retrospective review of adults imaged for outpatient shoulder pain from 1/1/2013 to 9/1/2015. To be categorized as "useful", a study had to meet one of the following criteria: change the clinical diagnosis or treatment plan, provide a final diagnosis, or guide definitive treatment. A utility score was assigned to each study based on the number of utility criteria met (range 0-4). A score of 1 was considered low utility; a score of greater than or equal to 2 was considered high utility. Statistical analysis included binary logistic regression and generalized estimating equations.
Results: 210 subjects (65% male); mean age 47 (range 18-84), underwent 302 imaging studies (159 X-ray, 137 MRI, 2 CT, 4 ultrasound) during the study period. 92.1% of all studies met minimum criteria for utility (score >1). Most commonly, diagnostic studies obtained during the outpatient workup of shoulder pain were found to guide definitive treatment (70.5%) or provide a final diagnosis (53%). Most X-rays were categorized as no or low utility (85.5%). 97.8% of the MRI studies were categorized as useful with most being high utility (73%). Overall, MRI was the most useful modality in all clinical scenarios ($P = 0.002$) and more likely to be high utility ($P < 0.001$) compared to X-rays. None of the investigated patient or injury characteristics were significant predictors of useful imaging.
Conclusion: Our study suggests that both radiographs and MRI are useful in the evaluation of adult unilateral shoulder pain in the outpatient setting. MRI appears to be the most useful imaging modality in terms of helping guide diagnosis and treatment selection. This serves as a potential first step towards the development of evidence based imaging algorithms that can be used and tested in future studies.

Introduction

Inappropriate imaging, defined as imaging that is performed in circumstances in which it is unlikely to improve patient outcomes, is an increasingly important problem in health care that exposes patients to serious quality and safety risks.[1] These risks include radiation exposure, reactions to intravenous contrast, increased patient stress and anxiety, and the potential for mismanagement or harm associated with false negative and false positive results.[2-7] Up to 30% of imaging studies performed in the United States have been estimated to be inappropriate.[1,8–10] As 75% of imaging takes place in the ambulatory setting, focusing on reducing inappropriate outpatient imaging would have a great effect for improving quality and safety of imaging.[11]

Shoulder imaging is one of the most common types of musculoskeletal imaging performed in the outpatient setting. The vast majority of studies on shoulder imaging have focused on test performance and diagnostic accuracy. Similar to other types of diagnostic imaging, only a small percentage of studies have examined the direct effect of shoulder imaging on diagnosis and treatment selection.[12–16] These prior studies did not include a simultaneous evaluation of the primary imaging modalities for shoulder pain, and have presented conflicting results for the proper use of these imaging modalities. When considered as a whole, these studies present an incomplete assessment of the usefulness of shoulder imaging in the outpatient setting.

The primary objective of this study was to examine and characterize the clinical utility (ie, usefulness) of the common shoulder imaging modalities for the evaluation of patients with primary shoulder complaints in the outpatient setting in terms of influencing treatment selection and diagnostic decision making. The secondary objective was to see if there were patient or injury related characteristics that could be used to guide the selection of useful shoulder imaging.

Materials and Methods

This study was approved by our institutional review board, informed consent was waived.

Sample Population

A retrospective review of patients who presented to one of three settings at our medical center (1) outpatient orthopaedic clinic, (2) emergency room, and (3) outpatient internal medicine offices from

This retrospective study was approved by our institutional review board, which granted a waiver of written informed consent.

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January 1, 2013 through September 1, 2015 with a chief complaint of unilateral shoulder pain was performed. Eligible subjects were identified through ICD-9 and CPT codes. Inclusion criteria consisted of adult patients, chief complaint of shoulder pain, had no known or established shoulder related diagnosis at the time of their initial encounter, had shoulder imaging (computed tomography [CT], magnetic resonance imaging [MRI], radiographs, or ultrasound) performed, and had clinical notes related to their visits in the electronic medical records. Our exclusion criteria consisted of patients who presented with an established diagnosis or etiology for their shoulder pain, other significant nonshoulder related complaints at that visit, bilateral shoulder pain, prior shoulder surgery, imaging performed at an outside institution, or did not have relevant or accessible electronic medical records.

Patient Characteristics

The following information was collected for each clinical visit: age, gender, history of trauma, chronicity of symptoms, sports-related injury, clinically suspected diagnosis, outpatient setting (orthopedics, emergency department, or internal medicine), type of imaging study ordered, imaging findings, and treatment selected. The chronicity of symptoms was categorized as acute, within 1 month; subacute, <1–6 months; and chronic, >6 months. The imaging modalities evaluated were radiographs, MRI, CT, and ultrasound. Treatments were organized into 1 of 3 categories: (1) conservative—defined as a treatment plan including one or more of the following rest, physical therapy, and anti-inflammatory medication; (2) procedural—defined as blind or image guided therapeutic joint injection; and (3) surgical—defined as open or arthroscopic surgery.

Outcome Variables

The primary outcome variable for this study was the "usefulness" of the imaging modality selected. A useful imaging examination was defined as a study that satisfied at least one of the following 4 criteria: changed the clinical diagnosis, guided a change in treatment selection, provided a final diagnosis, or guided definitive treatment. Our definition of "usefulness" was based on a prior hierarchical model of imaging efficacy proposed by Fryback and Thornbury[16] (Fig 1). A utility score was assigned to each study based on the number of criteria satisfied (range: 0-4) with a score of 0 defined as no utility, 1 low utility, and >2 high utility (Fig. 2-4). The cost of the imaging examination was not considered during this analysis.

For patients receiving multiple sequential imaging studies during their workup for shoulder pain, each diagnostic study was included and scored separately. Change in diagnosis and treatment selection was assessed by comparison to the information found in prior, relevant clinical notes. If there was a case where it was difficult to assess the utility of the imaging examination, a member of the research team contacted the ordering physician to better understand the role the imaging study had in the selection of treatment. If the utility remained in question at that point, then the intent to treat principal dictated that these cases be included as nonuseful: lack of sufficient evidence of utility implies nonutility.

Hierarchical levels	Efficacy	Description
Level 1	Technical	Image acquisition and quality
Level 2	Diagnostic outcome	Imaging diagnostic performance and yield
Level 3	Diagnostic thinking	Effects on clinical and diagnostic thinking
Level 4	Therapeutic	Effects on therapeutic selection
Level 5	Patient outcome	Effects on patient outcomes
Level 6	Societal	Effects on society

FIG 1. Adapted with permission from Fryback's hierarchical model of diagnostic efficacy. Imaging utility assessment used in this study was developed to capture diagnostic efficacy levels 3 and 4.

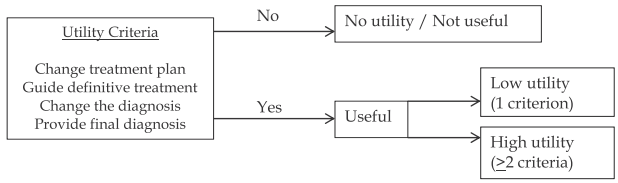


FIG 2. Flow diagram of imaging utility assessment.

Predictor Variables

The following patient related characteristics were examined to see if they could be used to predict the usefulness of an imaging study: age, gender, history of trauma, symptom chronicity, and injury setting (sports vs nonsports).

Statistical Analysis

Statistical analysis performed by a trained biostatistician included summary statistics of mean, range, and standard deviation. Binary logistic regression and generalized estimating equations based on binary logistic regression were used to model the predictor variables' association with utility. All statistical tests were conducted at the two-sided 5% significance level using SAS 9.3 software (SAS Institute, Cary, NC).

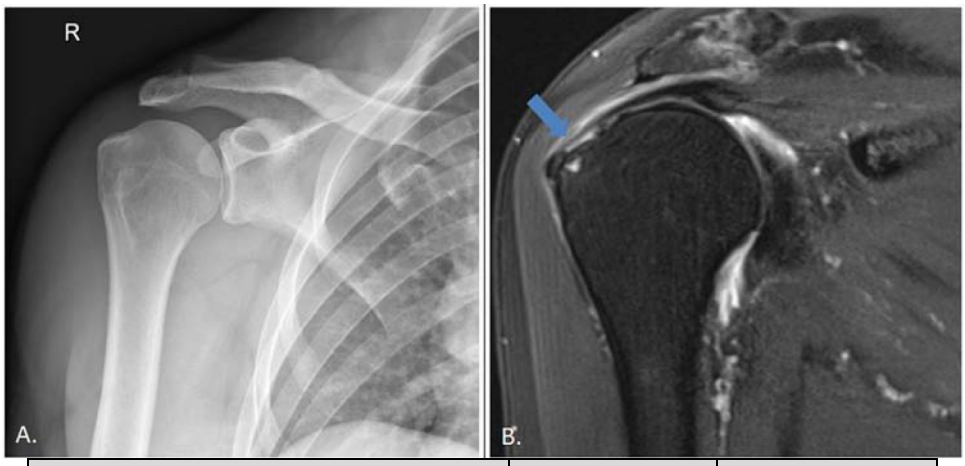
Results

Based on ICD-9 codes, CPT codes, and dates of service; 1702 eligible medical records were identified. Of these, 451 records were randomly selected and reviewed for inclusion. In total, 241 subjects were excluded, most common reasons for exclusion were presence of an established diagnosis or etiology for shoulder pain or the absence of imaging within our system.

This resulted in a total of 210 patients, 73 female and 137 male; (mean age = 47 year and range: 18-84) who were included in the study. In all, 144 (69%) of the patients were seen in the orthopaedic clinic, 65 (30%) patients were seen in the emergency room, and 1 patient (<1%) was seen in an outpatient internal medicine office. Our patient sample underwent a total of 302 imaging studies, including 159 radiographs, 137 MRIs (6 MR arthrograms), 2 CT, and 4 ultrasound, as part of their initial workup. 41% (86/209) of patients underwent more than 1 imaging examination during the study period, most commonly, radiographs followed by MRI. Patient demographics and injury characteristic are listed in Table 1.

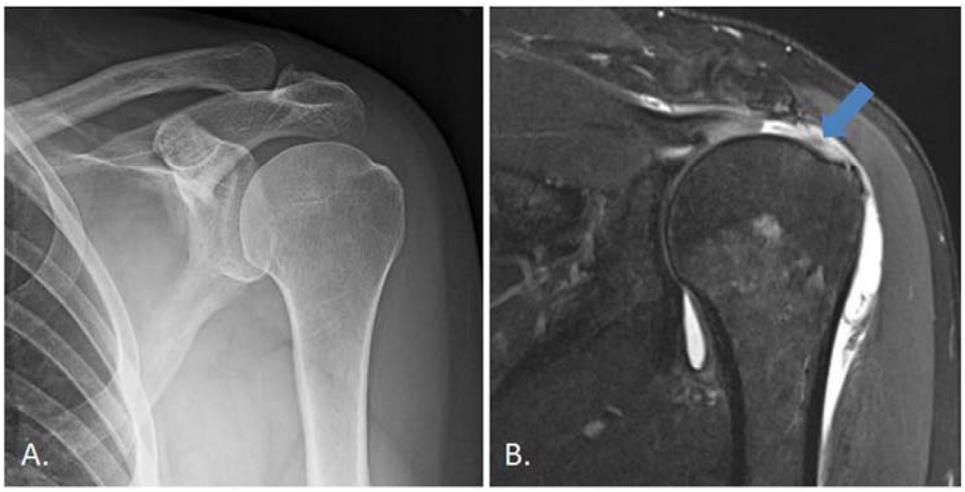
In total, 77% (234/302) of the studies were ordered in the outpatient orthopaedic clinic, 22% (67/302) were ordered in the emergency room setting, and 1 study (radiographs) was ordered in an outpatient internal medicine office. In all, 31% of the imaging studies were ordered with a clinical history of sports-related shoulder pain, whereas 47% of the imaging studies were ordered with a history of trauma related shoulder pain. The most common imaging indications for shoulder imaging were rotator cuff pathology (55%) and shoulder instability (15%) (Table 2).

Overall, 92.1% of the imaging studies met the minimum criteria for utility (utility score greater than or equal to 1), most commonly studies met utility criteria by guiding the selection of a definitive treatment, 70.5% (213/302); 53% (160/302) of the studies helped provide a final diagnosis, 21.5% (65/302) of the imaging changed diagnosis, and



Utility score (Example 1)	X-ray	MRI
Changed the diagnosis	0	0
Changed the treatment plan	0	0
Guided definitive treatment	1	0
Provided the final diagnosis	0	1

FIG 3. A 64-year-old man with chronic right shoulder pain. (A) Following clinical evaluation and radiographs showing mild acromioclavicular joint osteoarthritis, the clinical impression was rotator cuff strain or tear and conservative treatment plus MRI was recommended. (B) MRI showed a high grade partial thickness articular surface tear of the supraspinatus tendon (blue arrow). Conservative treatment was continued. In this scenario, both imaging modalities are useful. The X-ray achieves a utility score of 1 (low utility) for guiding definitive treatment and the MRI achieves a utility score of 1 (low utility) for providing the final diagnosis. (Color version of the figure available online.)



Utility score (Example 2)	X-ray	MRI
Changed the diagnosis	0	1
Changed the treatment plan	0	1
Guided definitive treatment	0	1
Provided the final diagnosis	0	1

FIG 4. A 55-year-old man with acute shoulder pain after a fall. (A) Following clinical evaluation and a negative radiograph, the clinical impression was rotator cuff tendinosis and conservative treatment plus MRI was recommended. (B) MRI showed a full thickness tear of the supraspinatus tendon (blue arrow). Surgery was recommended. In this scenario, only the MRI is useful. The X-ray achieves a utility score of 0 (no utility) and the MRI achieves a utility score of 4 (high utility). (Color version of the figure available online.)

TABLE 1
Demographics and injury characteristics of patients presenting for workup of shoulder pain in the outpatient setting.

	302 studies and 210 subjects
Age, mean (range)	47 (18-84)
Male	137/210 (65%)
Trauma	142/302 (47%)
Sports-related injury	93/302 (31%)
Chronicity	
Acute	141/302 (47%)
Subacute	76/302 (25%)
Chronic	79/302 (26%)
Subspecialty orthopedics	230/302 (77%)

TABLE 3
Characterization of clinical utility for all imaging studies performed for the evaluation of shoulder pain in the ambulatory setting.

Utility	All
Useful (utility score $\geq$ 1)	92.1% (278/302)
Not useful (utility score = 0)	9.3% (28/302)
Changed the diagnosis	21.5% (65/302)
Changed the treatment plan	21.1% (64/302)
Guided definitive treatment	70.5% (213/302)
Provided the final diagnosis	53.0% (160/302)

21.1% (64/302) of the studies changed treatment. These data are summarized in Table 3.

Overall, 84% (34/159) of radiographs met the minimum criteria for utility. Most radiographs were classified as low utility, 69.8% (111/159) whereas 14.5% (23/159) were defined as high utility, and 15.7% (25/159) of radiographs did not meet criteria for utility. Radiographs met utility criteria most commonly by helping to define the definitive treatment for patients (70.5%), followed by providing a final diagnosis (17%).

A total of 97.8% (134/137) of MRIs met the criteria for utility. Most MRI studies were classified as high utility, 73% (100/137), whereas 24.8% (34/137) were defined as low utility, and 2.2% (3/137) were defined as having no utility. MRI most commonly helped provide a final diagnosis, 92.7% (127/137), followed by helping define definitive treatment, 57.7% (79/137). Overall, MRI was significantly more useful than radiographs in all clinical scenarios ($P = 0.002$). A higher proportion of MRIs met minimum criteria for utility as compared to radiographs in the subacute and chronic settings ($P = 0.028$ and $P = 0.008$, respectively). In the acute setting, there was no statistically significant difference in the proportions of MRI and radiographs meeting minimum utility criteria ($P = 0.337$).

None of the investigated patient or injury characteristics including age, gender, chronicity, history of sports-related injury, or history of trauma emerged as statistically significant independent predictors of useful imaging. The association between chronicity of shoulder symptoms and MRI trended toward statistical significance ($P = 0.090$).

CT and ultrasound utility was not analyzed individually due to their limited use during this timeframe.

Discussion

The primary objective of our study was to examine and characterize the clinical usefulness of the common shoulder imaging modalities for the evaluation of primary shoulder complaints in the outpatient setting and to determine patient characteristic associated with useful examinations with the ultimate goal of serving as the first step toward the development of evidence-based imaging algorithms that can be used and tested in future studies. The clinical usefulness (or utility) of the imaging study obtained was assessed in terms of diagnostic thinking efficacy and therapeutic efficacy by observing the influence of study acquisition in establishing a clinical diagnosis and guiding treatment selection.

TABLE 2
Indications for shoulder imaging.

Indication/suspected diagnosis	Proportion, %
Rotator cuff	55
Instability	15
Labrum	12
Not specified	8
Acromioclavicular joint	5
Proximal biceps tendon	2
Fracture	1
Adhesive capsulitis	1

The information gained in this preliminary investigation is useful for the design and implementation of a prospective study. A utility score was developed that captures the usefulness of a diagnostic examination and applying this utility score across multiple modalities is feasible. The value of incorporating real time clinician input into this utility score was highlighted by this retrospective study design and will be pursued. The frequency of high utility examinations in our population, now known from these data, will serve to inform sample size calculations for future studies. Additionally, high utility examinations were not found to be significantly associated with any of the investigated patient characteristics which is an important consideration moving forward.

Although 92.1% of all the imaging studies met the minimum criteria for utility, MRI was much more likely to be considered a highly useful imaging examination in all clinical scenarios because of its consistently positive influence on both diagnosis and treatment selection.

We found 84% of radiographs to meet the minimal requirements for utility, typically helping guide treatment, whereas only 14.5% met criteria for high utility. In our analysis, the majority of radiographs were obtained and interpreted in conjunction with clinical assessment and physical examination. Our results are similar to a prior study of shoulder radiographs ordered in the emergency department for patients presenting with shoulder pain. In this study, 20% of the ordered radiographs were found to guide treatment.[12] This percentage of useful radiographs is similar to the 14.5% high utility rate of radiographs in our study.

We found MRI to be useful in 97.8% of cases with 73% of the imaging studies characterized as highly useful given their contribution to diagnosis and treatment selection. Our findings are similar to those from a prospective study by Sher et al[13] regarding the use of shoulder MRI in the outpatient setting. These authors found MRI to be useful in terms of making a diagnosis or treatment selection for common shoulder ailments such as labral tears, shoulder instability, and biceps tendon disease. On the other hand, a retrospective study of patients presenting with chronic, atraumatic shoulder pain by Bradley et al[14] found that the majority of shoulder MRI examinations had no significant effect on treatment selection or patient outcomes.

The main difference between our results and those by Bradley was likely related to the different definitions of utility. We considered diagnosis in addition to treatment when assessing MRI utility as opposed to this prior study which only included patient outcomes and treatment.

We were unable to study the utility of CT and ultrasound because of the low utilization of these modalities in our sample population, a limitation of our study.

The secondary objective was to determine if patient related factors could be used to guide the selection of useful shoulder imaging. We were unable to find any factors that could predict the usefulness of an imaging study for shoulder pain in the outpatient setting. We plan on further investigating this in future studies.

Our definition of utility and the corresponding utility score consisted of 4 clinical criteria based on how the imaging affected the diagnosis and treatment selected for our sample population. This scoring system was adapted from a hierarchical model of imaging efficacy used to assess the contribution of diagnostic imaging to the patient management process.[15] The model consists of 6 levels: level 1—measuring the technical quality of the imaging, level 2—assessing the diagnostic accuracy of the imaging interpretations, level—3 focusing on the effect that the imaging has on the referring physician's diagnostic thinking, level 4—examining the imaging's effect on the patient management plan, level 5—measuring the effect imaging has on overall patient outcomes, and level 6—analyzing the societal costs and benefits of diagnostic imaging.

For the purposes of this study, we focused on levels 3 and 4 as the technical quality (level 1) and diagnostic accuracy (level 2) for the common shoulder imaging modalities are well established and not in need of further validation. Given the persistent growing focus on inappropriate imaging and in its deleterious impact on health care, we believe that more studies are needed to examine the use of imaging in terms of the remainder of these levels (3–6) to determine imaging's true value and contributions to patient care. This can be difficult as imaging, in most cases, does not have a direct impact on measurable patient outcomes, as would a medication or surgical intervention. Imaging's contribution needs to be evaluated alongside other factors such as the referring physician's clinical judgment. For this initial study, we attempted to measure imaging's effect in this way through a review of medical charts and questions for the clinician if they arose when assessing the ordered imaging's usefulness. We understand that this may not be the most effective technique given the bias and questions of validity that are associated with this type of retrospective review, including selection bias, content validity, and predictive validity. We plan on continuing our analysis with a future prospective study that will measure the utility of shoulder imaging as it is being considered and ordered by the referring clinician.

There were several limitations for our study. First, the data were collected retrospectively which limited our ability to control the quality of the medical records that we were reviewing. Although most records were organized in a manner that allowed us to understand the decisions made for the patients for diagnosis and treatment selection and the effect of imaging on these decisions, there were certain cases that were more difficult to discern, due to lack of clinical information. Additionally, the retrospective nature also did not allow us to account for other information that could affect the clinician's decisions that would not be documented in the medical records, such as prior experiences and patient requests.

We attempted to control for selection bias and confounding factors such as physician treatment preference and patient expectations by including three different clinical settings with different medical personal at each location. Finally, the inability to more extensively evaluate the utility of ultrasound and CT in the outpatient setting is a limitation. For ultrasound, the low numbers are the result of timing as our sample population was selected during a period that ultrasound was being first introduced at our institution as a viable imaging option for patients with shoulder pain. For CT, it is likely related to its more specialized, and thus less frequent, use in scenarios such as shoulder instability patients with significant bone injuries. We are confident that our futures studies will include a greater proportion of ultrasound and CT examinations to determine their utility.

Conclusion

Our study suggests that both radiographs and MRI are useful in the evaluation of adult unilateral shoulder pain in the outpatient setting. MRI appears to be the most useful imaging modality for helping guide diagnosis and treatment selection. This serves as a potential first step towards the development of evidence-based imaging algorithms that can be used and tested in future studies.

References

1. Hendee WR, Becker GJ, Borgstede JP, et al. Addressing overutilization in medical imaging. Radiology 2010;257(1):240–5.
2. Salazar G, Quencer K, Aran S, et al. Patient satisfaction in radiology: Qualitative analysis of written complaints generated over a 10-year period in an academic medical center. J Am Coll Radiol 2013;10(7):513–7.
3. Brenner DJ, Hall EJ. Computed tomography—An increasing source of radiation exposure. N Engl J Med 2007;357(22):2277–84.
4. ACR Committee on Drugs and Contrast Media. ACR Manual on Contrast Media, Version 9, 2013.
5. Mold JW, Stein HF. The cascade effect in the clinical care of patients. N Engl J Med 1986;314(8):512–4.
6. Mortele KJ, Oliva MR, Ondategui S, et al. Universal use of nonionic iodinated contrast medium for CT: evaluation of safety in a large urban teaching hospital. AJR Am J Roentgenol 2005;184(1):31–4.
7. Cochran ST, Bomyea K, Sayre JW. Trends in adverse events after IV administration of contrast media. AJR Am J Roentgenol 2001;176(6):1385–8.
8. Gottlieb RH. Imaging for whom: patient or physician? AJR Am J Roentgenol 2005;185(6):1399–403.
9. Cascade PN, Webster EW, Kazerooni EA. Ineffective use of radiology: The hidden cost. AJR Am J Roentgenol 1998;170(3):561–4.
10. Brown RF, Shaver JW, Lamel DA: The Selection of Patients for X-Ray Examinations. Bureau of Radiological Health, US Food and Drug Administration Publication, 1980;8:80-8104.
11. United States Government Accountability Office. Medicare Part B Imaging Services. Rapid Spending Growth and Shift to Physician Offices Indicate Need for CMS to Consider Additional Management Practices Report to Congressional Requestors, 2008, Available at: http://www.gao.gov/products/GAO-08-452. Accessed April 10, 2015.
12. Fraenkel L, Lavalley M, Felson D. The use of radiographs to evaluate shoulder pain in the ED. Am J Emerg Med 1998;16:560–3.
13. Sher JS, Iannotti JP, Williams G, et al. The effect of shoulder magnetic resonance imaging on clinical decision making. J Shoulder Elbow Surg 1998;7:205–9.
14. Bradley MP, Tunng G, Green A. Overutilization of shoulder magnetic resonance imaging as a diagnostic screening tool in patients with chronic shoulder pain. J Shoulder Elbow Surg 2005;14:233–7.
15. Fryback DG, Thornbury JR. The efficacy of diagnostic imaging. Med Decis Making 1991;11:88–94.
16. Otero HJ, Fang CH, Sekar M, et al. Accuracy, risk, and the intrinsic value of diagnostic imaging: a review of the cost-utility literature. Acad Radiol 2012;19:599–606.