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Speeding Diagnosis and Saving Money Using Point of Care Ultrasound Rather Than MRI for Work-related MSK Injuries

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Speeding Diagnosis and Saving Money Using Point of Care Ultrasound Rather Than MRI for Work-related MSK Injuries

by

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Abstract

This descriptive retrospective cohort study utilized a large workers comp insurer database. All MRI's performed on peripheral joints during calendar year 2017 that were (a) 2 weeks after the initial clinic visit, or (b) greater than 6 weeks after injury, but (c) not more than 3 months after the date of injury were evaluated in this study. Individual diagnoses rendered on MRI reports for these cases were categorized as to whether ultrasound alone or ultrasound + xray could adequately provide the same diagnoses. Results showed that, ultrasound + xray would be able to provide all of the same diagnoses compared to MRI in 54% of cases vs 33% of cases using ultrasound alone, highlighting the utility of using ultrasound and xray together. The proportion of cases where ultrasound + xray could reasonably be substituted for MRI increases to 70% overall when less severe diagnoses, considered not likely to change management, were excluded from analysis. If point of care ultrasound was performed for all 1482 cases with subsequent MRIs pursued in only 30% of cases, a cost savings between $456,186 and $331,698 would be realized, translating to $308 to $224 per patient. Additionally, if ultrasound + xray was performed at the point of care during the first clinic visit for an injury, the definitive diagnoses could be reached on average 33.3 days earlier. In total, these results suggest a significant proportion of musculoskeletal workers comp injuries could be accurately and completely evaluated at the point of care using ultrasound and xray together. This could yield greater provider and patient confidence in the diagnosis and treatment plan as well as more expeditious accurate diagnoses leading to reductions in both direct and indirect costs.

Chapter 1: Introduction

Ultrasound imaging has become routine in multiple specialties outside of Radiology including Cardiology, OB, and Emergency Medicine. In the Orthopedic/Sports Medicine realm ultrasound seems to be particularly useful with a recent paper showing 96% agreement between the findings of ultrasound followed by MRI in evaluating extra-articular structures and pathology.[1] In addition to this, a plethora of musculoskeletal literature over the years describes the ability of ultrasound to evaluate structures and diagnose many pathologies in the extremities with similar accuracy compared to MRI but it has an advantage over MRI in that it can be done at the point of care.[2] In the interest of brevity, only pathology of the shoulder will be discussed in detail, though, similar evidence is available in the literature highlighting the utility of ultrasound in diagnosing pathology in all peripheral joints of the body.

The greatest abundance of literature evaluating the utility of diagnostic ultrasound describes shoulder pathology, where systematic reviews have shown equivalent or increased accuracy compared to MRI in diagnosing full thickness and partial thickness rotator cuff tears.[3,4] High accuracy in ultrasound diagnosis has also been shown for other common shoulder pathologies including joint effusion, calcific tendinosis, tendinopathy, biceps tendon tears and dislocations as well as moderate to high accuracy in diagnosing subacromial/subdeltoid bursitis and impingement which are exceedingly common.[4,5] Ultrasound attained moderate accuracy in diagnosis of rotator cuff muscle atrophy compared to MRI.[6,7]

A myriad of other shoulder related pathologies, such as pectoralis tears[8,9], nerve compression by vascular structures[10], posterior labral tears or degeneration[11], gout[12], ganglion cysts[13], and adhesive capsulitis[14,15] can be identified. Though these last few topics are currently underrepresented in the literature, making definite claims regarding accuracy premature at this point, it becomes clear that musculoskeletal ultrasound at the point of care has the ability to provide high quality diagnostic imaging, and is able to do so expeditiously, at a low cost.

Ultrasound is also dynamic, meaning joints, muscles, and tendons can be seen moving, whereas MRI is static. There is great value in being able to elicit and visualize subluxation, adhesion, friction, and impingement while they are happening rather than relying on the presence of secondary indicators of these pathologies on static images, if there even are any. Ultrasound has better resolution of musculoskeletal structures outside of joints as well as nerves and blood vessels where color doppler and compression can be utilized to analyze blood flow in real time. The exact location of pain can be quickly examined and often reproduced using compression with the ultrasound transducer, and if the examiner is unsure of possible pathology the patients unaffected arm or leg is available for comparison immediately. Patients also prefer ultrasound examination to MRI. Furthermore, when imaging foreign bodies or tissue near metal implants, MRI images become distorted, obscuring the adjacent tissue, whereas ultrasound continues to provide high quality imaging.[16,17,18,19,20]

The high utility of ultrasound in evaluating musculoskeletal structures and ability to perform these imaging exams at the point of care provides an opportunity to make ultrasound a routine part of work-related musculoskeletal injury evaluation in the Occupational Medicine clinic in order to achieve more cost-effective and expeditious diagnosis and treatment, helping to appropriately return workers to full-duty sooner. This is especially pertinent considering in a 2014 report:

> "OSHA estimates that work-related musculoskeletal disorders in the United States account for over 600,000 injuries and illnesses (34 percent of all lost workdays reported to the Bureau of Labor Statistics (BLS). These disorders now account for one out of every three dollars spent on workers' compensation. It is estimated that employers spend as much as $20 billion a year on direct costs for MSD-related workers' compensation, and up to five times that much for indirect costs, such as those associated with hiring and training replacement workers."[21]

The above quote refers to an estimation of both reported and non-reported occupational musculoskeletal disorders. In 2017, Bureau of Labor Statistics injury reporting data showed a total of 349,050 occupational musculoskeletal injuries in the US, broken down as follows: shoulder 14.9%, leg 11.5%, arm 5.1%, multiple parts 5.4%, other 19.7%. Back and abdomen comprise the remaining share of

injuries.[22] Further data from 2017 breaks down the rates of injuries by diagnosis and their associated median days away from work. See Table 1 below taken from this report.[23]

Table 1: "Chart 14: Median days away from work and incidence rate due to injuries and illnesses by nature, all ownerships, 2017" from Bureau of Labor Statistics 2017 Survey of Occupational Injuries and Illnesses Chart Data[23]

Year	Nature of injury or illness(1)	Median days away from work	Incidence rate per 10,000 full-time equivalent workers
2017	Tendonitis	33	0.2
2017	Fractures	31	8.7
2017	Carpal tunnel syndrome	30	0.6
2017	Multiple injuries with fractures	24	0.3
2017	Amputations	22	0.4
2017	Sprains, strains, tears	11	35.0
2017	Soreness, pain	9	17.1
2017	Multiple traumatic injuries	8	2.4
2017	Multiple injuries with sprains	7	1.1
2017	Heat (thermal) burns	5	1.4
2017	Bruise, contusions	5	8.6
2017	Chemical burns and corrosions	4	0.3
2017	Cuts, lacerations	4	7.2
2017	Cuts, lacerations, punctures	4	8.9
2017	Punctures (except gunshot wounds)	3	1.7

Footnotes:
(1)Data shown in columns correspond to nature of injury or illness based on the Occupational Injury and Illness Classification System 2.01 developed by the Bureau of Labor Statistics.
Source: U.S. Bureau of Labor Statistics, U.S. Department of Labor, November 2018

It then becomes clear that the burden of occupational musculoskeletal disorders is quite high for all parties including the injured workers themselves, the employers and national economy due to loss of productivity, and the workers compensation insurers who are responsible for covering both direct and indirect costs of injuries (i.e. medical care and wages). It is unknown how many of these workers undergo MRI to evaluate their injuries though guidelines suggest conservative management, waiting at least 4 weeks to pursue MRI in the absence of concerning physical exam findings (ex. joint instability or

deformity) due to the high cost of MRI.[24] Anecdotally, it is often discussed among medical providers that scheduling, performing, and receiving the report from an MRI routinely takes between 1-2 weeks; time that is essentially wasted, contributing to the cost of the injury as the diagnosis and therefore appropriate treatment plan is delayed.

The purpose of this study was to determine the proportion of peripheral joint MRI's obtained in workers compensation cases that could be substituted with a point of care ultrasound alone or ultrasound + xray since xray is often routinely performed on the first visit for most musculoskeletal injuries. Cost and time savings by making this substitution in appropriate cases were also estimated assuming an ultrasound could be performed in the office along with an xray on the first visit.

Chapter 2: Methods

This descriptive retrospective cohort study utilized a large workers compensation insurer database which represents 39,000 small to medium sized companies from a wide range of industries in 12 different states. All MRI's performed on peripheral joints during calendar year 2017 that were (a) at least 2 weeks after the initial clinic visit, or (b) greater than 6 weeks after injury, but (c) not more than 3 months after the date of injury were evaluated in this study.

A query was run in the insurer's database to identify all claims where a non-contrast MRI of an extremity was billed in 2017. The date of injury, first clinic visit, and MRI associated with those claims were then cross-referenced to identify cases that met inclusion criteria. Diagnoses rendered on MRI reports for these cases were transcribed into a spreadsheet and subsequently categorized as to whether ultrasound alone or ultrasound + xray could adequately provide the same diagnoses using a coding system we developed. The coded results were tabulated with percentages and 95% confidence intervals calculated as appropriate.

In general, MRI and ultrasound were considered equivalent for imaging extra-articular soft tissue structures such as nerve, tendon, muscle, ligament, bursa, synovium, adipose, etc. Exceptions to this rule included structures known to be impossible or difficult to image with ultrasound such as the superior and middle glenohumeral ligaments and many deep structures of the hip. MRI was always considered superior to ultrasound in evaluating intra-articular structures (meniscus, labrum, ACL, PCL, cartilage). MRI was considered superior to xray and ultrasound in evaluating diagnoses such as intra-articular fractures and chondromalacia. Bone alignment, fractures, and osteoarthritis (OA)/degenerative changes were considered to be both adequately imaged by MRI and xray, but not ultrasound.

Dates of the first clinic visit and dates MRI was performed were used to estimate time savings if ultrasound had been performed on the first visit. Direct imaging cost savings were estimated using the standard Florida state workers compensation fee schedule: $36 for a limited joint ultrasound study, $120 for a complete joint ultrasound study, $489 for a non-contrast joint MRI.

Chapter 3: Results

Cases Where Ultrasound Alone or Ultrasound + Xray Could be substituted for MRI

Of the 1,482 cases which met inclusion criteria (See Table 2), ultrasound alone, without xray, would be able to provide all of the same diagnosis compared to MRI in 33% of cases. However, when combined, ultrasound + xray would be able to provide all of the same diagnoses compared to MRI in 54% of cases. This highlights the utility of using ultrasound and xray together. See Table 3.

Table 2: *Study characteristics [Total # cases = 1482 (68% male)]*

Demographics	Mean	Std Dev	Median	Range
Age	46	12.7	48	17-79
Injury to MRI (# of days)	39.6	19.8	35	14-90
Clinic to MRI (# of days)	33.3	18.4	28	0-90

Table 3: *Diagnoses which could be made only by MRI, versus by MRI or Xray organized by joint of interest as well as # of cases that could be evaluated utilizing ultrasound + xray versus using just ultrasound alone without missing any diagnoses found on MRI*

Joint n (% of total cases)	Diagnoses where MRI is ideal or necessary (# cases)	Diagnoses where xray and MRI are roughly equivalent (# cases)	# of MRI cases that could be evaluated by just US (% per joint) [95%CI]	# of MRI cases that could be evaluated by US + xray (% per joint) [95%CI]
Shoulder **481** **(32%)**	Labrum (136); Capsule (21); Bone contusion/edema (16); Capsule ligaments (9), Other bone lesions (7); Loose body (5); Chondromalacia (2)	Fracture (26); Acromioclavicular (188); OA (33)	156 (32%) [27.9-36.1%]	312 (65%) [60.8-69.2%]
Knee **457** **(31%)**	Meniscus (264); Bone contusion/edema (93); Chondromalacia (62); ACL (90); PCL (21); Chondral lesion (22); Intra-articular fracture (11); Loose body (9); Other bone lesion (4)	OA (141); Fracture (29); Patellar tilt/sublux (5); Patella alta (2)	62 (14%) [10.8-17.2%]	108 (23%) [19.2-26.8%]
Hand/wrist **216** **(15%)**	Bone contusion/edema (49); Intra-articular fracture (4); Other bone lesion (2); Chondromalacia (1)	OA (39); Fracture (28); Carpal instability (5); Joint subluxation (2)	109 (50%) [43.4-56.7%]	160 (74%) [68.2-79.8%]
Foot/ankle **205** **(14%)**	Bone contusion (81); Other bone lesion (2); Osteomyelitis (2); Lis franc (1); Sinus tarsi (6); Intra-articular fracture (9)	Fracture (32); OA/degenerative (21); Enthesophyte (1); Avulsion (6); Pes planus (3); Hardware (1)	77 (38%) [31.4-44.6%]	108 (53%) [46.2-59.8%]
Hip **38** **(2%)**	Labrum (6); Obturator (1); Multifocal neoplasms (1); Bone contusion/edema (2)	Hardware (2); SIJ (1); Fracture (5); OA (8)	18 (47%) [31.1-62.9%]	29 (76%) [62.4-89.6%]
Elbow **85** **(6%)**	Loose body (2); Bone contusion/edema (4)	Fracture (3); OA (8)	69 (81%) [72.7-89.3%]	79 (93%) [87.6-98.4%]
All Joints **1482** **(100%)**	All of the above	All of the above	491 (33%) [30.6-35.4%]	798 (54%) [51.5-56.5%]

To aid in the interpretation of Table 3, consider the following example: A shoulder MRI that showed only rotator cuff or biceps pathology would be considered substitutable with ultrasound alone and therefore included in the 32% listed in column 4. However, if that same case showed a humeral neck fracture or AC joint arthrosis, it would only be considered substitutable by ultrasound + xray (not

ultrasound alone), and subsequently included in the 65% listed in column 5. Lastly if that same case included a labrum tear or glenohumeral ligament tear (which can only be imaged by MRI) it would not be considered substitutable at all.

While the addition of xray findings to ultrasound findings dramatically increases the proportion of cases that could be substituted/imaged completely without MRI (going from 33% to 54% overall), the proportion of cases that could be substituted further increases to 70% overall when diagnoses which can only be ascertained using MRI but are considered not likely to change management were excluded from analysis (i.e. bone contusions/edema, chondromalacia, ACL and PCL sprains, meniscus degeneration, labrum degeneration). In effect, only 30% of MRIs provided additional information that was likely to change management which varied by joint as follows: shoulder 28%, knee 59%, hand/wrist 3%, foot/ankle 10%, hip 21%, elbow 2%. See Table 4.

Table 4: *Number of cases that could be evaluated using ultrasound + xray without missing any diagnoses made by MRI versus the number of cases that could be evaluated using ultrasound + xray if diagnoses made on MRI which are not likely to change management are excluded from the analysis*

Joint n (% of total cases)	# of MRI cases that could be evaluated by US + xray (% per joint) [95%CI]	Diagnoses made by MRI which are not likely to change management	# of MRI cases that could be evaluated by US + xray if Dx in column 3 are excluded (% per joint) [95%CI]	Difference between columns 2 and 4
Shoulder **481** **(32%)**	312 (65%) [60.8-69.2%]	Bone contusion/edema (16); Chondromalacia (1); Labrum degeneration (22)	346 (72%) [68.0-76.0]	34 (7%)
Knee **457** **(31%)**	108 (23%) [19.2-26.8%]	Bone contusion/edema (93); Chondromalacia (62); ACL sprain (35); PCL sprain (9); Meniscus degeneration (11)	188 (41%) [36.5-45.5%]	80 (17%)
Hand/wrist **216** **(15%)**	160 (74%) [68.2-79.8%]	Bone contusion/edema (49); Chondromalacia (1)	210 (97%) [94.7-99.3%]	50 (23%)
Foot/ankle **205** **(14%)**	108 (53%) [46.2-59.8%]	Bone contusion/edema (81)	185 (90%) [85.9-94.1%]	77 (37%)
Hip **38** **(2%)**	29 (76%) [62.4-89.6%]	Bone contusion/edema (2)	30 (79%) [66.1-92.0%]	1 (3%)
Elbow **85** **(6%)**	79 (93%) [87.6-98.4%]	Bone contusion/edema (4)	83 (98%) [95.0-100%]	4 (5%)
All Joints **1482** **(100%)**	798 (54%) [51.5-56.5%]	All of the above	1042 (70%) [67.7-72.3%]	244 (16%)

To aid in the interpretation of Table 4, consider the following example: A wrist MRI that showed a partial tear of the flexor pollicis longus tendon and/or a distal radius fracture would be considered substitutable with ultrasound + xray and therefore included in the 74% listed in column 2. However, if that same case also showed edema of the scaphoid bone, it would not be part of the 74% considered substitutable in column 2, though it would be part of the 97% considered substitutable in column 4 after the diagnosis of bone contusion was removed from the analysis.

Potential Cost Savings if Ultrasound was Appropriately Substituted for MRI

If point of care ultrasound was performed for all 1482 cases the total cost would range from $53,352 (if all were limited joint studies) to $177,840 (if all were complete joint studies) versus $724,698 for MRIs. Total cost of imaging if ultrasound was performed in every case and MRI was additionally performed for only the 30% of cases where it could provide a diagnosis which might change treatment would therefore range from $268,512 to $393,000. Therefore, eliminating 70% of MRIs while performing ultrasounds on every patient amounts to a cost savings ranging between $456,186 and $331,698 for just the cases included in this study alone, which translates to a savings of $308 to $224 per patient. Of note, the cost of xray was not factored into the cost savings calculations because it is a basic imaging study which is required before MRI is approved by insurers and, therefore, it is assumed xray was performed prior to all MRIs.

Potential Time Savings if Ultrasound was Appropriately Substituted for MRI

In terms of time savings, if ultrasound + xray was performed at the point of care during the first clinic visit for an injury, the definitive diagnoses could be reached on average 33.3 days earlier (See Table 2), however, this does not include the additional time to get results back and review them with the patient at a subsequent visit. It is difficult to estimate how this time savings would affect management, however, it is reasonable to assume that a significant savings in indirect costs (ex. duty restrictions or time away from work) might be realized.

Chapter 4: Discussion

Rationale for Study Inclusion and Exclusion Criteria

This study captures MRI data starting at 2 weeks post initial clinic visit with the thought that MRIs performed within the first two weeks may represent cases with severe injuries where concerning findings were present on physical exam (ex. joint instability, structural deformity, or extreme pain) necessitating the most advanced and complete imaging immediately. MRIs performed within 2 weeks of the initial clinic visit but greater than 6 weeks from the date of injury were included, assuming providers were following guidelines where the elapsed time since the injury would be considered conservative management without adequate improvement (hence why they presented in clinic over a month after injury), and therefore MRI would be appropriate. MRIs performed after 3 months post injury were not included because, in conversation/agreement with our Occupational Medicine colleagues, advanced imaging at such a late date is often ordered in cases where a patient is paradoxically not progressing in spite of little to no objective evidence to suggest an unhealed injury. Because it is the most complete imaging modality, a negative MRI allows the provider to place the patient at maximal medical improvement status and discharge the case where it will undergo arbitration and/or independent medical evaluation. Because we did not conduct chart review of clinic notes, we would have no way to filter out those types of cases.

Representativeness of Study Data and Generalizability to the US Workforce

According to the medical director of the workers compensation insurer where this study was conducted, data from 2017 was representative of a typical year and was almost exactly on target with recent previous years and hence the insurer's predictions for total claims submitted and MRIs ordered. It is therefore likely that the proportions of MRIs by joint included in this analysis are also representative of a typical year. Given the insurer represents over 39,000 businesses in 12 states in a wide range of industries, it is also likely that this sample is reasonably representative of the US workforce in general.

Though no previous papers have been published with regard to utilization of ultrasound vs. MRI to evaluate musculoskeletal injuries in workers compensation cases, the results of this study do mirror a paper by Parker et al. which described a study in the general population.[25] In that paper, all musculoskeletal MRIs in a radiology database performed over the course of one year (n = 3,621) were analyzed in a similar fashion, revealing that 45.4% of primary diagnoses and 30.6% of total cases could be evaluated completely using only ultrasound, which, upon extrapolation, they estimated could save almost $7 billion in Medicare alone over the period of 2006-2020. The mean age and standard deviation between the Parker et al. paper and this study are nearly the same (45.6 and 15.9 vs. 46 and 12.7 respectively). Because the Parker et al. paper included "all-comers" and the present study includes only recent work injuries, the differences in population may explain the differences in percentage of cases where ultrasound could be appropriately substituted for MRI, though the results are admittedly still quite similar for multiple joints, suggesting the results of this study may be applicable to the broader fields of Orthopedics and Sports Medicine outside of the Occupational Medicine/workers compensation realm. See Table 5.

Table 5: *% of MRI cases that could be evaluated by* ***ultrasound alone****, categorized by joint, comparing this study vs. Parker et al.*

Joint	This study	Parker et al.
Shoulder	32%	37.7%
Knee	14%	10.9%
Hand/wrist	50%	77.2%
Foot/ankle	38%	40.1%
Hip	47%	18.8%
Elbow	81%	56.6%
All Joints	33%	30.6%

Unfortunately, the Parker et al. paper did not explore the enhanced utility of ultrasound when combined with xray results. Whereas our present study suggests that ultrasound + xray would be able to provide all of the same diagnoses compared to MRI in 54% of cases (an increase of 21% over using ultrasound alone), further increasing to 70% overall when diagnoses considered not likely to change management were excluded from analysis, it is reasonable to assume Parker et al. might have also been able to show a comparable increase in appropriate substitution with ultrasound + xray.

70% May Actually be an Underestimation

Although the appropriate substitution of ultrasound for MRI by excluding diagnoses not likely to change management is estimated to be 70%, the real percentage of MRI's that could be appropriately

substituted with ultrasound + xray is likely much higher than what we are able to estimate in this study given the results of other recent papers on knee meniscus and shoulder labrum tears.

To this point, it is important to consider that multiple papers have documented the extremely high prevalence of asymptomatic meniscus tears.[26,27,28,29] Most practitioners would likely agree that a diagnosis of knee meniscus tear on MRI (many of which may be incidental/correlate poorly with clinical findings) often leads to an Orthopedic referral and arthroscopic surgery. The appropriateness of arthroscopic surgery for MRI confirmed meniscus tears has recently been called into question by randomized clinical trials showing no difference in outcomes compared to physical therapy, even after two years of follow up provided the patients have no initial findings of knee instability, locking, are not obese, and can weight bear well enough to participate in exercise.[30,31,32,33,34,35,36] Furthermore, the size, shape, and location of meniscus tears had no effect on outcomes. This then begs the question: How useful is the information from an MRI if we should preferentially send patients to physical therapy as first line treatment in the absence of physical exam findings that would necessitate MRI (i.e. knee instability, locking, obesity, and inability to weight bear well enough to participate in exercise)?

Admittedly, a limitation of the present study is that physical exam findings were not reviewed and therefore it is unknown how many cases included had a clinical presentation which would necessitate MRI consistent with the aforementioned parameters. However, of the 264 cases where meniscus pathology was found on MRI, and subsequently included in the 59% of knees examined that we determined could not be substituted with ultrasound + xray (See Tables 3 & 4), only 4 had extrusions, 8 had bucket tears/flipped fragments/or prolapse, and 7 had intra-articular loose bodies. It may follow then that a large proportion of those 264 knees with meniscal pathology (representing 17% of total cases included in this study) might not have required MRI to achieve appropriate management, and instead could have appropriately utilized the less costly and faster alternative of ultrasound + xray.

In an analogous line of inquiry, recent papers have highlighted the extremely high prevalence of asymptomatic shoulder labral tears in the general population especially as age increases, although the prevalence is also high in asymptomatic young athletes as well.[37,38,39,40,41] In a randomized trial

comparing labral repair vs biceps tenodesis vs sham surgery there were no significant differences in outcomes between groups.[42] Additionally, surgeons seem to have a low level of agreement in how to treat labral tears, and labral repairs in patients over 36 years old often fail.[43,44] The latest guidelines conclude that 2/3 of labral injuries improve adequately with therapy, and surgery should be reserved until after at least 3 months of directed therapy has failed or in the presence of shoulder instability with significant consideration for age as a predictor of outcome along with pathology of the biceps.[45,46] So, as with meniscus tears in the knee, we must then ask: How useful is the information from an MRI if we should preferentially use conservative management in the absence of physical exam findings that would necessitate MRI (i.e. shoulder instability, biceps pathology)?

In our present study, labral tears were seen on MRI in 113 cases (representing 7.6% of total cases in the study) and subsequently included in the 28% of shoulder exams that we determined could not be substituted with ultrasound + xray. Again, a limitation of the present study is that physical exam findings were not reviewed and therefore it is unknown how many of the cases included had a clinical presentation which would necessitate MRI, however, it seems likely that a large proportion of the labral tears found on MRI might have been incidental, providing no benefit in a preferentially conservative management plan.

Of course, after performing a thorough history and physical exam the etiology of a patient's pain can be cryptic in some cases even with the addition of ultrasound to visualize extra-articular structures. In the absence of physical exam findings such as joint instability or deformity that would necessitate an MRI, and where the provider is unsure as to whether the source of a patient's pain is intra-articular vs. extra-articular, a diagnostic injection of anesthetic is a quick an easy way to rule this in or out at the point of care.[47,48] Therefore, having access to an ultrasound in the clinic can prove invaluable, both through routine use of ultrasound diagnostic exams and subsequent ultrasound-guided diagnostic injections of anesthetic to distinguish between intra- and extra-articular pathology induced pain for appropriate cases at the point of care.

To be clear, we do not believe ultrasound could or should replace MRI because both have value over the other in different scenarios. In evaluating MSK work injuries we believe ultrasound's place is at

the point of care coupled with a good history and physical, helping to rule out red flags, and increasing the likelihood of a correct diagnosis and subsequent optimal treatment plan so that workers return to duty as quickly as possible, reducing indirect costs. It's appropriate use at the point of care will also lead to direct cost savings by reducing the number of unnecessary MRI's ordered as subsequent specialist referral and treatment for incidental findings.

Conclusion

The results of our present study suggest that the majority of musculoskeletal workers comp injuries could be accurately and completely evaluated at the point of care using ultrasound and xray together instead of MRI, and this number may be well in excess of 70%. This substitution, if implemented appropriately, could yield greater provider and patient confidence in the diagnosis and treatment plan as well as more expeditious accurate diagnoses leading to substantial reductions in both direct and indirect costs.

Future directions in this area of research include confirmation of the results of this study with other data sets which hopefully will correlate imaging findings with clinical findings, as well as head-to-head trials of MRI vs ultrasound in evaluating MSK work injuries which may be able to highlight the added value of dynamic imaging and power doppler use at the point of care. We also envision studies which would use point of care ultrasound to follow injuries over time, tracking recovery and describing its use in performing appropriate interventional procedures in the office for these patients. Our group is currently conducting analyses similar to those performed in this study to describe of the utility of ultrasound + xray in evaluating MSK work injuries over the acute post-injury period of 0 days to 2 weeks. We will then use these data in aggregate to delineate patterns of injury, developing Bayesian conditional probability network-based ultrasound scanning algorithms which are simplified to aid providers in point of care injury evaluation, similar to the FAST scan in emergency medicine.

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