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Original Article

Non-contrast MRI diagnosis of adhesive capsulitis of the shoulder

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ABSTRACT

Purpose: To investigate non-contrast MRI findings of clinical adhesive capsulitis.
Methods: 31 non-contrast, non-arthrographic, shoulder MRIs were evaluated for coracohumeral ligament thickness, rotator interval infiltration, and axillary recess thickening/edema.
Results: In detection of adhesive capsulitis, sensitivity is 76.7% and specificity is 53.3% for coracohumeral ligament thickening, sensitivity is 66.7% and specificity is 55.2% for coracohumeral ligament thickening and rotator interval infiltration, and sensitivity is 23.3% and specificity is 86.7% for coracohumeral ligament thickening, rotator interval infiltration, and axillary recess thickening/edema.
Conclusions: Adhesive capsulitis can be accurately diagnosed on non-contrast MRI shoulder examinations with appropriate clinical criteria without direct MR arthrography.

1. Introduction

Adhesive capsulitis is a common cause of pain, restricted range of motion, and referral to subspecialty orthopedic surgery and sports medicine clinics [1–5]. The orthopedic clinical exam for adhesive capsulitis shows high sensitivity and specificity for confident diagnosis of adhesive capsulitis and is the reference standard for diagnosis [6–10]. However, patients with adhesive capsulitis often suffer from concomitant shoulder pathologies including rotator cuff and glenohumeral lesions, leading to a more difficult physical examination and a more difficult diagnosis. In the latter scenario, patients are often referred for MRI. As such, routine noncontrast MRI may be less commonly considered as a reliable modality in confirming the diagnosis of adhesive capsulitis and may be more likely ordered to primarily exclude rotator cuff and glenohumeral lesions.

Several findings have been described with adhesive capsulitis based on arthroscopic [11–13], open surgical [14–16], and imaging experience [17–27] including thickening of the coracohumeral ligament, rotator interval infiltration of the subcoracoid fat, and thickening and edema at the axillary recess and inferior glenohumeral ligament. Direct and indirect MR arthrographic findings of adhesive capsulitis or frozen shoulder are well described [17–20] and include an imaging adaptation of the observations above. However, adhesive capsulitis most commonly occurs in patients age 45 to 60 years old, a population for whom direct and indirect MR arthrography is rarely ordered in our region. Several recent studies have been performed describing noncontrast MRI findings of adhesive capsulitis and their role in the diagnosis of clinical adhesive capsulitis [25–27]. Sofka et al. described noncontrast MRI findings with clinical stage of adhesive capsulitis [25]. Gondim Teixeira et al. described noncontrast MRI findings of adhesive capsulitis compared to indirect MR arthrogram findings with sensitivities and specificities based on single MR criterion [26]. Zhao et al. described the frequency of noncontrast MRI findings of adhesive capsulitis but without sensitivity or specificity calculations [27]. No published study to date has strictly evaluated routine noncontrast MRI shoulder examinations with sensitivities and specificities for specific MRI findings and constellations of MRI findings to accurately diagnosis adhesive capsulitis.

In our study, we sought to investigate specific noncontrast MRI findings as well as constellations of noncontrast MRI findings for confirmation of clinical adhesive capsulitis.

2. Materials and methods

Institutional review board approval at two institutions was obtained prior to the start of this study. Cases were recruited in a single orthopedic shoulder clinic at one institution, and the reviewers were from a separate institution. A retrospective review of records and images without informed consent was performed in accordance with Health Insurance Portability and Accountability Act. We performed a subspecialty

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orthopedic surgery/sports medicine clinic database search from January 2010 and December 2011 for patients discharged with a primary or isolated diagnosis of adhesive capsulitis or frozen shoulder and without a history of recent trauma or prior MRI. Then, the same investigators accrued an age- and gender-matched control group without a clinic discharge diagnosis of adhesive capsulitis, frozen shoulder, rotator cuff tear, glenoid labrum tear or glenohumeral arthritis and also lacking a recent trauma history or prior MRI at the time of clinic visit. All patients were examined in a subspeciality shoulder clinic by a single orthopedic subspecialist. Clinical diagnostic assessment included evaluation for clinical history of shoulder pain and clinical physician exam findings of restricted active and passive range of motion of the humerus with external rotation <90°, internal rotation <75°, flexion <90°, or abduction < 90°, which was then compared with the contralateral shoulder. From these two groups, 31 patients had a noncontrast MRI within one week after the clinic visit, and these were sorted into the subject and control groups. One patient with clinical suspicion of adhesive capsulitis was excluded due to the presence of a clear traumatic labral tear. MR imaging of the shoulder was performed using standard protocol on a 1.5 Tesla scanner with a dedicated shoulder receiver coil (Siemens Magnetom, Erlangen, Germany). Coronal oblique T1-weighted spin echo non-fat suppressed (FOV 16–18 cm, TE minimum, TR 400–800), coronal oblique T2-weighted fast spin echo (FSE) fat suppressed (FOV 16–18 cm, TE 30–45, TR > 1500), axial proton density weighted FSE fat suppressed (FOV 10 cm, TE 10-20, TR 3000), and sagittal oblique T2-weighted FSE non-fat suppressed (TE 110, TR > 2000) sequences were acquired as a part of all MRI exams. Images were obtained using a slice thickness of 3–4 mm with a 0.5 mm gap.Two fellowship trained musculoskeletal radiologists with 5 and 13 years experience were blinded and reviewed the MR examinations in on a P.A.C.S. (Picture Archiving and Communication System) workstation. The readers reviewed anonymized cases with a random study number independently. Maximal coracohumeral ligament thickness was measured on the non-fat suppressed sagittal oblique sequence, and thickness >2 mm was considered abnormal. Rotator interval infiltration of the subcoracoid fat was graded as none, mild, moderate, or severe using the non-fat suppressed sagittal oblique and the non-fat suppressed coronal oblique sequences. Mild infiltration of rotator interval fat was defined as replacement of <25% of the fat signal. Moderate infiltration was defined as 25%–50% replacement of fat signal, and severe infiltration was defined as replacement of >50% of the volume of normal fat signal in the interval (Fig. 1). The axillary recess was evaluated for thickening >2 mm at its most inferior point on the coronal fluid sensitive, fat suppressed sequences. Axillary recess pericapsular edema was also evaluated on the coronal fluid sensitive, fat suppressed sequences (Fig. 2).The sensitivity and specificity for detection of adhesive capsulitis was calculated based on presence of one, two, or three criteria, using orthopedic surgery physical examinations as the reference. The sensitivity and specificity for each reader and in consensus was performed. Frequencies of each of the criteria individually were also calculated. Mean thickness for the coracohumeral ligament in the two groups was calculated, and a two tailed Student's *t*-test was performed to determine

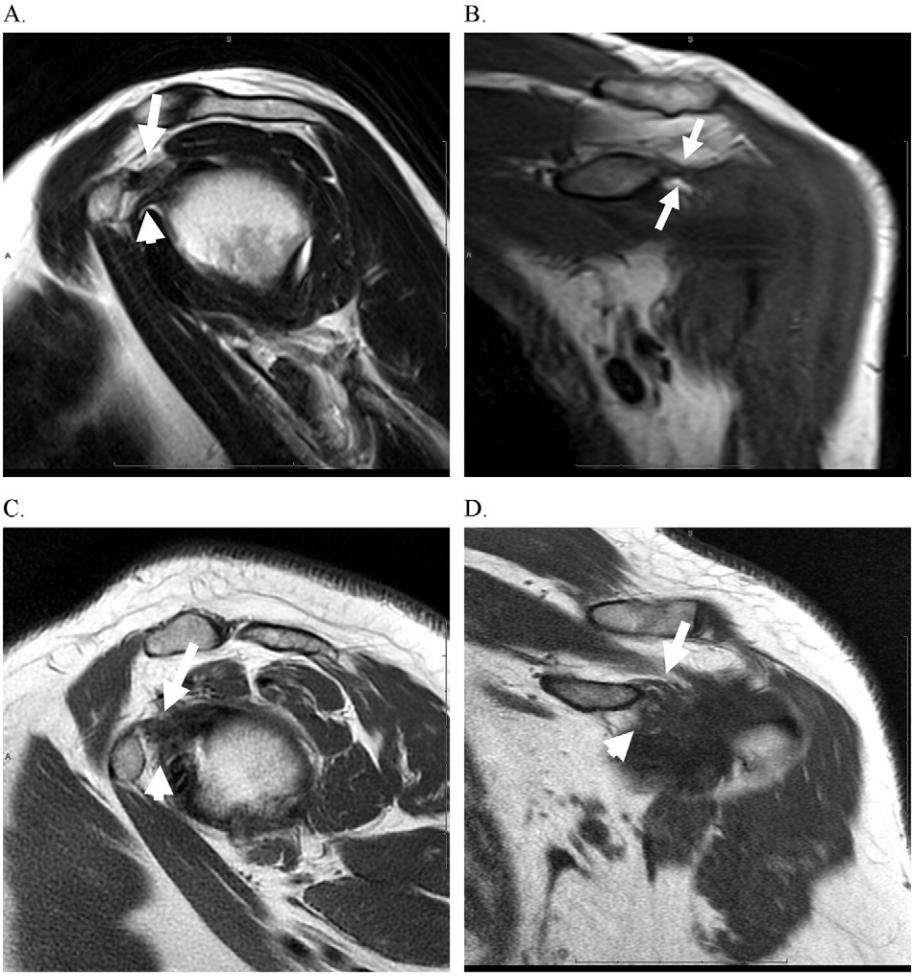

Fig. 1. A 62-year-old woman with clinical adhesive capsulitis. (A) Sagittal oblique T2-weighted fast spin echo non-fat suppressed and (B) coronal T1-weighted spin echo non-fat suppressed MR images show thickening of the coracohumeral ligament (white arrow) and moderate rotator interval infiltration of the subcoracoid fat (white arrow head). A 49-year-old woman with clinical adhesive capsulitis. (C) Sagittal oblique T2-weighted fast spin echo non-fat suppressed and (D) coronal T1-weighted spin echo non-fat suppressed MR images show marked thickening of the coracohumeral ligament (white arrow) and severe rotator interval infiltration of the subcoracoid fat (white arrow head).

Fig. 2. A 53-year-old woman with clinical adhesive capsulitis. Coronal oblique T2-weighted fast spin echo fat suppressed sequence shows thickening and edema of the axillary recess (white arrows).

statistical significance ($p < 0.05$). A two tailed McNemar's Chi square test with Yate's correction was performed to determine statistical significance ($p < 0.05$) of sensitivities and specificities using one, two, or three MRI criteria. Inter-rater agreement (kappa) was also calculated.

3. Results

The initial database search yielded 16 subjects, ages 38–72 years old with a mean age of 56 years, 6 males and 10 females, with noncontrast, nonarthrographic, shoulder MRI exams using keywords "adhesive capsulitis" and "frozen shoulder" as part of their history. One patient with clinical suspicion of adhesive capsulitis was excluded due to the presence of a traumatic labral tear. Age and gender matched control subjects were obtained for indications other than suspicion for adhesive capsulitis. A total of 30 noncontrast shoulder MRIs with an identical protocol were included in the study (15 subjects in each group) with a mean age 55.8 years (10 men, 20 women).

Using the single criterion of coracohumeral ligament thickening generated a consensus sensitivity of 76.7% and specificity of 53.3% for detection of clinical adhesive capsulitis. The mean and standard deviation for coracohumeral ligament thickness was 3.40 ± 1.25 mm in patients with clinical adhesive capsulitis and 2.60 ± 0.93 in the control group ($p < 0.01$). Using the two criteria of coracohumeral ligament thickening and infiltration of the rotator interval fat generated a consensus sensitivity of 66.7% and specificity of 55.2%. Using all three criteria of coracohumeral ligament thickening, rotator interval infiltration, and axillary recess thickening ± pericapsular edema generated a consensus sensitivity of 23.3% and specificity of 86.7% (Table 1). There was a statistically significant difference ($p < 0.05$) for sensitivities in detection of clinical adhesive capsulitis using one or two criteria versus three criteria. There was no statistically significant difference ($p = 0.25$) in sensitivities using one versus two criteria. There was a statistically significant difference ($p < 0.05$) for specificities in detection of clinical adhesive capsulitis using one or two criteria versus three criteria. There was no statistically significant difference ($p = 1$) in specificities using one versus two criteria. Interobserver agreement was strong for coracohumeral ligament thickening, moderate for coracohumeral ligament thickening and rotator interval infiltration, and fair for coracohumeral ligament thickening, rotator interval infiltration, and axillary recess thickening ± edema. Frequencies of each of the criteria individually were calculated (Table 2).

Table 1
Sensitivity, Specificity and Interobserver Agreement values based on 1-, 2-, 3- criteria assessment.

MRI signs of adhesive capsulitis	Sensitivity (%)		Specificity (%)		κ
	Reader 1	Reader 2	Reader 1	Reader 2	
Coracohumeral ligament thickening	86.7	67.7	60.0	46.7	0.65
Coracohumeral ligament thickening + rotator interval infiltration	66.7	66.7	66.7	46.7	0.53
Coracohumeral ligament thickening + rotator interval infiltration + axillary recess thickening/edema	40.0	6.7	86.7	86.7	0.26

4. Discussion

Adhesive capsulitis is among the most common diagnoses in patients seen in orthopedic shoulder and sports medicine clinics [1–5], but is much less frequently reported at MRI. MRI has been proven sensitive and specific for shoulder lesions including rotator cuff tendinopathy, glenoid labrum tears, and arthropathies, but its value in confirming a diagnosis of adhesive capsulitis has not been clearly established. Direct and indirect MR arthrography has been shown to accurately diagnose adhesive capsulitis or frozen shoulder [17–20], but adhesive capsulitis is most prevalent in the 45 to 60-year-old age group, a population for which direct or indirect MR arthrography is rarely ordered. Effective nonoperative treatment regimens for adhesive capsulitis have been established, and delayed diagnosis can be a cause of significant morbidity and protracted syndromes [9,12,16,28]. Given the prevalence of concomitant pathologies such as impingement, rotator cuff tendinopathy, and degenerative arthropathies in this population, routine noncontrast shoulder MRI examinations are frequently ordered in patients with clinical adhesive capsulitis. While some MRI findings of adhesive capsulitis have been described previously, we sought to establish a specific algorithm for confidently confirming the presence of adhesive capsulitis with routine, noncontrast MRI.Rotator cuff interval findings in adhesive capsulitis including thickening of the coracohumeral ligament itself and fibrosis or synovitis in the rotator interval fat have been described in the orthopedics literature based on arthroscopy and open surgical evaluation [11–16]. The anatomy of these structures is thought to play an important role in the restriction of external rotation of the shoulder seen in the setting of adhesive capsulitis [10,14,29]. Our study shows a statistically significant difference in coracohumeral ligament thickness between study group subjects with clinical adhesive capsulitis compared to control subjects, with high sensitivity and reasonable specificity. Observation of rotator interval infiltration of the subcoracoid fat in conjunction with coracohumeral ligament thickening marginally improved specificity for detection of adhesive capsulitis; however, there was not a statistically significant difference in sensitivities or specificities based on one versus two criteria assessment. Gondim Teixeira et al. previously reported low sensitivities for detection of adhesive capsulitis based on coracohumeral ligament thickness >4 mm [26]. However, the cut off coracohumeral thickness may have significantly traded off sensitivity for specificity in this series.Contrary to the findings at the rotator interval, imaging findings associated with adhesive capsulitis at the axillary recess have been debated in the literature. Several studies have described the MRI findings of thickening and edema of the axillary recess or inferior glenohumeral ligament in adhesive capsulitis [20,22,25,26], while other studies have not found similar findings [17,19]. Song et al. and Gondim et al. described high sensitivity and specificity for adhesive capsulitis based on thickening of the axillary recess and increased T2 signal of the inferior glenohumeral ligament [20,26], respectively, while Sofka et al. demonstrated similar thickening and signal of the axillary recess in only one of the four clinical stages of adhesive capsulitis [25]. In our study, a constellation of observations including coracohumeral ligament thickening, rotator interval infiltration, and thickening/edema of the axillary recess

Table 2
Frequency of MRI findings of adhesive capsulitis.

MRI signs of adhesive capsulitis	No. of shoulders			
	Reader 1		Reader 2	
	Adhesive capsulitis (n = 15)	Control group (n = 15)	Adhesive capsulitis (n = 15)	Control group (n = 15)
Coracohumeral ligament thickening	13	6	10	8
Rotator interval infiltration of subcoracoid fat	10	8	9	10
Mild	3	2	5	5
Moderate	5	5	3	4
Severe	2	1	1	1
Axillary recess	13	5	5	4
Edema	7	2	4	2
Thickening	6	3	1	2

yielded high specificity and a statistically significant difference in sensitivity and specificity compared to using one or two criteria alone. The axillary recess was considered thickened if it measured >2 mm, noting variability of measurements of the axillary recess reported in the literature [19,22,24,25]. As this measurement can be difficult because patients with adhesive capsulitis often do not externally rotate on the scanner, axillary recess pericapsular edema was also included in our analysis. The increased specificity with inclusion of the axillary recess findings suggests that axillary recess involvement may be seen as synovitis and fibrosis at the rotator interval evolves.Routine noncontrast MRI shoulder examinations provide multiple imaging planes and both fat suppressed and non-fat suppressed sequences, ideal for an algorithmic approach in the assessment for adhesive capsulitis. As such, the use of both specific MRI findings and constellations of MRI findings is practical to maximize accurate diagnosis of adhesive capsulitis. Based on the results of our study, clinical criteria for adhesive capsulitis can be used in conjunction with a practical 1, 2, or 3 criteria noncontrast MRI system, guided by the level of clinical suspicion. In the setting of high clinical suspicion for adhesive capsulitis, the isolated finding of coracohumeral ligament thickening >2 mm yields a strong sensitivity for a confirmatory diagnosis. On the contrary, coracohumeral ligament thickness equal to or <2 mm may help to exclude adhesive capsulitis. In the setting of moderate clinical suspicion for adhesive capsulitis, the addition of infiltration of the rotator interval fat may be useful to improve confidence of diagnosis. In the setting of atypical or low initial clinical suspicion for adhesive capsulitis, the constellation of findings of axillary recess thickening/edema in conjunction with rotator cuff interval findings of coracohumeral ligament thickening and infiltration of the rotator interval fat strongly suggests a diagnosis of adhesive capsulitis with high specificity and may raise suspicion for adhesive capsulitis. Implementing this system at our institution for 500 consecutive routine MRI shoulder examination has yielded a prevalence of adhesive capsulitis in our MRI reports of 6.8%, similar to the estimated prevalence of adhesive capsulitis in orthopedic shoulder clinic of 5–6% [8,19].There are several limitations to our study. There was no arthroscopic or surgical pathology correlation in our study. However, as adhesive capsulitis is generally not treated with surgery, a reference standard of clinical adhesive capsulitis based upon subspecialty physical examination was used, which has been accepted in recent orthopedic literature. Given that current treatment for adhesive capsulitis is largely directed toward physical therapy and percutaneous steroid/anesthetic injections, histological specimens were not available for analysis. Additionally, given the retrospective design of our study, information regarding the clinical stage of adhesive capsulitis at the time of imaging was not available to review.

5. Conclusion

In conclusion, adhesive capsulitis can and should be accurately and consistently diagnosed on routine noncontrast shoulder MRI in conjunction with appropriate clinical criteria. The finding of a thickened coracohumeral ligament shows strong sensitivity for adhesive capsulitis while the constellation of coracohumeral ligament thickening, rotator interval infiltration of the subcoracoid fat, and axillary recess thickening/edema yields great specificity for adhesive capsulitis.

Disclosures

None.

Conflict of interest

The authors declare that they have no conflict of interest.

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