



Deciphering pain through imaging: what do MRI and ultrasound reveal in calcific tendinopathy?

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Abstract

Objective To assess the relationship between imaging findings and clinical symptoms in rotator cuff calcific tendinopathy using magnetic resonance imaging and ultrasound, focusing on calcification morphology, bursitis, and pain severity.

Materials and methods This retrospective study included 60 patients with rotator cuff calcific tendinopathy. Ultrasound (US) and magnetic resonance imaging (MRI) were used to evaluate calcification size, shape, localization, acoustic shadowing, and associated bursitis. The Constant-Murley Score was used to assess pain severity. Interobserver reliability was measured for US findings. Statistical analyses included correlation tests and regression models.

Results Calcification morphology and bursitis were significantly associated with pain severity. Fragmented and multifocal calcifications correlated with higher pain scores, while arc-shaped calcifications showed milder symptoms. Bursitis presence strongly correlated with increased pain. US demonstrated high interobserver agreement and was superior in detecting inflammation, while magnetic resonance imaging better characterized deep structural changes.

Conclusion Bursitis and calcification morphology are key determinants of pain severity in rotator cuff calcific tendinopathy. US provides real-time inflammation assessment, while magnetic resonance imaging enhances structural evaluation. These findings support a combined imaging approach for accurate diagnosis and treatment planning.

Keywords Calcific tendinopathy · Rotator cuff · MRI · Ultrasound · Bursitis · Shoulder pain · Acoustic shadowing

Introduction

Rotator cuff calcific tendinopathy is a prevalent degenerative condition of the shoulder joint, typically resulting in pain and functional impairment [1, 2]. The primary characteristic of the disease is the calcification process, marked by the deposition of calcium hydroxyapatite crystals within the rotator cuff tendons [3]. While calcific tendinopathy is often asymptomatic, it can induce significant discomfort accompanied by a marked inflammatory response, particularly during the resorptive phase [4]. Throughout this procedure, other complications may arise, such as subacromial-subdeltoid bursitis and intra-articular inflammation [1–3].

Calcific tendinopathy is known to progress through a well-defined sequence of pathological stages: the formative, resorptive, and post-calcific phases. In the formative phase, calcium hydroxyapatite crystals are gradually deposited within the tendon with minimal inflammatory response [3–5]. The resorptive phase is characterized by increased vascularization, macrophage infiltration, and liquefaction of the deposits, often correlating with acute and severe pain. Finally, during

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the post-calcific phase, fibroblastic activity leads to tendon remodeling and healing. High-resolution ultrasound can differentiate these phases based on plaque morphology and Doppler vascularity: arc-shaped calcifications often indicate the formative or quiescent phase, while fragmented, nodular, or cystic morphologies are typically associated with the resorptive phase and intense symptoms [3–5].

Imaging techniques are essential in clinical care for identifying calcifications, assessing inflammatory processes, and guiding therapy planning [5–7]. Conventional radiography is the primary diagnostic technique commonly employed to identify calcifications [6, 7].

Magnetic resonance imaging (MRI) is an advanced technique that offers superior soft tissue contrast and identifies intra-articular inflammatory disorders [5–7]. However, its sensitivity for detecting calcific tendinopathy is limited and may not consistently reveal calcific foci, primarily due to the tendency of small or poorly mineralized deposits to appear isointense to surrounding soft tissues on MRI [6–8]. This limitation has been noted in comparative studies showing that ultrasound is generally more sensitive than MRI in detecting calcific deposits, especially in the resorptive phase [5–7]. Currently, US is distinguished as a dynamic imaging technique, offering real-time assessment and comprehensive analysis of anatomical features [8]. A significant advantage of US is the ability to immediately detect and assess inflammation by palpation [8]. Furthermore, alterations associated with inflammation can be readily detected, such as the thickening of the subacromial-subdeltoid bursa and the increase in intra-articular fluid volume [8, 9].

This study aims to evaluate the relationship between imaging findings and clinical symptoms in patients with rotator cuff calcific tendinopathy using both US and MRI. Specifically, we want to investigate the impact of calcification morphology, localization, acoustic shadowing, and the presence of bursitis on symptom severity. Additionally, the study compares the diagnostic contributions of US and MRI in assessing inflammatory changes and structural characteristics of calcifications.

We hypothesize that there is no statistically significant difference between US and MRI in detecting the morphology and localization of calcifications, associated bursitis, and inflammatory changes in patients with rotator cuff calcific tendinopathy. Furthermore, we propose that specific imaging features, such as morphology, location, and acoustic shadowing, are associated with symptom severity.

Materials and methods

Patient population

This retrospective study comprised 60 patients diagnosed with calcific tendinopathy between January 2022 and

February 2023. Demographic information of the patients, including age, gender, symptom duration, and dominant hand, was documented.

All 60 patients underwent both MRI and shoulder US examinations. The interval between MRI and ultrasound examinations varied between 1 week and 3 months, with ultrasound always performed after MRI. Functional assessment using the Constant-Murley Score (CMS) was performed on the same day as the ultrasound examination by an orthopedic specialist, ensuring that clinical evaluation coincided with the imaging findings.

Pediatric patients, individuals with complete-layer rotator cuff tears, shoulder injuries, osteoarthritis, inflammatory rheumatic diseases, benign or malignant bone lesions, and those who received steroid injections within the past 3 months or underwent surgery were excluded from the study.

Patients with calcifications located outside the tendons, such as cases of calcific bursitis or calcific periarthritis, or with calcifications or inflammatory changes extending into the bony cortex of the greater tuberosity were excluded from the study.

To confirm the diagnosis of calcific tendinopathy, all patients included in this study were retrospectively identified based on existing shoulder radiographs and/or CT scans obtained prior to the study period. These images were reviewed by musculoskeletal radiologists to confirm the presence of calcific deposits within the rotator cuff tendons before inclusion. No patients were included based solely on clinical diagnosis without imaging confirmation.

The research was carried out following the acquisition of ethics committee permission, and informed consent was obtained from all participants. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Ultrasound assessment

An US examination of both shoulders was conducted in B-mode using a Samsung V7 sonography device equipped with a 5–12 MHz multi-frequency linear transducer.

High-resolution US was used to assess rotator cuff tendons, utilizing specialized positioning procedures for each tendon [8, 10].

During the examination, the patients' arm postures were modified as follows: Supraspinatus tendon: The shoulder was assessed while the patient extended their arm in internal rotation to retrieve a wallet from the back. Infraspinatus tendon: The patient was positioned to reach the contralateral shoulder for assessment. Subscapularis tendon: The arm was maintained in a neutral position; the tendon insertion was

observed through external rotation. Biceps long head: The arm was maintained in a neutral position, the elbow was flexed at 90°, and the forearm was supinated.

The ultrasonographic examination assessed the size of the calcific lesions (transverse and longitudinal measurements), their location, morphological characteristics, and associated diseases (bursal thickening, glenohumeral joint effusion).

Calcifications were classified into three morphological categories: (1) Arciform: hyperechogenic arcuate structure with or without shadowing. (2) Fragmented/punctate: a structure with a minimum of two distinct hyperechogenic foci with or without shadowing. (3) Nodular: hyperechoic nodular formation with or without shadowing (Fig. 1).

The thickness of the subacromial-subdeltoid bursa was measured at its widest position and compared to the contralateral side. A thickness of 2 mm or greater was considered indicative of bursitis (Fig. 2).

Glenohumeral joint effusion is characterized as a hypoechoic region located between the posterior glenoid labrum and the infraspinatus tendon.

The assessment was conducted at various intervals by two independent radiologists with 19 and 3 years of experience, and interobserver reliability was evaluated.

Assessment with magnetic resonance imaging

Magnetic resonance imaging was conducted with patients in the supine position, the shoulder in slight external rotation, utilizing a 1.5 Tesla MR device (Optima MR450w, GE Healthcare) and an 8-channel shoulder coil.

The scanning protocol comprised the subsequent sequences:

- Coronal oblique T1-weighted fast spin echo (FSE): TR/TE (ms): 416/13 FOV (mm): 160 mm, slice thickness (mm): 3, bandwidth (Hz/Px): 334, flip angle (°): 90
- Coronal oblique T2-weighted fat-suppressed FSE: TR/TE (ms): 5660/110 FOV (mm): 160, slice thickness (mm): 3, bandwidth (Hz/Px): 391, flip angle (°): 150
- Oblique sagittal fat-suppressed proton density FSE: TR/TE (ms): 3770/54, FOV (mm): 160, slice thickness (mm): 3, bandwidth (Hz/Px): 334, flip angle (°): 90
- Axial proton density fat-suppressed FSE: TR/TE (ms): 4120/54, FOV (mm): 160, slice thickness (mm): 3, bandwidth (Hz/Px): 250, flip angle (°): 136

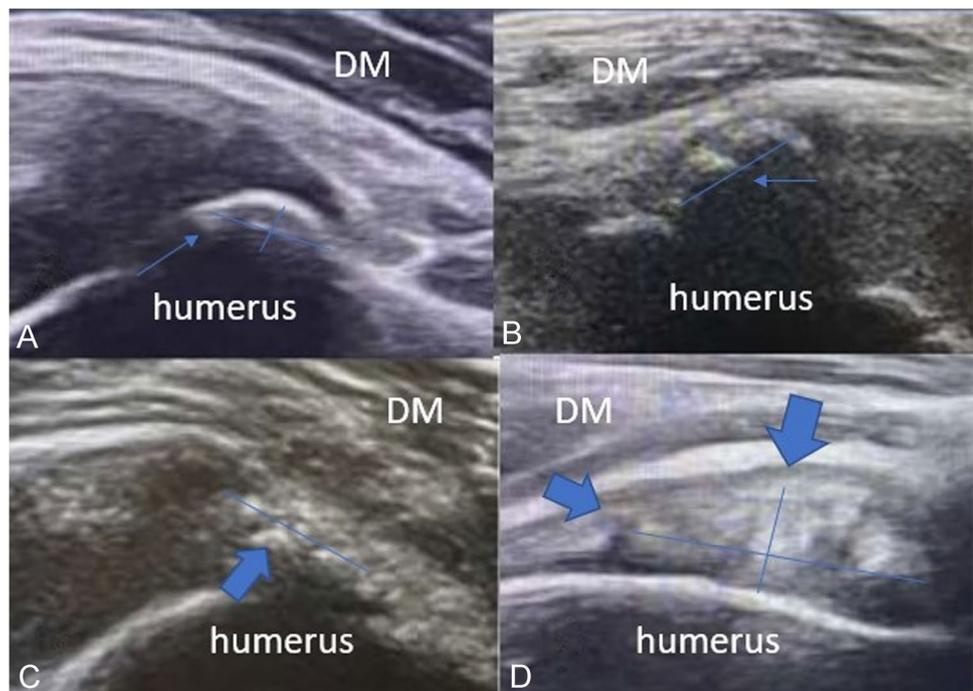
Calcific lesions were characterized as hypointense or band-like areas of signal loss on all sequences of MRI (Fig. 3).

Calcific lesions were categorized as unifocal or multifocal, with the dimensions of the biggest lesion recorded.

On MRI, subacromial-subdeltoid (SA/SD) bursitis was evaluated using proton density (PD) sequences in both coronal and axial planes. SA/SD bursitis was defined as a distended fluid-filled structure located between the deltoid muscle and the acromion, as well as the supraspinatus/infraspinatus tendons.

The degree of bursitis was assessed by measuring the fluid thickness on axial fat-suppressed PD images as follows:

Fig. 1 Ultrasonographic evaluation of different patients shows the types of crystal morphology observed at the attachment site of the supraspinatus muscle tendon to the humerus (H): arc-shaped (A), fragmented (B)/punctate (C), and nodular (D)-shaped (DM: Deltoid muscle). Calcific tendinopathy is marked with thin blue arrows in A and B, and calcific tendinopathy is marked with thick blue arrows in C and D. In all figures, thin blue straight lines indicate the medial–lateral and anteroposterior extension of calcific tendinopathy



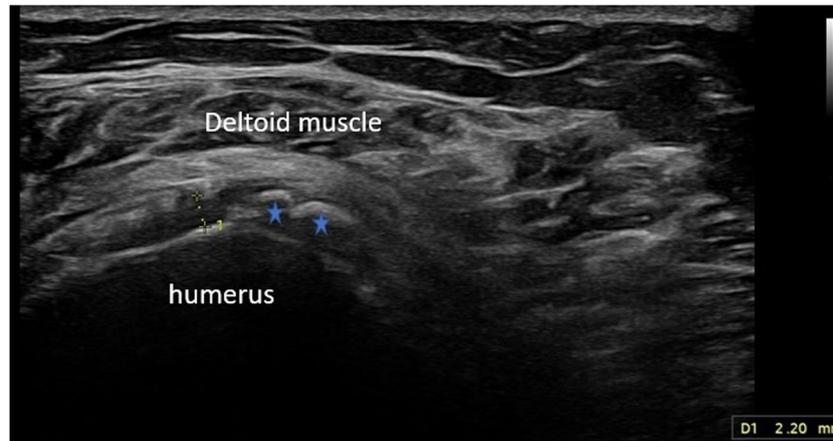
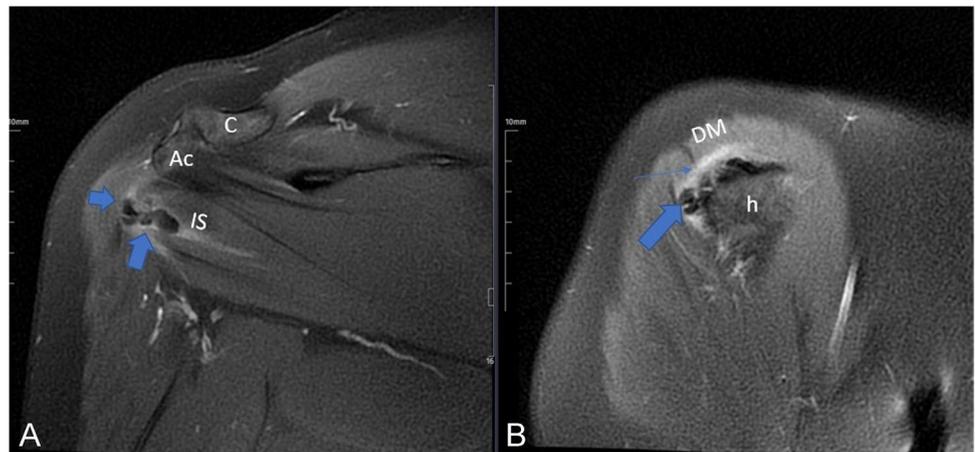


Fig. 2 A 49-year-old female patient; the measurement of fluid in the subdeltoid bursa is seen with the patient in a sitting position, while the patient extended their arm in internal rotation to retrieve a wallet from the back holding the US linear probe in the transverse plane. The thickness of the subdeltoid bursa has increased by 2.2 mm (dot-

ted line with cursors). Blue stars indicate two arc-shaped calcifications in the supraspinatus tendon. There is no acoustic shadowing posteriorly. The patient described moderate pain on physical examination

Fig. 3 A 39-year-old female patient was describing severe pain. Multifocal CT foci observed in the coronal plane (A) and sagittal plane (B) fat-suppressed PD (proton density) sequence images are marked with thick blue arrows. Hyperintensity due to subdeltoid bursitis is shown with a thin blue arrow. C, clavicle; AC, acromion; IS, infraspinatus muscle; DM, deltoid muscle; h, humerus



0–2 mm, mild; 2–3 mm, moderate; 3 mm, severe. Glenohumeral joint effusion is characterized by hyperintense fluid collection within the joint space on the coronal oblique PD sequence.

The MRI evaluations were performed at different time points by two radiologists with 19 and 16 years of experience in musculoskeletal imaging, and interobserver reliability was evaluated.

Orthopedic evaluation

The Constant-Murley Score (CMS) was employed for functional evaluation. The score is categorized as follows: (1) painless (75–100 pts); (2) mildly symptomatic (50–75 points); (3) moderately symptomatic (25–50 points); (4) highly symptomatic/severe pain (0–25 scores).

All assessments were conducted by an orthopaedist, and the outcomes were juxtaposed with symptom intensity.

Statistical analysis

All data were analyzed using NCSS 2022 statistical software (NCSS, LLC. Kaysville, Utah, USA).

Continuous variables were reported as mean \pm standard deviation, while categorical variables were presented as frequencies and percentages.

The relationship between US and MRI findings was evaluated using Pearson correlation analysis. Interobserver reliability for continuous variables, such as measurements of bursitis thickness, was assessed using the intraclass correlation coefficient (ICC). For categorical variables, including the presence or absence of joint effusion, Cohen's kappa coefficient was used. Group differences were assessed using

the chi-square test for categorical variables and either the independent *t*-test or the Mann–Whitney *U* test for continuous variables, depending on data distribution.

A *p*-value of $p < 0.05$ was considered statistically significant.

Results

This study comprised 60 patients diagnosed with rotator cuff calcific tendinopathy, comprising 45 women (75%) and 15 men (25%), with a mean age of 48 ± 8.8 years (range, 32–67 years). The mean duration of symptoms was 13 months, with a range from 20 days to 4 years. In 41 patients (68%), the dominant hand was the right, whereas in 19 patients (32%), it was the left, with the affected shoulder located on the dominant side in 70% of cases.

The detailed comparison of US and MRI findings, including interobserver correlation and morphological classifications, is presented in Table 1. The correlation between the two radiologists was excellent for all morphological classifications, with the highest agreement in nodular calcifications ($r = 0.98$, $p < 0.001$). Arc-shaped and fragmented/punctate calcifications also showed strong interobserver reliability ($r = 0.94$ and $r = 0.91$, respectively).

The presence of bursitis and calcification morphology demonstrated a significant correlation with pain severity, with fragmented and multifocal calcifications being associated with higher symptom intensity ($p < 0.001$), while

nodular calcifications had a weaker but still significant association ($p < 0.01$) (Table 2).

The relationship between calcification localization, morphology, presence of bursitis, and pain severity highlights the strongest correlation between supraspinatus involvement and bursitis ($r = 0.72$, $p < 0.001$). Infraspinatus calcifications were more frequently associated with moderate-severe pain (71%), while the only teres minor case exhibited nodular morphology and was linked to both bursitis and severe symptoms (Table 3).

No statistically significant relationship was found between the size of the calcific deposit and the pain score ($p > 0.05$).

Discussion

Our findings confirmed the study hypothesis, demonstrating that US and MRI showed similar diagnostic performance in identifying calcification morphology, bursitis, and glenohumeral joint effusion, with no statistically significant difference between modalities.

This study compares the diagnostic usefulness of US and MRI and looks at the relationship between imaging findings and clinical symptoms in people with calcific rotator cuff tendinopathy.

The results show that having bursitis and calcification morphology is the best way to predict how severe the pain will be. The study significantly links fragmented and multifocal calcifications to worse symptoms.

Table 1 Interobserver reliability and correlation analysis of ultrasound and magnetic resonance imaging (MRI) findings in calcific tendinopathy

Variable	US (Rad.1) (<i>n</i> = 60)	US (Rad.2) (<i>n</i> = 60)	ICC (<i>r</i>)	MRI (Rad.1) (<i>n</i> = 60)	MRI (Rad.2) (<i>n</i> = 60)	ICC (<i>r</i>)	<i>p</i> -value
Localization							
Supraspinatus	56 (93%)	55 (92%)	0.82	52 (87%)	53 (88%)	0.89	<0.001
Infraspinatus	4 (7%)	5 (8%)	0.68	7 (11%)	6 (10%)	0.88	<0.001
Teres minor	0	0	-	1 (2%)	1 (2%)	1.0	<0.001
Morphology							
Arc-shaped	24 (40%)	23 (38%)	0.94				
Fragmented/punctate	33 (55%)	34 (57%)	0.91				
Nodular	3 (5%)	3 (5%)	0.98				
Multifocal	-	-		32 (53%)	32 (53%)	1.0	<0.001
Single focus	-	-		28 (47%)	28 (47%)	1.0	<0.001
Bursitis and joint effusion							
Subacromial-subdeltoid bursa thickening	31 (52%)	30 (50%)	0.89	28 (47%)	30 (50%)	0.89	<0.001
Glenohumeral joint effusion	33 (55%)	32 (53%)		30 (50%)	35 (58%)	0.71	<0.01

Ultrasound (US) and magnetic resonance imaging (MRI) show a high level of correlation in terms of calcific tendinopathy location, morphological features, single/multifocal distribution, and inflammatory changes. While the US is more advantageous in determining inflammatory processes (bursitis and joint fluid increase) thanks to its dynamic examination ability, MRI stands out as a more powerful method, especially in detecting multifocal calcifications. Correlation analysis was performed using the Pearson correlation coefficient (*r*). $p < 0.001$ was accepted as a strong correlation, and $p < 0.01$ as a strong correlation

Rad radiologist, ICC intraclass correlation coefficient

Table 2 Correlation between bursitis, calcification morphology, and pain severity based on ultrasound and MRI findings

Variable	Mild pain (n = 22)	Moderate pain (n = 20)	Severe pain (n = 10)	No pain (n = 8)	Correlation coefficient (r)	p-value
Bursitis (US)	8 (36%)	14 (70%)	9 (90%)	0	0.81	<0.001
Bursitis (MRI)	7 (32%)	13 (65%)	8 (80%)	2 (25%)	0.78	<0.001
No bursitis (US)	14 (64%)	6 (30%)	1 (10%)	8 (100%)	-	
No bursitis (MRI)	15 (68%)	7 (35%)	2 (20%)	6 (75%)	-	
Fragmented/punctate (US)	5 (23%)	12 (60%)	9 (90%)	1 (12%)	0.76	<0.001
Arc-shaped (US)	15 (68%)	6 (30%)	1 (10%)	7 (88%)	-	
Nodular (US)	2 (9%)	2 (10%)	1 (10%)	0	0.65	<0.01
Multifocal (MRI)	4 (18%)	10 (50%)	8 (80%)	2 (25%)	0.74	<0.001
Single focus (MRI)	18 (82%)	10 (50%)	2 (20%)	6 (75%)	-	

Correlation between bursitis, calcification morphology, and pain severity based on ultrasound and MRI findings. The presence of bursitis showed a strong positive correlation with pain intensity in both ultrasound (US) and magnetic resonance imaging (MRI). The fragmentation of calcification (fragmented/punctate or multifocal) was found to be associated with higher pain levels. Calcifications in nodular form were found to be less symptomatic than fragmented and multifocal calcifications but were still associated with moderate-severe pain. The US is more advantageous in determining inflammatory processes (bursitis and joint fluid increase) thanks to its dynamic examination ability, while MRI stands out as a more powerful method, especially in determining multifocal calcifications

Table 3 Relationship between CT localization, morphology, and clinical symptoms

Localization	Arc-shaped (n,%)	Fragmented /Punctate (n,%)	Nodular (n,%)	Bursitis + (n,%)	Moderate- severe pain (n,%)	Correlation coefficient (r)	p-value
Supraspinatus (n = 56)	22 (39%)	30 (54%)	4 (7%)	28 (50%)	27 (48%)	0.72	<0.001
Infraspinatus (n = 7)	2 (29%)	3 (43%)	2 (28%)	4 (57%)	5 (71%)	0.65	<0.01
Teres minor (n = 1)	0	0	1 (100%)	1 (100%)	1 (100%)	-	-

Significant relationships were found between the location, morphological features, and clinical findings of calcific tendinopathy. In particular, infraspinatus and teres minor involvement is associated with more severe clinical symptoms, and the presence of bursitis is an important factor in the increase of these symptoms. Correlation analysis was performed using the Pearson correlation coefficient (*r*). $p < 0.001$ was accepted as a forceful correlation, and $p < 0.01$ as a strong correlation

The study also indicates that US is a valuable dynamic imaging tool for evaluating acoustic shadowing, detecting calcification morphology, and assessing tendon structure in real time. However, the visibility of acoustic shadowing on ultrasound may be influenced by technical parameters such as probe frequency, gain settings, depth, and the angle of insonation [7, 8]. Although our study did not find a statistically significant correlation between acoustic shadowing and pain severity, this feature may still hold diagnostic utility, for example, in identifying mature, well-mineralized deposits or in guiding ultrasound-based interventions such as percutaneous lavage [9, 10]. On the other hand, MRI remains useful for identifying deeper structural involvement, as well as detecting subacromial-subdeltoid bursitis and glenohumeral joint effusion, which may not always be visible on US [6, 7].

Our findings align with previous studies reporting that bursitis is significantly associated with symptom severity in calcific tendinopathy, emphasizing its role as a primary indicator of pain and functional limitations [9–11].

The relationship between bursitis and pain suggests that swelling in the subacromial-subdeltoid bursa makes symptoms worse, which makes it an important area to treat. Similar studies have shown that patients with coexisting bursitis often experience prolonged pain duration and reduced response to conservative treatments [9–11].

The classification of calcific tendinopathy on US was based on previously published studies that specifically address US-based morphological categorization, which we referenced in the manuscript [2, 4]. Additionally, certain morphological details visible on US could not be reliably identified on MRI. Therefore, calcifications on MRI were

grouped into only two categories: unifocal and multifocal. This discrepancy in morphological classification between modalities constitutes a methodological limitation of the study. The inability to apply the same granularity to MRI data as was possible with US restricts direct cross-modality comparisons. As a result, conclusions regarding morphology–pain correlations may be biased toward the superior resolution and classification capacity of US [4, 6, 7].

More often than not, fragmented/punctate and multifocal formations were associated with moderate to severe pain. This was seen when looking at the shape of the calcifications. This finding fits with other research that says fragmented calcifications are usually in a resorptive phase, which causes a stronger inflammatory response that makes pain worse [2–4].

On the other hand, arc-shaped calcifications, which usually indicate a more stable phase, were associated with less pain [2–4]. This finding supports the idea that pain severity is not just based on the presence of a calcification but also on its evolutionary stage [12]. These findings are consistent with the pathological framework of calcific tendinopathy [3, 5]. Arc-shaped calcifications, typically associated with the formative or quiescent phase, tend to be asymptomatic or mildly symptomatic due to minimal inflammation [2–5]. In contrast, fragmented or punctate calcifications correspond to the resorptive phase, which is characterized by increased vascularity and phagocytic activity, often resulting in acute pain. Nodular forms may represent an intermediate or late resorptive stage [2–5]. This phase-based interpretation supports the observed association between morphology and pain severity in our study and provides a pathophysiological rationale for symptom variation among patients.

Interestingly, our study found that teres minor calcification was associated with the highest pain severity, despite being the least frequently affected tendon. However, this observation is based on a single patient and should be interpreted as anecdotal rather than conclusive. This finding might be explained by the anatomical characteristics of the teres minor muscle, which is located deep in the body [8] and plays a biomechanical role in external rotation and posterior shoulder stability [12, 13]. Calcifications in this region may potentially exert pressure on adjacent neurovascular structures, thereby intensifying pain and functional impairment, particularly due to its proximity to the posterior glenohumeral joint and the quadrilateral space [12, 13].

Although the size of the calcific deposit did not show a significant association with shoulder pain in our study, the location of the deposit remains a clinically important factor, particularly when positioned near the subacromial impingement zone [2, 4]. This is consistent with the findings of Loew et al., who demonstrated a relationship between calcific tendinopathy and subacromial impingement based on radiographic and MRI assessments [14]. However, in

our cohort, the number of patients with calcifications near the critical impingement zone was limited, which may have prevented us from confirming this association.

Also, teres minor involvement in rotator cuff pathology is frequently missed, which can delay the right treatment and make symptoms worse [15]. These findings suggest that teres minor calcifications should be considered in patients with persistent posterior shoulder pain, particularly when standard treatments fail to provide relief [15, 16].

From a clinical perspective, these results underscore the importance of targeting inflammation rather than just the calcification itself in symptomatic patients. Since having bursitis is strongly linked to having a lot of pain, US-guided interventions like bursal steroid injections or lavage procedures may help symptoms more than treatments that only focus on getting rid of calcification [9–11, 17].

From a therapeutic standpoint, the imaging features described in this study may help guide clinical decision-making. Fragmented or punctate calcifications, which are often associated with the resorptive phase and a higher degree of inflammation, may benefit more from interventional approaches such as ultrasound-guided lavage or corticosteroid injection [17, 18]. In contrast, arc-shaped calcifications, which are generally stable and less symptomatic, may be managed conservatively [4]. Dynamic ultrasound evaluation, with its ability to assess vascularity and inflammation in real time, may be particularly useful during the resorptive phase to both diagnose active inflammation and guide intervention [9, 13].

Keeping a closer watch on patients with fragmented or multifocal calcifications and using stronger pain management techniques may be necessary, as these shapes are associated with a higher level of inflammation [17].

This study, despite its strengths, should acknowledge several limitations. First, the retrospective design might cause selection bias, which makes it harder to prove a link between imaging findings and clinical symptoms. Second, the performance of MRI and US examinations at different time points could potentially affect direct comparisons due to variations in disease progression. Third, interobserver variability remains a potential limitation, although ICC analysis demonstrated excellent agreement between radiologists. Lastly, the relatively small number of patients with infraspinatus and teres minor calcifications limits the statistical power of subgroup analyses, and larger, prospective multicenter studies are needed to validate these findings.

Recent advances in MRI technology, particularly zero echo time (ZTE) sequences, offer promising improvements in the imaging of calcific tendinopathy [5, 19]. Unlike conventional MRI, ZTE enables superior visualization of calcific deposits due to its ability to capture signal from short T2 tissues, such as hydroxyapatite [19]. Moreover, ZTE has been reported to distinguish between formative and resorptive phases of

calcification based on plaque shape, margin sharpness, and internal signal heterogeneity [5]. Incorporating ZTE into routine shoulder MRI protocols may improve phase-specific characterization and optimize clinical decision-making. Future studies comparing ZTE with ultrasound and conventional MRI could further elucidate its diagnostic and prognostic utility in patients with symptomatic calcific tendinopathy [5]. Future research should focus on prospective studies with standardized imaging protocols to further refine diagnostic and therapeutic approaches for calcific tendinopathy.

In conclusion, this study shows that bursitis and the shape and type of calcification are important factors that affect how painful rotator cuff calcific tendinopathy is. Both MRI and US provide valuable assessment of crystal morphology, the presence of bursitis, and the presence of glenohumeral joint effusion.

Data availability The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate This study was approved by the Institutional Review Board of T.C. Health Sciences University, Umraniye Research and Training Hospital. The ethics approval number is E-54132726–000-273642866.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Conflict of interest The authors declare no competing interests.

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