Skeletal Radiology (2019) 48:245–250
https://doi.org/10.1007/s00256-018-3018-1

SCIENTIFIC ARTICLE

Incidence of rotator cuff tears in the setting of calcific tendinopathy on MRI: a case controlled comparison

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Received: 9 February 2018 / Revised: 18 June 2018 / Accepted: 19 June 2018 / Published online: 7 July 2018

Abstract

Objective To compare the incidence of rotator cuff tears on shoulder MRI in patients who have rotator cuff calcific tendinopathy with that in patients without calcific tendinopathy in a frequency-matched case–control study.

Materials and methods Retrospective review shoulder MRIs of 86 patients with rotator cuff calcific tendinopathy and an 86-patient age-, gender-, and laterality-matched control group using frequency matching.

Results No statistically significant difference (odds ratio: 0.72, 95% confidence interval: 0.38–1.38, $p = 0.32$) was found in the incidence of rotator cuff tear in the calcific tendinopathy (27.9%) and control groups (34.9%). A significant ($p < 0.001$) difference in the size of rotator cuff tear was seen between the two groups, with 12.5% of tears being full-thickness in the calcific tendinopathy group and 63.3% of tears being full-thickness in the control group. Only 3 of the 24 (12.5%) rotator cuff tears present in the calcific tendinopathy group occurred at the site of tendon calcification.

Conclusion Patients presenting with indeterminate shoulder pain and rotator cuff calcific tendinopathy are not at increased risk for having a rotator cuff tear compared with similar demographic patients without calcific tendinopathy presenting with shoulder pain. Calcific tendinopathy and rotator cuff tears likely arise from different pathological processes.

Keywords Calcium apatite · Calcific tendinopathy · Rotator cuff tear · Periarthritis · Musculoskeletal · Hydroxyapatite

Introduction

Calcific tendinopathy is exceedingly common in the shoulder, being present in approximately 3–8% of asymptomatic shoulders and 33–42% of shoulders with symptoms of subacromial pain syndrome [1–5]. Calcific tendinopathy of the rotator cuff can present with severe subacromial pain resulting in a limited range of motion, which can mimic symptoms of a rotator cuff tear, making differentiation between these two entities a clinical challenge [6, 7]. This is an important distinction to make; however, rotator cuff tears may require surgical intervention whereas symptoms of calcific tendinopathy usually resolve with nonsurgical management or minimally invasive techniques such as Barbotage [7].

The association between rotator cuff calcific tendinopathy and rotator cuff tear is controversial. Jim et al. reported seeing rotator cuff tears on arthrography in 28% of patients with calcific tendinopathy, and a study of 74 rotator cuff tears by Wolfgang found tendon calcification in 23% of patients [8, 9]. However, operative studies by McLaughlin and Asherman and Friedman reported that rotator cuff tears occur only rarely in the setting of calcific tendinopathy, and an ultrasound study by Chiou et al. of 94 patients with rotator cuff calcific tendinopathy found no cases of rotator cuff tear associated with the region of calcification [1, 10, 11]. We suspect previous studies reporting a correlation between rotator cuff tears and calcific tendinitis suffered from selection bias, as these studies were based on operative findings, and only patients refractory to conservative management would progress to surgical intervention.

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We hypothesize that a low incidence of rotator cuff tears might be seen in the setting of calcific tendinopathy on MRI. In our experience, rotator cuff tears are infrequently associated with calcific tendinopathy of the rotator cuff on shoulder MRI, although, to our knowledge, a study of rotator cuff tears diagnosed on MRI in the setting of calcific tendinopathy has not been previously performed. The purpose of our study is to clarify the relationship between calcific tendinopathy and rotator cuff tears on shoulder MRI.

Materials and methods

Approval of the study was obtained from our institutional review board. A retrospective review was performed on the reports of all shoulder MRIs performed at our institution during the period December 2008 through November 2017. Reports were searched for any mention of calcific tendinopathy. A total of 3,187 reports were reviewed, with 100 reports (3.1%) mentioning calcific tendinopathy. The 100 shoulder MRIs with reports mentioning calcific tendinopathy were then reviewed independently by one musculoskeletally trained radiology faculty with 10 years of experience for evidence of calcific tendinopathy. Calcifications of calcific tendinopathy from hydroxyapatite deposition were defined as round areas of either homogeneous or heterogeneous low signal on all imaging sequences and with a globular appearance of calcifications on radiographs if available. Punctate calcifications or calcifications with a stippled appearance were considered to be dystrophic calcifications; however, none of the patients in this study had calcifications with this appearance. Fourteen additional shoulder MRIs were excluded based on no calcific tendinopathy being identified upon review, leaving a total of 86 shoulder MRIs included in the study. All MRI examinations included triplanar fluid-sensitive (either proton density or T2-weighted) fat-suppressed sequences, which were utilized for identifying and measuring rotator cuff calcifications and rotator cuff tears. None of the studies included gradient echo images.

Radiographs of the symptomatic shoulder performed within 30 days of the MRI were also reviewed if available. Forty-seven of the patients (54.7%) in the calcific tendinopathy group had shoulder radiographs performed within 30 days of the MRI (mean = 6.2 days, range = 0–30 days). All 47 patients had calcifications visible on radiographs that corresponded to calcifications identified on MRI.

Age, gender, and shoulder involved for each patient was recorded. Medical records were searched for a history of relevant co-morbidities (diabetes, hypothyroidism, amyloidosis, end-stage renal disease, inflammatory/crystalline arthritis, connective tissue disease, prolonged steroid use, previous high energy trauma, and previous shoulder surgery). Medical records were also reviewed for reports from surgery performed on the injured shoulder within 3 months of the shoulder MRI. Each MRI was assessed for the location of the calcific tendinopathy. Location of the calcification was recorded as the rotator cuff tendon involved, in addition to whether the calcifications were articular sided, bursal sided, or interstitial within the tendon. If more than one tendon demonstrated calcification, the tendon containing the largest focus of calcification was used for statistical analysis.

The rotator cuff of the calcific tendinopathy patients was assessed for a rotator cuff tear on MRI. Rotator cuff tear location and size were recorded with size categorized as either partial- or full-thickness tearing. Tear location was recorded based on tendon involved, with partial tears also recorded as articular-sided, bursal-sided, or interstitial.

A cohort of 86 age-, gender-, and laterality-matched patients with shoulder MRIs without calcific tendinopathy was created using frequency matching, with age being grouped by decade. For frequency matching, patients were selected so that the overall age, gender, and laterality of the control group match the study group. This is in distinction to individual matching where each study patient is matched with a control patient with the same age, gender, and laterality of the examination. The rotator cuff of the control group was also assessed for rotator cuff tear on MRI. Rotator cuff tear location and size were recorded for the matched control group using an identical method to the study group. Medical records of the control group were searched for a history of the co-morbidities evaluated in the calcific tendinopathy group in addition to the history of surgical intervention on the injured shoulder within 3 months of the MRI being performed.

The comparison between the case and the control groups with respect to age, gender, and laterality, in addition to the incidence, location, and size of the rotator cuff tear was conducted by two-sample t tests for continuous variables and by the Chi-squared test (or Fisher's exact test as appropriate) for categorical variables. The odds ratio and its 95% confidence interval (CI) of having rotator cuff tear in the calcific tendinopathy compared with control groups was calculated. Among the patients with calcific tendinopathy, the size of the calcification was compared using the Wilcoxon rank sum test. In addition, we stratified patients with calcific tendinopathy into three groups: partial-thickness tear, full-thickness tear, and without rotator cuff tear. We compared the patient demographics and the location, size, and types of the calcific tendinopathy among these three groups by analysis of variance (or Kruskal–Wallis test as appropriate) for continuous variables and Fisher's exact test for categorical variables. All statistical analyses were performed by the departmental statistician using SAS 9.4 (SAS Institute, Cary, NC, USA) and a p value <0.05 was considered significant.

Results

A small difference was seen in age between the calcific tendinopathy (mean age 51.6 years) and control (mean age 48.1 years) groups. Although this difference was marginally statistically significant ($p = 0.05$), the small difference in age is unlikely clinically significant. No statistically significant difference was seen in gender or shoulder laterality between the two groups (Table 1). None of the patients from either group reported high-energy trauma preceding presentation for shoulder MRI. MR arthrography was performed in 30 patients (34.9%) in the calcific tendinopathy group and in 23 (26.7%) patients in the control group (Table 1). The incidence of diabetes and hypothyroidism was higher in the calcific tendinopathy group as these two entities have a known association with calcific tendinopathy, although, only the incidence of diabetes reached statistical significance (Table 1). No significant difference was seen in the incidence of inflammatory arthritis, connective tissue disease, or previous shoulder surgery between the two groups (Table 1). Only 1 of the 6 shoulder surgeries in the calcific tendinopathy group involved the rotator cuff (16.7%), and only 2 of the 5 shoulder surgeries in the control group involved the rotator cuff (40%).

A trend was seen in rotator cuff tears being more prevalent in the control group; however, this did not reach statistical significance ($p = 0.32$; Table 1). Full-thickness rotator cuff tears were much more common in the control group (63.3% of tears) compared with the calcific tendinopathy group (12.5% of tears; $p < 0.001$). Location of rotator cuff tears did not vary significantly between the two groups ($p = 0.61$) with more than 90% of rotator cuff tears occurring in either the supraspinatus or infraspinatus tendons for both the control and calcific tendinopathy patients. There was poor concordance between the location of the calcifications and rotator cuff tear (Fig. 1). Of the 24 calcific tendinopathy patients with rotator cuff tear, 16 (67%) had cuff tears occurring in a tendon different than the tendon affected by calcification. Of the 8 patients who had calcification and rotator cuff tear occurring in the same tendon,

Table 1 Demographics and tear incidence comparison between calcific tendinopathy patients and the control group

Variable	Total ($N = 172$)	Calcific tendinopathy group ($N = 86$)	Control group ($N = 86$)	p value
Patient age (mean ± SD)	49.8 ± 11.9	51.6 ± 11.5	48.1 ± 12.1	0.05*
Patient gender, *n* (%)				0.88**
Female	93 (54.1)	46 (53.5)	47 (54.7)	
Male	79 (45.9)	40 (46.5)	39 (45.3)	
Comorbidities, *n* (%)				
Diabetes	21 (12.2)	15 (17.4)	6 (7.0)	0.04**
Hypothyroid	10 (5.8)	7 (8.1)	3 (3.5)	0.19**
Inflammatory/crystalline arthritis	6 (3.5)	3 (3.5)	3 (3.5)	1.0***
Connect tissue disease	1 (0.6)	0 (0.0)	1 (1.2)	1.0***
Prior shoulder surgery	11 (6.4)	6 (7.0)	5 (5.8)	0.76**
Shoulder side				0.76**
Left	78 (45.3)	40 (46.5)	38 (44.2)	
Right	94 (54.7)	46 (53.5)	48 (55.8)	
Arthrogram				0.25**
Yes	53 (30.8)	30 (34.9)	23 (26.7)	
No	119 (69.2)	56 (65.1)	63 (73.3)	
Rotator cuff tear, *n* (%)				0.32**
No	118 (68.6)	62 (72.1)	56 (65.1)	
Yes	54 (31.4)	24 (27.9)	30 (34.9)	
Rotator cuff tear size, *n* (%)				<0.001***
Full-thickness	22 (40.7)	3 (12.5)	19 (63.3)	
Partial-thickness	32 (59.3)	21 (87.5)	11 (36.7)	
Rotator cuff tear location, *n* (%)				0.61***
Supraspinatus	46 (85.2)	19 (79.2)	27 (90.0)	
Infraspinatus	5 (9.3)	3 (12.5)	2 (6.7)	
Subscapularis	3 (5.6)	2 (8.3)	1 (3.3)	

*Denotes p values obtained using a two-sample t test

**Denotes p values obtained using the Chi-squared test

***Denotes p values obtained using Fisher's exact test

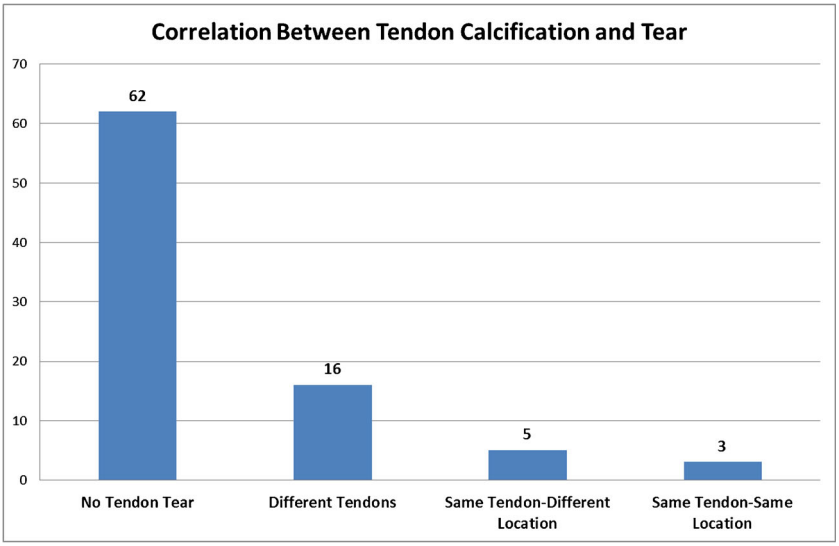

Fig. 1 Correlation between the rotator cuff tear and tendon calcification location

only 3 (13% of all rotator cuff tears) had a rotator cuff tear that corresponded to the exact site of tendon calcification.

A total of 12 patients (14.0%) in the calcific tendinopathy group underwent shoulder surgery within 3 months of the shoulder MRI. Seven of the 24 patients (29.2%) with calcific tendinopathy and rotator cuff tear on MRI proceeded to rotator cuff repair within 3 months of the MRI. Of the remaining 5 surgeries in the calcific tendinopathy group, 40 were for removal of tendon calcifications and 1 was for manipulation under anesthesia. Twenty-three patients (26.7%) in the control group underwent shoulder surgery within 3 months of the shoulder MRI. Eleven of the 30 patients (36.7%) in the control group with rotator cuff tear on MRI had rotator cuff repair. The remaining 12 surgeries in the control group comprised 4 labral repairs, 4 debridements, 2 manipulations under anesthesia, 1 AC repair, and 1 biceps tenodesis.

A statistically significant ($p = 0.02$) difference was seen in age between calcific tendinopathy patients with and without rotator cuff tear with rotator cuff tear patients being 4–8 years older on average than patients with no tear. A trend ($p = 0.07$) was seen toward patients with partial-thickness rotator cuff tears having larger calcifications, with the partial-thickness tear group having a calcification volume nearly twice the volume of the group with no rotator cuff tear. The full-thickness tear group had considerably smaller average size of calcifications, although the sample size of this group was very small ($n = 3$).

Discussion

The association between calcific tendinopathy and rotator cuff tears has been a point of debate for decades. In determining a relationship between calcific tendinopathy and rotator cuff tears, there are three methods by which these two pathological conditions may be related that need to be considered:

1. Calcific tendinopathy and rotator cuff tears share a similar pathogenesis
2. Calcific tendinopathy develops as a result of rotator cuff tears
3. Calcific tendinopathy predisposes to the development of rotator cuff tears

Calcific tendinopathy and rotator cuff tears share a similar pathogenesis

The etiology of calcific tendinopathy is uncertain. Originally, calcific tendinopathy was thought to arise from tendon fiber degeneration and focal necrosis resulting in calcium formation [12–14]. In the mid-1970s, Uhthoff and associates proposed a metaplasia mechanism for calcific tendinopathy in which tendon fibers transformed into fibrocartilage that subsequently underwent calcification [15, 16]. This proposed etiology of calcific tendinopathy by Uhthoff et al. has remained widely popular, although, a more recent study by Archer et al. has called into question this stepwise progression of tendon metaplasia with eventual calcification owing to the calcified fibrocartilage not having the typical immunohistochemical markers of chondrocyte-mediated calcium formation [17]. Our results are similar to those previously reported by Uhthoff and Archer, which suggests a pathway of calcium deposition in hydroxyapatite-related calcific tendinopathy separate from tendon degeneration with subsequent calcification.

Calcific tendinopathy develops as a result of rotator cuff tears

Rotator cuff tears most commonly occur as the result of tendon degeneration. Tendon degeneration is almost uniformly present in patients with rotator cuff rupture and this degeneration of the rotator cuff is associated with decreased

vascularity of the tendon [18, 19]. A relative avascular region in the rotator cuff has been described, termed the "critical zone," which exists approximately 1 cm medial to the insertion of the supraspinatus and anterior infraspinatus tendons and is a frequent site of rotator cuff degeneration and tear [19, 20]. This region has also been identified as a common location of rotator cuff calcification [19], and the association of calcifications with this avascular critical zone is a common reason why some believe that calcific tendinopathy is associated with degenerative tearing of the rotator cuff.

There are several features of calcific tendinopathy that argue against the calcifications of calcific tendinopathy arising as the result of tendon degeneration or avascularity. Calcific tendinopathy related to hydroxyapatite deposition occurs most frequently in patients 30–60 years old, but is also seen in patients as young as 3 years of age [2, 21]. By comparison, degenerative rotator cuff tears are seen with increasing frequency as patient age increases [22]. The avascular "critical zone" is also confined to the supraspinatus and anterior infraspinatus with no similar avascular regions identified in the subscapularis or teres minor [19]. Although many cases of calcific tendinopathy occur in this avascular region, it is not uncommon for calcific tendinopathy to involve other regions of the rotator cuff, or for the calcifications to be confined to the subdeltoid bursa, without evidence of tendon involvement. In our study, 16% of patients with calcific tendinopathy had calcification involving the subscapularis tendon, which has no identifiable avascular zone.

Despite clinical evidence that calcific tendinopathy related to hydroxyapatite deposition does not represent a precursor or sequela of degenerative tendon tearing, there is a clear association between rotator cuff tendon calcification and rotator cuff tears, both on histology and macroscopically [9, 18, 23, 24]. Yet, this type of calcification deposited at the site of rotator cuff tear appears to be histologically distinct from the calcifications seen in hydroxyapatite deposition. Riley et al. found that 33% of patients with degenerative rotator cuff rupture had significant calcium formation at the site of the tendon tear [25]. However, the calcifications associated with degenerative rotator cuff tears demonstrated variable phosphorus concentrations and calcium:phosphorus ratios. This suggests that multiple different calcium compounds might be responsible for the calcium mineralization seen in degenerative cuff tears. By comparison, all patients with calcific tendinopathy resembling hydroxyapatite deposition had phosphorus concentrations and calcium:phosphorus ratios consistent with hydroxyapatite crystals.

Calcific tendinopathy predisposes to the development of rotator cuff tears

Few studies have correlated the presence of rotator cuff tears with calcific tendinopathy on imaging. A study by Jim et al. of arthrography in symptomatic patients with calcific tendinopathy found that 27% had rotator cuff tears, with 68% of the tears being full-thickness [8]. It should be noted that the average age of patients in the study by Jim et al. was more than 61 years old, an age group in which degenerative rotator cuff tears are very common. Thirty-five percent of patients in our control group had rotator cuff tears, with 63% of those tears being full-thickness, which is similar to the prevalence of rotator cuff tears seen in the study by Jim et al. This suggests that the high prevalence of rotator cuff tears encountered in their study is likely more related to the age of the study population than the presence of rotator cuff calcification. Also, no correlation was made by Jim et al. between the location of the calcifications and tendon tear. We found that only 13% of rotator cuff tears present in patients with calcific tendinopathy occurred at the site of tendon calcification, which further suggests that calcific tendinopathy does not predispose to rotator cuff tears.

In a study using ultrasound to evaluate 94 patients with rotator cuff calcific tendinopathy, Chiou et al. reported no rotator cuff tears associated with the tendon calcifications [11]. The average patient age in Chiou's study was 57 years, which makes the absence of any rotator cuff tear surprising given the high prevalence of rotator cuff tears in this age group. Chiou et al. did not specify whether the entire rotator cuff was examined under ultrasound or just the region of calcification, and they did not specify the distribution of the tendon calcifications. Both of these factors would significantly alter the rate of expected rotator cuff tear. Nevertheless, our study did have similar findings to that of Chiou et al., in that only 3% of calcific tendinopathy patients (3 out of 86) had a rotator cuff tear that coincided with the region of tendon calcification, which again supports the hypothesis that calcific tendinopathy might not be associated with rotator cuff tears.

There are several limitations to our study. As our study used MRI instead of surgery as the gold standard for diagnosing rotator cuff tears, microtears or healed tears of the rotator cuff may have been underappreciated. The MRIs in our study and control groups also contained a mixture of unenhanced and arthrogram studies, which likely created some heterogeneity in the accuracy of MRI in diagnosing rotator cuff tears, as MR arthrography may be slightly more sensitive and specific in the diagnosis of rotator cuff tears compared with unenhanced MRI [26]. Finally, calcific tendinopathy was diagnosed based on MRI appearance, without confirmation of calcification being present on radiographs. All cases of calcific tendinopathy in this study were diagnosed based on consensus from two musculoskeletal trained radiologists, and calcification was visible on radiographs in all cases where radiographs were available. However, it is possible that some of the cases may have been diagnosed as calcific tendinopathy, without any visible calcification on radiographs.

Conclusion

Patients presenting with indeterminate shoulder pain and rotator cuff calcific tendinopathy are not at increased risk for having a rotator cuff tear compared with similar demographic patients without calcific tendinopathy presenting with shoulder pain. Calcific tendinopathy and rotator cuff tears likely arise from different pathological processes.

Acknowledgements 1. Memorial Hospital System in Houston.

2. We acknowledge the support provided by the Biostatistics/Epidemiology/Research Design (BERD) component of the Center for Clinical and Translational Sciences (CCTS) for this project. CCTS is mainly funded by a grant (UL1 TR000371) from the National Center for Advancing Translational Sciences (NCATS), awarded to the University of Texas Health Science Center at Houston. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NCATS.

Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflicts of interest.

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