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SCIENTIFIC ARTICLE

Calcific tendinopathy of the rotator cuff: the correlation between pain and imaging features in symptomatic and asymptomatic female shoulders

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Abstract
Objective To provide new epidemiological data regarding the prevalence, distribution and macroscopic features of shoulder rotator cuff calcific tendinopathy (calcific tendinopathy), and to identify the characteristics of calcific deposits associated with shoulder pain.
Materials and methods Three hundred and two female volunteers (604 shoulders) who had been referred to a gynaecological clinic participated in the study. The subjects underwent a high-resolution ultrasonography of both shoulders, and those with a diagnosis of calcific tendinopathy compiled a standardized questionnaire relating to shoulder symptoms. We determined the prevalence of symptomatic and asymptomatic rotator cuff calcific tendinopathy, and compared differences in distribution and macroscopic features of the symptomatic and asymptomatic calcifications.
Results The prevalence of calcific tendinopathy was 17.8 % (103 shoulders). Ninety-five shoulders (15.7 %) were symptomatic; of these, calcific tendinopathy was found in 34 shoulders (33 %) on imaging. Of the 509 asymptomatic (84.3 %) shoulders, calcific tendinopathy was observed in 69 cases (67 %). Among tendons, supraspinatus (53.4 %) and infraspinatus (54.6 %) were the most frequently involved. The majority of calcific deposits were of maximum diameter between 2 and 5 mm (77.9 %), and were linear in form (69.9 %). The involvement of multiple tendons and a location in the supraspinatus tendon were found to be significantly correlated with pain (p=0.023, p=0.043 respectively), as were age (p=0.041) and an excessive body mass index (p=0.024).
Conclusion In this sample from the general population of working age females, both intrinsic factors (location in supraspinatus, multiple tendon involvement) and extrinsic variables (age, abnormally high BMI) were correlated with pain in calcific tendinopathy. Level of evidence: Level III, cross-sectional study, prevalence study.

Keywords Calcific tendinopathy · Rotator cuff · Pain · Ultrasonography · Population-based study

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Introduction

Calcifying tendinopathy (calcific tendinopathy) of the shoulder is a common disorder, characterised by the presence of calcium phosphate crystals within the rotator cuff tendons. The prevalence of calcific tendinopathy in adults, evaluated with x-rays, has been reported to be between 2.7 and 10.3 % [1–4], and is higher in women than in men, especially between 30 and 60 years of age [5, 6]. The condition is bilateral in approximately 10 % of subjects [5, 7], and its etiology and pathogenesis are still largely unknown. Uthoff et al. outlined a cyclical, evolutionary development of the calcifying process, resulting in spontaneous resolution of the calcification, but the reason why pain is associated with calcium resorption is still unclear [6]. Another unexplained feature of this condition is that approximately one third of the subjects affected by shoulder calcific tendinopathy are completely asymptomatic [8].

In the literature very little can be found about the prevalence, distribution and macroscopic features of shoulder calcifications among large population samples. The few existing studies are not recent, and are mainly based on the radiographic appearance of calcifications [1, 4, 7]. Indeed, there have been only limited attempts to analyse possible links between the characteristics of calcifications and symptoms [6, 8–10].

Although most of the literature relates to conventional x-ray observations, B-mode ultrasound (US) has proved to be an excellent diagnostic tool for identifying and localizing calcification within the rotator cuff tendons [2, 11]. Its accuracy has been reported to be comparable to that of magnetic resonance imaging (MRI) [12]. Recent developments in high-resolution US technology enable the detection of very small calcific deposits, modifying the former knowledge about the epidemiology and the distribution of shoulder calcifications. Previous classifications based on acoustic shadow no longer seem appropriate and terminology should be developed that more accurately describes the actual morphology and presentation.

Given the lack of information regarding the origin and the natural history of calcific tendinopathy and, consequently, of a rationale for the treatment of the symptomatic forms, we believed that providing more data about this topic would be useful for developing guidelines for diagnosis and optimal treatment. We hypothesised that factors related to the macroscopic features of calcific deposits could differentiate asymptomatic from symptomatic rotator cuff calcific tendinopathy. Thus, the aim of this study was to provide epidemiological data regarding of the prevalence, distribution and macroscopic features of shoulder calcific tendinopathy, and to identify the characteristics of calcific deposits associated with shoulder pain. We chose an exclusively female population as females have a higher prevalence of periarticular calcifications.

Materials and methods

Between January and March 2013 all the patients referred to a gynaecological clinic for routine screening were asked if they were willing to participate in our study. Inclusion criteria for our study included female gender and age between 18 and 60 years old. Exclusion criteria were current pregnancy, having had previous shoulder surgery or shoulder fractures, or a diagnosis of cancer. Three hundred and two female volunteers (604 shoulders) met the inclusion/exclusion criteria and agreed to participate. All subjects signed an informed consent form, and the research was performed according to the Declaration of Helsinki principles.

Anthropometric characteristics, arm dominance, and systemic diseases that could affect the musculoskeletal system (i.e., diabetes and thyroid disease) were recorded before the subjects underwent a high-resolution ultrasonography of both shoulders. The US was performed by a single consultant radiologist with more than 10 years of musculoskeletal scanning experience (Logiq E9, G.E. Healthcare, Milwaukee, WI, USA), with a 15 MHz matrix linear probe (ML 6-15 D). The radiologist was blinded to the arm dominance and symptoms of the subjects. All examinations were performed according to a routine shoulder protocol, and the subjects were not informed of the results of the ultrasound examination.

Investigations included transverse and longitudinal planes for the supraspinatus, the subscapularis, the infraspinatus and teres minor tendons, in order to identify periarticular calcifications and their characteristics. The supraspinatus tendon was examined with the patient's shoulder in internal rotation, with the dorsum of the hand placed on the back in order to expose the supraspinatus from beneath the acromion. The probe was previously placed in the transverse orientation at the mid portion of the humeral head to visualize the tendon short axis; then the probe was rotated parallel to the humeral shaft to visualize the tendon long axis. The tendon appears as a hyperechoic fibrillar layer deep in the deltoid muscle, convex-shaped on transverse images, and convex, tapered and inserting at the greater tuberosity on longitudinal views. The infraspinatus and teres minor tendons were examined with the patient's hand placed on the contralateral shoulder, and the transducer was oriented in the axial plane until the head of the humerus was seen adjacent to the posterior glenoid labrum. Between the deltoid muscle and the external rotator tendons the subacromial-subdeltoid bursa was seen, appearing as a hypoechoic line of a thickness of less than 2 mm with a variable amount of peribursal echogenic fat. The subscapularis tendon was examined with the arm externally rotated, pulling the insertion of subscapularis tendon with it. The tendon was traced both longitudinally and transversally from its insertion into the lesser tuberosity to the point at which it becomes hidden to ultrasound by the coracoid process medially. A dynamic view of the subscapularis tendon was obtained when the shoulder of the subject was moved into external rotation.

The long head of the biceps tendon was identified in the intertubercular groove on the anterolateral aspect of the humerus with the arm in a neutral position, the elbow flexed to 90° and the forearm half pronated on their lap. This tendon was easily recognizable, due to the oval-shaped echogenic structure, surrounded by a 1–2 mm thick halo of fluid within the synovial sheath.

Rotator cuff calcifications were defined as echogenic focus with or without posterior acoustic shadowing. Due to the compound scanning technique, the acoustic extinction behind a calcific deposit is almost eliminated (it is evident only in the comparatively rare case of really dense targets) [13], revealing a substantially different morphology of calcifications. In light of this technical advance, we adopted the following terminology—"granular": calcifications with partially defined margins and irregular echogenicity (encompassing the previously

defined "arc-shaped", "nodular" and "fragmented" calcifications); "nodular": cystic appearance with a sediment-type content (previously "cystic" calcifications); and "linear": slight thickening following the course of the collagen fascicle (Figs. 1 and 2). The maximum diameter of the calcifications was measured, and they were classified as follows: less than 2 mm; between 2 and 5 mm; and greater than 5 mm. Finally, calcifications were defined as insertional if they were located within 1 cm from the tendon-bone insertion (the so-called "critical zone"), intermediate between 1 and 2 cm, and proximal if located more than 2 cm from the insertion. Tendon involvement was defined on the basis of the evaluation described in the preceding, considering the infraspinatus and teres minor together.

All subjects then responded to a questionnaire that investigated pain of the upper limb, based on the criteria of the Nordic Musculoskeletal Questionnaire [14]. The questionnaire was administered by an orthopaedic specialist, to ensure that each subject fully understood the questions. This questionnaire asked whether the subject had pain in their shoulders, and to describe the characteristics of the symptoms if pain was present. In order to capture chronic, acute and continuous symptoms, "pain" in our questionnaire was defined as being pain for at least one day a month, or for at least seven consecutive days, in the past year. A positive response to either of these possibilities was defined as a "symptomatic shoulder". A negative response was deemed an "asymptomatic shoulder".

Statistical analysis

We determined the prevalence of the calcific tendinopathy in all shoulders, and then in the symptomatic and asymptomatic subgroups. The sample was divided into four age classes of a decade each, and the percentage of shoulders with calcific tendinopathy in each decade was calculated. A logistic regression analysis was used to identify the factors involved in the presence of pain in calcific tendinopathy, using general factors

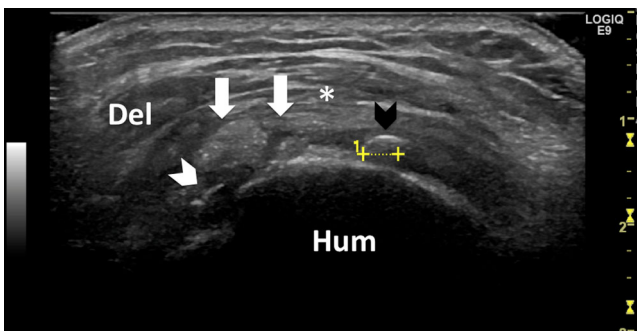

Fig. 1 Grey-scale US transverse scan of the supraspinatus tendon showing the three types of calcifications. *From left to right*: a small "linear" calcification following the course of the collagen fascicles (*white arrowhead*); a "nodular" cloud-like calcification (*arrows*) and a "granular" arc-shaped calcification (*black arrowhead*). *subdeltoid-subacromial bursa; *Del* deltoid; *Hum* humeral head

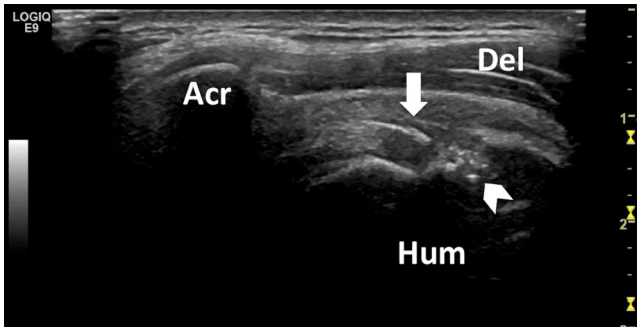

Fig. 2 Grey-scale US longitudinal scan of the supraspinatus tendon shows a "linear" calcification (*arrow*), following the course of the collagen fascicles in the insertional area of the tendon; irregular profile of the humeral head (*arrowhead*) under the insertional area of the tendon. *Acr* acromion; *Del* deltoid; *Hum* humeral head

(age, BMI, dominancy, multi-tendon involvement) as explanatory variables. In addition, another logistic regression was performed using specific factors (tendon involved, morphology and dimension of the calcific deposits), in order to identify the characteristics of the calcifications involved in the presence of pain. The Chi-square test was used to compare the dimensions of calcifications with respect to morphology, and to compare the presence of granular or nodular calcifications greater than 5 mm diameter among the different tendons. All statistical analyses were conducted with the IBM SPSS Statistics 21 software program (IBM Corporation, North Castle Drive, Armonk, NY 10504-1785, USA), and the critical value for significance was set at $p<0.05$.

Results

The anthropometric characteristics of the whole cohort are shown in Table 1. The right arm was dominant in 93.7 % of subjects. Three subjects had diabetes.The prevalence of calcific tendinopathy revealed by ultrasound was 17.1 % (103 shoulders). Of the 103 shoulders affected by calcific tendinopathy, approximately one third were symptomatic and two thirds asymptomatic. When these data were analysed against the shoulders without calcific tendinopathy, there was a significant correlation between calcific tendinopathy and pain (Table 2).

Table 1 Age and anthropometric characteristics of the sample. *SD* standard deviation

	Mean	SD	95 % CI
Age (years)	38.46	9.51	37.78–39.54
Height (cm)	163.53	6.13	162.84–164.23
Weight (kg)	62.11	12.01	60.75–63.47
BMI (kg/m^2)	23.21	4.21	22.73–23.68

Table 2 Results of US examination and pain questionnaire

	Symptomatic shoulders	Asymptomatic shoulders	Total shoulders
Calcific tendinopathy	33.0 % (*n*=34)	67.0 % (*n*=69)	100 % (*n*=103)
No calcific tendinopathy	12.2 % (*n*=61)	87.8 % (*n*=440)	100 % (*n*=501)
Total	15.7 % (*n*=95)	84.3 % (*n*=509)	100 % (*n*=604)
Odds ratio=3.554 (95 % CI: 2.177–5.803)*			

*Statistically significant correlation between pain and calcific tendinopathy. *n* number of shoulders

The supraspinatus tendon was the most frequently involved, followed by the infraspinatus (and teres minor), (53.4 and 45.6 % respectively). Calcifications with a maximum diameter between 2 and 5 mm were present in about three quarters in both symptomatic and asymptomatic shoulders (Table 3). Calcifications larger than 10 mm were observed in only four shoulders, two of which were symptomatic, and two were asymptomatic. The calcifications were insertional in almost all shoulders (97 %, 100 shoulders). Intermediate and proximal calcific deposits were present in only two and one asymptomatic shoulders, respectively. Fifteen symptomatic shoulders (44.1 %) and 14 asymptomatic shoulders (20.3 %) had multifocal distribution of calcifications (i.e. more than one calcification in the same shoulder).

Only one shoulder affected by calcific tendinopathy showed thickening of the subacromial-subdeltoid bursa (SSB) and this was symptomatic. SSB thickening was present in two other shoulders without rotator cuff calcific deposits; one was symptomatic and one was asymptomatic. The prevalence of calcific tendinopathy increased significantly with age in all shoulders (χ^2=50.992, p<0.001) (Fig. 3).

Table 3 Characteristics of calcifications observed on US: comparison between symptomatic and asymptomatic shoulders

		Symptomatic shoulder (*n*=34)	Asymptomatic shoulder (*n* =69)
Tendon involved	Supraspinatus	64.7 % (*n*=22)	47.8 % (*n*=33)
	Infraspinatus	50.0 % (*n*=17)	44.9 % (*n*=31)
	Subscapularis	32.4 % (*n*=11)	37.4 % (*n*=21)
Dimensions	<2 mm	0 % (*n*=0)	5.8 % (*n*=4)
	2–5 mm	77.6 % (*n*=24)	77.7 % (*n*=49)
	>5 mm	41.2 % (*n*=14)	36.2 % (*n*=25)
Morphology	Linear	77.6 % (*n*=24)	58.1 % (*n*=47)
	Granular	35.3 % (*n*=12)	37.4.0 % (*n*=29)
	Nodular	5.9 % (*n*=2)	4.3 % (*n*=3)

n number of shoulders

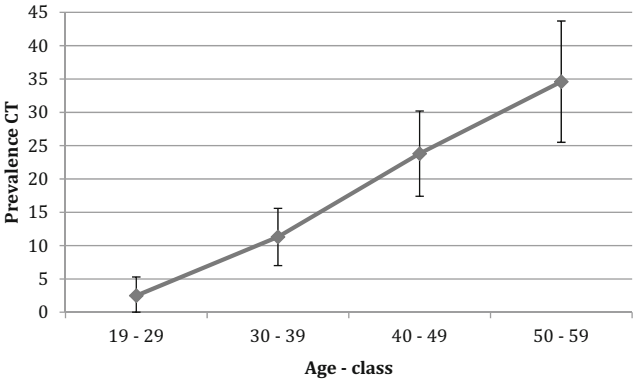

Fig. 3 Prevalence of calcific tendinopathy (calcific tendinopathy) with age

Radiological features of the calcific deposits

There was a total number of 192 separate calcifications found in the 103 shoulders with calcific tendinopathy. When the distribution of calcifications by location, (i.e. in which tendon they were located) and by morphology was analysed, a statistically significant relationship between these variables was observed χ^2=16.670, p=0.001 (Table 4).

Granular and nodular calcifications were found to be significantly larger than linear calcifications (χ^2=41.309, p < 0.001). Granular or nodular calcifications>5 mm were significantly more likely to be present in the supraspinatus and the infraspinatus tendons, both when the tendons were considered separately (χ^2=13.187, p <0.001), and when they were considered together (χ^2=5.458, p =0.019)

Results of regression analysis

The first regression analysis of the 103 shoulders affected by calcific tendinopathy tested the association between pain and the variables of age, BMI, arm dominance and multiple tendon involvement (i.e. calcific tendinopathy in more than one tendon). Only arm dominance was not correlated to pain (Table 5).In the second regression, the tendon location of the calcification was analysed for its association to pain. Of all these variables, only the presence of a calcification in the supraspinatus was significantly correlated with pain (Table 6).

Discussion

This study identified several characteristics of rotator cuff calcifications, and some systemic features extrinsic to the shoulder, that were associated with shoulder pain. Furthermore, the study gives new epidemiological data regarding calcific tendinopathy of the rotator cuff. In this sample taken from the general population of working age females, the prevalence of rotator cuff calcific tendinopathy was higher than that

Table 4 Distribution of calcific deposits by location and by morphology

Tendon	Morphology of calcific deposit			Total
	Linear	Granular	Nodular	
Supraspinatus	80.2 % (*n*=73)	18.7 % (*n*=17)	1.1 % (*n*=1)	100 % (*n*=91)
Infraspinatus (+ teres minor)	56.4 % (*n*=31)	36.4 % (*n*=20)	7.2 % (*n*=4)	100 % (*n*=55)
Subscapularis	89.1 % (*n*=41)	10.9 % (*n*=5)	0 % (*n*=0)	100 % (*n*=46)
Total	75.5 % (*n*=145)	21.9 % (*n*=42)	2.6 % (*n*=5)	100 % (*n*=192)

n number of calcifications

reported in other studies, as were the number of asymptomatic calcifications [1, 4]. However, it should be noted that most reports use radiographic observations and relate to selected populations, which influence the prevalence observed. Our relatively high prevalence may firstly be explained by the technological advances of US that allow the visualisation of even smaller deposits. The resolution of new US equipment is now so high that details as small as 300 μ can be detected. Secondly, as females have been shown to be more commonly affected by calcific tendinopathy, a higher prevalence is to be expected in an exclusively female population [3, 5, 6]. These conclusions are supported by a recent study published by the current authors, which used the same high resolution US in a female population, and reported a prevalence of calcific tendinopathy of 24.4 % [15].

However, the most striking difference we observed was in the distribution of calcifications in terms of tendon involvement, size and morphology. All previous reports are in agreement that the supraspinatus tendon is most commonly involved (from 51.5 to 90 %), with negligible rates for the other tendons [1, 3, 8]. We confirmed the most frequent localisation in the supraspinatus tendon; however, the infraspinatus and the subscapularis tendons seemed to be much more frequently of interest than previously reported [3]. In our study, the infraspinatus was involved in approximately half the shoulders affected with calcific tendinopathy, and most unusually, the subscapularis tendon was involved in approximately one third of the calcifications. The calcific deposits in the subscapularis were mainly linear and smaller than those observed in the supraspinatus/infraspinatus tendons, which may account for the very low prevalence of subscapularis tendon calcifications in the studies that used only plain radiographs for diagnosis [1]. Although it seems harder to explain the difference reported by other authors who employed US for diagnosis and yet observed less than 10 % of subscapularis calcifications and less than 2 % of infraspinatus calcifications, we should take into account that US frequency with lesser spatial resolution was used in the cited study (bandwith: 5–12 MHz instead of 6–15 MHz of our study) [8]. Another difference was apparent in the distribution of multifocal calcific deposits: we observed a prevalence of 28.2 % as compared with 8 % previously reported [9]. In agreement with the literature, almost all the calcifications in our cohort were insertional. Finally, with regard to a possible relationship between location (i.e. tendon involved) and symptoms, only calcifications in the supraspinatus tendon were found to be significantly related to pain (Table 6).

We could not confirm the existence of a relationship between pain and dimensions of the calcification observed by the other authors [1, 8]. Bosworth reported that symptoms mostly occurred when calcifications were larger than 1.5 cm in diameter and this finding has been substantially confirmed by a more recent study [1, 8]. However, the latter study reports a population specifically affected by shoulder calcific tendinopathy; therefore, it is reasonable to suppose that the presence of large calcifications would be more frequent than among a non-selected population. In our cohort, we observed only four cases of calcific deposits greater than 1 cm, even though the study group was larger than that of Le Goff et al. and taken from the segment of population more frequently

Table 5 Results of logistic regression analysing factors linked to pain in rotator cuff calcific tendinitis

Variables	*p*	Odds ratio	95 % CI	
			Lower	Upper
Age	0.041*	1.078	1.003	1.158
BMI (>25/<25 km/m^2)	0.024*	2.868	1.148	7.169
Arm dominance (dominant/non-dominant)	0.381	1.514	0.599	3.827
Multiple tendon involvement (yes/no)	0.033*	2.890	1.090	7.659

*Statistically significant at $p<0.05$

Table 6 Results of logistic regression analysing factors linked to pain in rotator cuff calcific tendinitis

	Variables	*p*	Odds ratio	95 % CI	
				Lower	Upper
Tendon involved	Supraspinatus (yes/no)	0.043*	3.135	1.036	9.488
	Infraspinatus (yes/no)	0.155	2.318	0.729	7.372
	Subscapularis (yes/no)	0.189	2.195	0.679	7.098
Dimension	< 2 mm (yes/no)	0.153	8.255	0.458	148.928
	2–5 mm (yes/no)	0.147	7.006	0.505	97.133
	>5 mm (yes/no)	0.172	9.136	0.383	218.146
Morphology	Linear (yes/no)	0.999	0	0	0
	Granular (yes/no)	0.155	0.168	0.014	1.967
	Nodular (yes/no)	0.234	0.243	0.024	2.500

*Statistically significant at $p<0.05$

affected by shoulder calcific tendinopathy [8]. Most of the subjects showed calcifications with a maximum diameter of between 2 and 5 mm. Nevertheless, our data did agree with previous findings in the literature with regard to symptoms: small calcifications (with a diameter <1 cm) do not correlate with shoulder pain. This conclusion may explain the higher number of asymptomatic calcifications we observed than in other reports as most of the calcifications identified were smaller than those reported [5, 8]. Another conclusion that can be drawn from our experience is that the presence of large calcifications is not a frequent occurrence.

In the literature, fragmentation of the calcific deposit has been shown to be the one morphological characteristic correlated with pain [8, 10] and may imply the acute resorption of the calcification leading to the spontaneous resolution of symptoms [16]. Although we used a different morphological classification to those on which these reports are based (in order to reflect the increased detail given by higher resolution US), our terminology encompasses all the previous classes of calcific deposits. Nevertheless, in our analysis we found that no aspect of morphology was correlated to pain. As stated above, this may be due to the smaller size of calcifications observed in our cohort.

Although some intrinsic characteristics of calcifications were significantly correlated to pain, the strongest correlations we observed were related to factors external/extrinsic to calcifications like age and an abnormally high BMI. The increase of pain with age, strictly resembles the observations for rotator cuff tears [17, 18], and likewise, an abnormal BMI has been shown to be a risk factor for developing a rotator cuff tendinopathy or tear [19, 20].

There are some clear limitations to this study. Firstly, it is a cross-sectional study, so diachronic changes of pain were not recorded. Secondly, the exclusively female study population may affect our conclusions regarding the characteristics of calcifications and their relationship to pain, as women have been shown to experience and report pain differently to men [21]. Thirdly, we did not perform color Doppler scan in conjunction with the US, as recommended by some authors as being predictive of whether a calcification is painful or not [8, 10]. However, in a recent study conducted on selected patients affected by shoulder calcific tendinopathy, Le Goff et al. observed a positive power Doppler signal in only 36 % of symptomatic shoulders, and in the presence of very large calcifications (mean dimension of 1.93×1.46 cm) [8]. In spite of the limitations of this study, we believe that the accurate study design (radiologist was blinded to all patient information), the large number of subjects studied, and the high quality imaging technology used may give a new insight into the morphology, distribution and frequency of different types calcifications, adding knowledge to the epidemiology of calcific tendinopathy.

Conclusions

Calcific tendon deposits of the shoulder are a frequent occurrence in the general population, although only one third are painful. The hypothesis of this study was whether shoulder pain, in the presence of rotator cuff calcifications, could be correlated to the macroscopic features of the calcific deposits. We observed that pain is actually correlated to several factors that can be intrinsic to tendons (i.e. location at supraspinatus and multiple tendon involvement) or extrinsic (i.e. age and BMI). However, further prospective studies are required to elucidate factors that can be involved in the occurrence and development of symptoms.

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Conflict of interest The authors declare that they have no conflict of interest

References

1. Bosworth BM. Calcium deposits in the shoulder and subacromial bursitis: a survey of 12,122 cases. J Am Med Assoc. 1941;116: 2477–82.
2. Farin PU, Jaroma H. Sonographic findings of rotator cuff calcifications. J Ultrasound Med. 1995;14:7–14.
3. Clavert P, Sirveaux F. Société française d'arthroscopie: Les tendinopathies calcifiantes de l'épaule [Shoulder calcifying tendinitis]. Rev Chir Orthop Reparatrice Appar Mot. 2008;94(8):S336–55.
4. Mavrikakis ME, Drimis S, Kontoyannis DA, Rasidakis A, Moulopoulou ES, Kontoyannis S. Calcific shoulder periarthritis (tendinitis) in adult onset diabetes mellitus: a controlled study. Ann Rheum Dis. 1989;48:211–4.
5. McKendry RJ, Uhthoff HK, Sarkar K, Hyslop PS. Calcifying tendinitis of the shoulder: prognostic value of clinical, histologic, and radiologic features in 57 surgically treated cases. J Rheumatol. 1982;9(1):75–80.
6. Uhthoff HK, Loehr JW. Calcific tendinopathy of the rotator cuff: pathogenesis, diagnosis, and management. J Am Acad Orthop Surg. 1997;5:183–91.
7. De Palma AF, Kruper JS. Long-term study of shoulder joints afflicted with and treated for calcific tendinitis. Clin Orthop. 1961;20:61–72.
8. Le Goff B, Berthelot JM, Guillot P, Glémarec J, Maugars Y. Assessment of calcific tendonitis of rotator cuff by ultrasonography: comparison between symptomatic and asymptomatic shoulders. Joint Bone Spine. 2010;77(3):258–63.
9. Ogon P, Suedkamp NP, Jaeger M, Izadpanah K, Koestler W, Maier D. Prognostic factors in nonoperative therapy for chronic symptomatic calcific tendinitis of the shoulder. Arthritis Rheum. 2009;60(10):2978–84.
10. Chiou HJ, Chou YH, Wu JJ, Hsu CC, Huang DY, Chang CY. Evaluation of calcific tendonitis of the rotator cuff: role of color Doppler ultrasonography. J Ultrasound Med. 2002;21(3):289–95.
11. Papatheodorou A, Ellinas P, Takis F, Tsanis A, Maris I, Batakis N. US of the shoulder: rotator cuff and non-rotator cuff disorders. Radiographics. 2006;26(1), e23.
12. Teefey SA, Rubin DA, Middleton WD, Hildebolt CF, Leibold RA, Yamaguchi K. Detection and quantification of rotator cuff tears: comparison of ultrasonographic, magnetic resonance imaging, and arthroscopic findings in seventy-one consecutive cases. J Bone Joint Surg Am. 2004;86-A(4):708–16.
13. Entrekin RR, Porter BA, Sillesen HH, Wong AD, Cooperberg PL, Fix CH. Real-time spatial compound imaging: application to breast, vascular, and musculoskeletal ultrasound. Semin Ultrasound CT MR. 2001;22(1):50–64.
14. Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sørensen F, Andersson G, et al. Standardized Nordic Questionnaire for the analysis of musculoskeletal symptoms. Appl Ergon. 1987;18:233–7.
15. Sansone V, Meroni R, Boria P, Pisani S, Maiorano E. Are occupational repetitive movements of the upper arm associated with rotator cuff calcific tendinopathies? Rheumatol Int. 2014. doi:10.1007/s00296-014-3086-z.
16. Chiou HJ, Chou YH, Wu JJ, Huang TF, Ma HL, Hsu CC, et al. The role of high-resolution ultrasonography in management of calcific tendonitis of the rotator cuff. Ultrasound Med Biol. 2001;27(6): 735–43.
17. Yamamoto A, Takagishi K, Kobayashi T, Shitara H, Osawa T. Factors involved in the presence of symptoms associated with rotator cuff tears: a comparison of asymptomatic and symptomatic rotator cuff tears in the general population. J Shoulder Elb Surg. 2011;20(7):1133–7.
18. Tashjian RZ. Epidemiology, natural history, and indications for treatment of rotator cuff tears. Clin Sports Med. 2012;31:589–604.
19. Wendelboe AM, Hegmann KT, Gren LH, Alder SC, White GL, Lyon JL. Associations between body-mass index and surgery for rotator cuff tendinitis. J Bone Joint Surg Am. 2004;86:743–7.
20. Gumina S, Candela V, Passaretti D, Latino G, Venditto T, Mariani L, et al. The association between body fat and rotator cuff tear: the influence on rotator cuff tear sizes. J Shoulder Elb Surg. 2014;23(11):1669–74.
21. Frot M, Feine JS, Bushnell MC. Sex differences in pain perception and anxiety: a psychophysical study with topical capsaicin. Pain. 2004;108:230–6.