Received:
15 May 2015

Revised:
2 November 2015

Accepted:
25 November 2015

doi: 10.1259/bjr.20150407

Cite this article as:

Bazzocchi A, Pelotti P, Serraino S, Battaglia M, Bettelli G, Fusaro I, et al. Ultrasound imaging-guided percutaneous treatment of rotator cuff calcific tendinitis: success in short-term outcome. *Br J Radiol* 2016; **89**: 20150407.

INTERVENTIONAL MSK PROCEDURES SPECIAL FEATURE: FULL PAPER

Ultrasound imaging-guided percutaneous treatment of rotator cuff calcific tendinitis: success in short-term outcome

¹ALBERTO BAZZOCCHI, MD, PhD, ¹PATRIZIA PELOTTI, MD, ¹SALVATORE SERRAINO, MD, ¹MILVA BATTAGLIA, MD, ²GRAZIANO BETTELLI, MD, ³ISABELLA FUSARO, MD, ^{4,5}GIUSEPPE GUGLIELMI, MD, ²ROBERTO ROTINI, MD and ¹UGO ALBISINNI, MD

¹Diagnostic and Interventional Radiology, The "Rizzoli" Orthopaedic Institute, Bologna, Italy

²Shoulder and Elbow Surgery Unit, The "Rizzoli" Orthopaedic Institute, Bologna, Italy

³Physical Therapy and Rehabilitation Unit, The "Rizzoli" Orthopaedic Institute, Bologna, Italy

⁴Department of Radiology, University of Foggia, Foggia, Italy

⁵Department of Radiology, Scientific Institute "Casa Sollievo della Sofferenza" Hospital, Foggia, Italy

Address correspondence to: Dr Alberto Bazzocchi

E-mail: abazzo@inwind.it

Objective: Rotator cuff calcific tendinitis (RCCT) is a common cause of shoulder pain in adults and typically presents as activity-related shoulder pain. Between non-surgical and surgical treatment options, today a few minimal invasive techniques are available to remove the calcific deposit, and they represent a cornerstone in the management of this painful clinical condition. The aim of the work was a retrospective evaluation of double-needle ultrasound-guided percutaneous fragmentation and lavage (DNL), focused on understanding the factors which are of major importance in determining a quick and good response at 1 month.

Methods: A series of 147 patients affected by RCCT and suitable for DNL were evaluated. A systematic review of anamnestic, clinical and imaging data was performed in 144 shoulders treated in a single-centre setting. Clinical reports and imaging examinations were revisited. The inclusion criteria were submission to DNL, therefore fitness for the percutaneous procedure, and following 1-month follow-up. There was no exclusion owing to risk of bias. The treatment was defined as successful for constant shoulder modified score (CSS) improvement of >50% at 1 month.

Results: In 70% of shoulders, the treatment resulted in a quick and significant reduction of symptoms (successful). On the whole, CSS increase at 1 month was estimated

at $91.5 \pm 69.1\%$. CSS variations were significantly related to age of patients (better results between 30 and 40 years old), calcification size (more relevant improvement for middle-sized calcifications, 12–17 mm), sonographic and radiographic features of calcific deposits (softer calcifications) and thickening of subacromial/subdeltoid bursa walls. In the final model of stepwise regression for CSS variation, ultrasound score pre-treatment and post-treatment, the distance between bursa and calcification before treatment and the size of post-treatment calcification area were shown to be independently correlated to success. Numeric rating scale score for pain showed similar results. Pain at admission was also related to age, calcification size, ultrasound and Gärtner score, power Doppler positivity, bursal wall thickening and biceps tenosynovitis.

Conclusion: The success of the procedure with quick improvement in function and symptoms is warranted in soft and middle-sized calcifications, in young adults.

Advances in knowledge: Ultrasound-guided percutaneous procedures for RCCT must be safe, effective and with prompt pain relief and function restoration. This study shows which clinical picture is more favourable to this purpose and actual prognostic factors for DNL (soft and middle-sized calcifications, in young adults, are more favourable).

INTRODUCTION

Rotator cuff calcific tendinitis (RCCT) is a common condition, occurring in up to 20% of painful shoulders and even present in up to 7.5% of asymptomatic shoulders.

Females are more frequently affected by this condition (70% of cases), typically during their 5th decade of life. The classic clinical manifestation is a low-grade subacute pain that usually increases at night. In many cases,

however, RCCT can be a highly disabling disorder with pain resistant to high doses of oral anti-inflammatory drugs.^{1–3} There are numerous theories on the pathogenesis of RCCT, as well as associations with human physiopathology and disorders.^{4–7} At the same time, the tendon enthesis also deserves consideration.⁸ However, the aetiopathogenesis of RCCT is still not clear, and the mechanism of calcium deposition—predominantly hydroxyapatite, in rotator cuff tendons—is a matter of debate.^{9,10} The origin is considered multifactorial as a result of extrinsic and intrinsic factors.⁴ Apart from anatomical or biomechanical conditions (*i.e.* extrinsic factors), intrinsic factors include changes related to ageing, vascularity, overloading, endocrinological status, genetics etc. The supraspinatus tendon is most commonly affected (80% of cases), followed by the infraspinatus (15%) and subscapularis (5%).² Calcific deposits can also be found in numerous other tendons in the body, with different clinical evolutions. However, intratendinous rotator cuff calcifications tend to be reabsorbed after a period of acute pain. RCCT is thought to be an active, cell-mediated process, although the exact pathophysiology remains unclear.¹¹

Notwithstanding the epidemiology and impact of RCCT, no standard of care has been established, and management of the disease is still variable.¹¹ There is poor literature evidence on the complications of this condition with little consensus on the treatment of choice. And even the question is still there... Calcifications in the cuff: take it or leave it?¹²

There are a number of conservative treatment options available: non-steroidal anti-inflammatory drugs and multiple modalities are often used to manage pain and inflammation; physical therapy can help improve scapular mechanics and decrease dynamic impingement; and corticosteroid injections. More “radical” treatment options include shock wave therapy,¹³ image-guided procedures¹⁴ and surgery.^{15–17}

In the 1990s, ultrasound-guided techniques were developed to address this issue.^{18,19} Today, ultrasound-guided percutaneous treatment is pivotal.^{2,20} Ultrasound-guided needle aspiration and lavage techniques can remove calcium deposit and provide long-term improvement in pain and function in these patients.²¹ The technique is based on shared mainstay; however, several technical features were independently introduced and can make the difference.^{22–24}

The adjunct of ultrasound-guided needling and lavage to ultrasound-guided corticosteroid injection in the subacromial/subdeltoid bursa was demonstrated to significantly improve clinical and radiographic outcomes at 1 year.²⁵ Following a specific rehabilitation protocol after the procedure may also result in better outcomes.^{26–28}

Ultrasound-guided needling also showed better results in function restoration and pain relief in the short term than extracorporeal shock wave therapy, both improving clinical outcome and eliminating calcific deposit.²⁹

The correct selection of patients to be submitted to ultrasound-guided percutaneous treatment is crucial.

The evolution of calcification submitted to treatment has been investigated for ages, from several points of view: histopathological, imaging and clinical.^{30–32}

First, radiologic course of the calcific deposits in RCCT: does the initial radiologic aspect affect the final results? Excellent or good results (72%) in terms of clinically significant improvement were obtained with conservative treatment regardless of location, size, symptoms and radiologic type of calcifications.³¹

In a study comparing symptomatic and asymptomatic shoulders (62 patients), positive power-Doppler signal within the calcific deposit and subacromial/subdeltoid widening were demonstrated as strongly associated with pain; larger and fragmented calcifications were also more symptomatic.³³

Typically, the most painful and symptomatic phase is when a fragmentation of the calcification develops and fragments starts to migrate to the bursa enhancing bursitis, pain and function limitations.

In such a benign, self-limiting, young patient-affecting disease, the treatment of choice should be both of low invasivity and with a pain relief as immediate as possible.

The purpose of our study was a retrospective review of a single-centre experience of double-needle ultrasound-guided percutaneous treatment of fragmentation and lavage (DNL) in RCCT, in order to explore anamnestic, clinical and imaging features as potential prognostic factors in determining the success and the clinical and imaging outcomes in the first month after the procedure. Hence, the primary aim of this work was to assess the correlation between different features of calcifications and patients presenting with RCCT and short-term clinical success of DNL as treatment of choice, to further address selection criteria and expectations for DNL. A secondary aim includes the analysis of such factors to understand which feature or clinical condition was more related to pain in RCCT.

METHODS, MATERIAL AND POPULATION

After a clinical experience of more than 10 years, with 1000 of treated patients, an established approach at our institute (The “Rizzoli” Orthopaedic Institute) was performed with a treatment course including (a) clinical and radiological screening and evaluation, (b) half-day hospitalization setting supported by clinical evaluation, imaging-guided intervention (DNL), physiatrist evaluation and teaching session, and discharge, and (c) clinical and radiological evaluation repeated 1 month later, and further on, if necessary.

A series of 147 patients submitted to DNL for RCCT in a single-centre setting within the last year were evaluated. The inclusion criteria were submission to DNL, therefore fitness for the percutaneous procedure, and following 1-month check. There were no exclusion criteria owing to risk of bias. However, exclusion criteria for DNL were the presence of comorbidities which might undermine the safety and efficacy of the procedure (*e.g.* tendon tears, infection, systemic conditions counterindicating drugs used in the procedure etc.).

A systematic review of anamnestic, clinical and imaging data was performed. Clinical reports and imaging examinations were revisited. An independent reader performed the analysis, blinded concerning patients' name, case history and imaging examinations (random presentation).

Patients undergoing the procedure were typically screened for suitability by ultrasound to consider the status of the calcific deposit and tendon, as well as symptoms and clinical condition, and to exclude unwanted potential comorbidities (*e.g.* ipsilateral concomitant cuff tears). Conventional X-ray examinations and MRI could be available.

Ultrasound examinations and ultrasound-guided procedures were performed by three expert musculoskeletal radiologists.

When an RCCT was suitable for DNL, this was the treatment of choice.

Ultrasound-guided procedure

The classic procedure was guided by ultrasound imaging (HI VISION Preirus, Hitachi Medical Corporation, Tokyo, Japan) with a 6–14 MHz high-resolution broadband linear-array transducer to approach the shoulder. After informed consent, patients were positioned lying in lateral decubitus, on the opposite side of the shoulder undergoing treatment. After adequate disinfection, ultrasound-guided injection of local anaesthesia [maximum 10 ml of 2% mepivacaine chloridrate, Mepicain (Monico SPA, Venezia/Mestre, Italy), 22-gauge needle] into the subacromial/subdeltoid bursa, subcutaneous tissues and around the calcification was performed with the intent to reduce intraprocedure pain and to test the status and adhesion of the bursal walls. At this time, the presence and the severity of adhesive bursitis could be assessed and the distension produced by the injection of anaesthetic liquid to unstick the bursa.

Two 18-gauge needles were inserted inside the calcification under continuous ultrasound monitoring. Depending on the calcification composition, a needling/fragmentation was performed or not. Calcification was then washed with a 20-ml syringe of saline solution (NaCl 0.9%) connected to one of the needles. Under pulsed pressure exerted, the solution entered from one needle and drained through the other, without any aspiration. This step was repeated a number of times until the flushed fluid was completely free of visible calcium and the calcification was collapsed and removed as much as possible. Where necessary, for biggest deposits, one more needle was used to support needling or lavage. Once the washing phase was completed, one of the two needles was extracted from the shoulder and the other needle was slightly pulled out to place the tip into the subacromial/subdeltoid bursa and 1 ml of methylprednisolone acetate (40 mg ml⁻¹ Depo-Medrol, Pfizer, New York, NY) was injected under direct ultrasound guidance. Finally, ultrasound examination was performed after the procedure to detect any potential immediate complication (abnormal bleeding, tendon ruptures etc.) and any adverse event was recorded (*e.g.* vagal reaction). Medication followed the procedure and instant ice was applied when necessary. The mean total duration of the treatment was estimated to be about 45 min (Figure 1).

Extracare

In the morning, patients were admitted and evaluated by an orthopaedic surgeon, then underwent the procedure and thereafter each patient was observed for approximately 30 min and later evaluated by physiatrists also for a teaching session on the standard recovery exercise plan. The patient's home programme, recommended below the pain threshold, was based on (1) exercises for shoulder lowering and decoaptation to be performed also in common daily activities, (2) assisted and active self-mobilization (recovery of range of motion), (3) isometric strengthening of rotator cuff and deltoid, (4) stretching in elevation, abduction and rotation.^{27,28} The programme was tested with the assistance of a therapist. At the end of the morning patients were discharged from the department, with anti-inflammatory drugs on demand and physiatrist programme to be performed in the subsequent month.

Follow-up

All patients underwent clinical and ultrasound follow-up at 1 month and continued to be managed depending on the short-term outcome. Those patients who experienced recurrence of their initial pain or discomfort underwent additional ultrasound and clinical examinations to reconsider bursitis or the presence of residual calcific deposits for potential retreatment (Figures 1 and 2).

The tendon and shoulder affected by calcium deposit in each patient were recorded, and the ultrasound (and X-ray) appearance of the calcium deposit was described as well as other comorbidities. The calcification was classified as hard (when manifesting with a hyperechoic rim, thick wall and strong posterior acoustic shadow—Type 0), medium (when manifesting with a thin irregular hyperechoic profile and inconstant hard acoustic shadow—Type 1), soft (when manifesting with a homogeneous hyperechoic appearance with light or no light and minimal posterior acoustic shadow—Type 2) or fluid (when manifesting with a thin peripheral hyperechoic rim and hypoechoic and/or anechoic centre—Type 3).²²

Ultrasound features and morphology of the calcification were assessed; furthermore, calcification size, fragmentation, thickening of subacromial/subdeltoid bursa walls, distance between subacromial/subdeltoid bursa and calcification, power-Doppler tendon and bursa evaluation and Gärtner and Heyer³⁴ scores were considered.

The presence of other conditions was reviewed (*e.g.* calcific enthesitis, tendinosis and tendonitis of the long head of biceps). Calcifications and shoulder conditions were considered both before and after the treatment.

Numeric rating scale (NRS) score for pain and constant shoulder modified score (CSS) before and after the treatment were collected and analysed; the CSS missed the "strength of abduction", therefore the total score was adapted to 75 points (instead of 100 points) (Table 1).

Variables were also considered regarding sex, age and patient anamnesis; cardiovascular diseases, hypothyroidism and allergy

Figure 1. Type 1 calcification of the supraspinatus [(a), arrows] with radiological appearance [(b), arrowhead]. Needling [(c), broken arrows indicating needles] and lavage [(d), star] of the calcification with 1-month follow-up ultrasound examination show none to minimal remains (e).

were the most prevalent reported comorbidities and were tested as well in correlations.

Treatment success was defined as “good” for CSS increase of >50%, “fair” for CSS improvement between 10% and 50% and “poor” to none for lower CSS variation (or unsuccessful for no variation at all or worsening of symptoms) (Table 2).

The primary end point was to assess which and how factors (regarding calcifications and patients) influenced the outcome of the DNL procedure and to establish which combination of factors may independently favour a good outcome.

t-test was used to explore the significance of differences between pre-treatment and post-treatment (1-month) values (e.g. NRS and CSS). Through univariate and multivariate statistic analysis, the CSS (and NRS) variation was compared with patients’ clinical parameters, imaging findings and anamnestic data. Mann–Whitney *U* test and Spearman test were appropriately used to correlate all variables to Δ CSS and Δ NRS; furthermore, stepwise regression was performed to explore the parameters which are more likely responsible or are predictive for treatment success (CSS improvement) and NRS score quick decrease (1 month); the same analyses were performed to also correlate variables to pre-treatment status (both NRS and CSS), to understand which parameters are more detrimental, produce pain and function impairment.

RESULTS

147 patients were analysed, 91 (61.9%) females and 56 (38.1%) males, with mean age 50.8 ± 8.8 years (30–73 years old); 14 of the patients underwent 2 treatments (6 females and 8 males), 4 of the patients underwent 3 treatments (2 females and 2 males)

and 1 of the patients (female) underwent 4 treatments; 9 patients were treated bilaterally, in different sessions; thus, a total of 172 shoulders were reviewed, 97 (56.4%) right and 75 (43.6%) left. Concerning tendons, 89.3% of calcifications were found in supraspinatus, 5.0% in subscapularis, 2.5% in infraspinatus and 3.2% already migrated into the subacromial/subdeltoid bursa. No relationship was found between side of the pathology and dominant limb. In 28 out of 172 (16.3%) shoulders, the calcification was found to be reabsorbed at the time of treatment (typically 2–6 weeks after the first evaluation); thus, 144 shoulders were treated.

After 1 month, 70% (101) of shoulders got a significant reduction of symptoms (good outcome), 28.6% (41) shoulders were less successful (fair outcome) and 1.4% (2) procedures were totally unsuccessful (with even decrease of CSS). On the whole, CSS increase was estimated at 1 month to be $91.5 \pm 69.1\%$ (minimum, 20.4%; maximum, 316.7%) (Table 3); NRS score changed from 6.7 ± 1.6 to 3.6 ± 2.1 (both $p < 0.01$).

CSS variations were correlated to age of patients ($p < 0.002$, rho 0.257), with better results shown in patients between 30 and 40 years old (average increase 127.7%). DNL success was related to calcification size (average size 14.9 ± 4.8 mm; from 6 to 33 mm), with more relevant increase in CSS for middle-sized calcifications (12–17 mm) and CSS variation 114.1% ($p < 0.001$; rho 0.344). As expected, the success was also related to sonographic features per type of calcific deposit ($p < 0.02$; rho 0.274). Only one of the calcific deposits belonging to Type 0 was treated, with a 33.3% of CSS improvement; the greatest improvement was found for Type 2–3 calcifications (117.6% in CSS), and Gärtner and Heyer score was 3 ($p < 0.01$; rho 0.513–126.8% in CSS) (Figure 2). A strong

Figure 2. Soft calcification of the supraspinatus at ultrasound [(a), arrows] with previous radiographic finding [(b), arrowhead] and lavage of the calcification [(c), stars show liquids swelling the calcification “room”]. Elastosonographic appearance of the calcification immediately before treatment, enhancing the characterization of the calcification and highlighting its softness [(d) broken arrows] images of 1-month follow-up examination (e and f).

relationship ($p < 0.0005$; $\rho = 0.424$) between CSS increase and thickening of subacromial/subdeltoid bursa walls existed.

20 (11.6%) patients suffered from thyroid pathology, in particular hypothyroidism under treatment, as formerly assessed by other authors;⁶ moreover, 59 (34.3%) patients suffered from allergic disorders, mainly from pollens and drugs, especially antibiotics. In this study, these findings did not show a consistent correlation with the results in terms of success of treatment.

Stepwise regression for CSS variation showed to be retained in the final model ultrasound score pre-treatment and post treatment (+association), the distance between bursa and calcification pre-treatment (−association) and post-treatment calcification area size (−association). Stepwise regression for NRS variation showed ultrasound score pre-treatment (+association), the distance between bursa and calcification pre-treatment (−association) and the distance between bursa and calcification post treatment (+association).

In a multiple regression model with NRS score as the dependent variable, the following parameters were found to be independently correlated: ultrasound score pre-treatment (+), Gärtner

score pre-treatment (−), distance between bursa and calcification pre-treatment (−), thickening of bursa wall pre-treatment (−), tendonitis of the long head of biceps pre-treatment (+), ultrasound score post treatment (+) and distance between bursa and calcification pre-treatment (−) (Figure 3). Even hypothyroidism (+) and cardiovascular diseases (+) showed a significant correlation.

Pain (NRS score) at admission was related to age ($+p = 0.007$, $\rho = 0.210$), calcification size ($+p = 0.0008$, $\rho = 0.324$), Gärtner score ($+p = 0.02$, $\rho = 0.439$), ultrasound score ($+p = 0.002$, $\rho = 0.336$), power Doppler positivity ($+p = 0.003$, $\rho = 0.520$), bursal wall thickening ($+p = 0.007$, $\rho = 0.300$) and biceps tenosynovitis ($+p = 0.03$, $\rho = 0.245$). CSS before treatment was not significantly related to any of the investigated elements.

Furthermore, in a final model of stepwise regression, there was no parameter that independently correlated with NRS or CSS at admission.

The post-treatment management of patients was quite totally free from undesirable effects; in particular, only 4 (2.3%) patients showed lipothymia or small pressure increase, expression of a vagal reaction, which was easily solved.

Table 1. Constant shoulder score (modified)

Pain	Score	Activity level	Score	Arm positioning	Range of motion						Internal rotation	Score	Score
					Forward flexion	Lateral elevation	Score	External rotation	Score	Internal rotation			
Severe	0	Unaffected sleep	Yes	Up to waist	31–60°	31–60°	2	Hand behind head, elbow forward	2	Lateral thigh		2	0
Moderate	5		No	Up to xiphoid	61–90°	61–90°	4	Hand behind head, elbow back	4	Buttock		4	2
Mild	10	Full recreation/sport	Yes	Up to neck	91–120°	91–120°	6	Hand to top of head, elbow Forward	6	Lumbosacral junction		6	4
None	15		No	Up to top of the head	121–150°	121–150°	8	Hand to top of head, elbow back	8	Waist (L3 vertebral level)		8	6
		Full work	Yes	Above head	151–180°	151–180°	10	Full elevation	10	T12 vertebra		10	8
			No							Interscapular (T7 vertebral level)			10

DISCUSSION

Several investigations were performed on the origin and evolution of RCCT, as well as on its management. Ogon et al³² investigated prognostic factors in non-operative therapy for chronic symptomatic RCCT (420 patients). Failure of non-operative treatment was observed in 27% of patients. Negative prognostic elements were found in bilateral occurrence, anterior acromion localization, subacromial extension and size (large calcifications), while Gärtner Type 3 deposits and the absence of acoustic barrier were found to be positive factors.³²

Several techniques were proposed to treat and to solve RCCT, and ultrasound-guided percutaneous procedures represent a valid mini-invasive solution. Different methods were developed, and DNL is a well-established option, although different approaches are available and preferred from authors to authors within the same technique. No evidence exists in favour of using a specific size/number of needles. Imaging follow-up is not necessary, and it is not suggested for routine use.³⁵ Alternatives to steroid injections should also be explored.³⁶ In a recent study, injection of xylocaine alone after ultrasound-guided treatment of RCCT provided a longer pain relief period than that of a mixture of xylocaine with corticosteroid.³⁷

Lanza et al³⁶ recently conducted a systematic review of the efficacy of ultrasound-guided needle lavage in treating RCCT, including 11 articles. Heterogeneity among studies precluded meta-analysis. An average of 55% pain improvement was estimated at an average of 11 months, with a 10% minor complication rate.³⁶ This kind of procedure seems to guarantee safety and limited costs.² However, cost-effectiveness studies are missing and should better address this point. Additional high-quality evidence is required to determine the relative efficacy of ultrasound-guided needle lavage.³⁵ Future studies should aim at structural uniformity, including the use of the constant score to assess outcomes.³⁶

A theory based on tissue hypoxia describes a “critical zone” in the rotator cuff that becomes vulnerable to calcification, 1 cm from the insertion of the supraspinatus on the greater humeral tuberosity.⁹ The lower third of the infraspinatus tendon, critical zone of the supraspinatus tendon³⁸ and pre-insertional fibres of the subscapularis tendon are the most commonly affected locations in these tendons. According to Uhthoff and Loehr,⁹ tissue hypoxia precedes fibrocartilaginous metaplasia and necrosis, which is then followed by a propensity for calcification deposits. They described a cyclic course of RCCT, usually related to clinic, and four stages are recognized:³⁹

- Pre-calcification stage: patients usually do not have any symptoms in this stage. At this time, sites where calcifications tend to develop undergo cellular changes that predispose tissues to calcium deposition.
- Calcific stage: during this stage, calcium is excreted from cells and it then coalesces into calcium deposits. When this happens, calcium looks like chalky; it is not a solid piece of bone. Once the calcification has formed, a so-called resting phase begins; this is not a painful period and it may last for a varied length of time; the typical clinical manifestation in this stage is a subacute low-grade shoulder pain that commonly increases at night.²

Table 2. Treatment success and cut-off

Treatment success	
Good	Score >50%
Fair	0 < score ≤50 %
Unsuccessful	Score ≤10

- Resorptive stage: after the resting phase, a resorptive phase begins; it involves vascular invasion and migration of phagocytic cells and oedema from intratendinous pressure.⁴⁰ This is the most painful phase of RCCT and sharp acute pain limiting shoulder movement occurs; during this stage, fever due to rupture of the calcification into the adjacent structures is occasionally reported.² In the resorptive stage, the calcium deposit has been described as toothpaste like.
- Post-calcific stage: at this stage, pain usually breaks down, as calcification disappears while making way to a restored appearance of rotator cuff tendon.

RCCT is a benign although disabling condition. It is reported as a self-healing condition undergoing spontaneous resolution; in some patients, however, it is the cause of chronic debilitating pain and functional disability;⁴¹ if the disease is asymptomatic, it does not require treatment.⁴⁰ Owing to the evolution of calcifications, there is no consensus on the management, whether conservative or interventional approach should be used. The chosen treatment should be minimally invasive, complication free, effective and with fast results.²

DNL is a well-established procedure, and this was proved to be successful. Soft calcifications, in middle or advanced resorptive stages, are usually more suitable for DNL. It is not infrequent that a delay in the procedure scheduling results in no need for procedure, since a few weeks or months after the suitability is assessed

by ultrasound, the calcification can conclude its resorptive phase. Thus, studies should look at long-term results but also at the aim of assessing and finding the optimal method for quick and stable pain relief for patients after the procedure. However, there is little evidence on the factors predicting the good outcome in a short term. These might support choices for submitting or not calcifications to DNL, and to understand what to expect from this. Technique and methods can be reconsidered in light of these factors.

The importance of a standardized procedure, supported by a correct plan of exercise for the optimal recovery of function, should be emphasized. The mobilization of the shoulder after treatment is useful for the complete detachment of the bursa, to sustain shoulder rehabilitation and to improve the range of movement in short and long terms.

In 70% of shoulders, the treatment got a quick and significant reduction of symptoms (the treatment was completely successful). CSS increase was $91.5 \pm 69.1\%$, considering both successful and less or non-successful treatments. CSS variations were significantly related to age of patients (better results between 30 and 40 years old), calcification size (more relevant improvement for middle-sized calcifications, 12–17 mm), sonographic and radiographic features of calcific deposits (softer calcifications go better results) and thickening of subacromial/subdeltoid bursa walls. In the final model of stepwise regression for CSS variation, ultrasound score pre-treatment and post treatment, the distance between bursa and calcification before treatment and the size of post-treatment calcification area were shown to be independently correlated to success. NRS score for pain showed similar results.

It might speculate that the better results in patients 30–40 years of age can depend on the more healthy tendons, on potentially different and more favourable susceptibility to pain or on possible higher compliance to physiatrist treatment.

Table 3. Epidemiological summary

Epidemiological summary					
Sex	Females	91	%	61.8	
	Males	56	%	38.2	
Age	Mean $\pm$ SD	50.8 $\pm$ 8.8	Min	30	
			Max	87	
Side	Right	97	%	56.4	
	Left	75	%	43.6	
Tendons	Supraspinatus		%	89.3	
	Subscapularis		%	5	
	Subacromial bursa		%	3.2	
	Infraspinatus		%	2.5	
Constant shoulder score improvement	Mean $\pm$ SD	91.5 $\pm$ 69.1	Unsuccessful	%	1.4
			Fair	%	28.6
			Good	%	70

max, maximum; min, minimum; SD, standard deviation.

Figure 3. Some of the typical conditions that might be present in rotator cuff calcific tendinitis: subacromial/subdeltoid bursitis [with acute inflammation and power Doppler positivity (a), arrows], calcification fragments migrated to the bursa enhancing bursitis and effusion [(b), broken arrow] and acute biceps tenosynovitis [(c), arrowhead].

Calcification of medium size obtained better scores. Small calcification may produce few symptoms, with less limitation in the range of movement and less pain, as also assessed by the correlation with NRS at admission; moreover, smaller deposits may be more difficult to be targeted and fragmented and transformed in fluid-filled chamber during lavage. On the other hand, the biggest calcifications are usually made up of different parts with different compounds, and this may result in a more challenging treatment; therefore, even for those calcifications which are considered suitable, the treatment can be more inhomogeneous, leaving bigger residual fragments, some of them migrating into the subacromial/subdeltoid bursa thereafter.

Sonographic features (and, with a few limitations, radiographic ones) and morphology of the calcific deposit, with symptoms, are features too commonly regarded as the cornerstone for suitability. The analysis of this study confirmed the best results for softer calcifications, although a few harder calcifications can deserve satisfying results and consideration.

Subacromial/subdeltoid bursa wall thickening is a sign of bursitis, mainly responsible for symptoms: when bursitis is present, it is expected to benefit from both injection of liquid drugs and from calcification removal. Moreover, bursa wall thickening together with size of calcification can be considered responsible even for potential impingement subacromial syndrome. The inverse association between the distance between bursa and calcification before the treatment and CSS improvement, independent of other factors, may be explained as well. Calcifications next to the bursa usually gave rise to more significant pain, in a more advanced resorptive phase.

The size of post-treatment calcification area was also inversely correlated to CSS improvement, confirming that removing as much as possible of the calcification is crucial.

Pain at admission was related to not only age, calcification size, ultrasound and Gärtner score and bursal wall thickening but also to power Doppler positivity and biceps tenosynovitis.

Relationship between endocrine or immunologic disorders and incidence and evolution of RCCT or success of treatments, both conservative and non-conservative, should be further and more appropriately investigated. As well, a deeper comprehension of pathophysiology of the disease and of the procedure requires a different investigative approach. Results from this study may enlighten or inspire the optimization of the procedure and new investigations to be carried out.

This is a retrospective study, thus limited by known conditions and drawbacks, both in imaging and clinical evaluations (control of variables). However, this study was performed in a single-centre with long-term experience and where the procedure is well-established and standardized. The importance to assess efficacy in short term is great in such a disease which often reaches the apex in pain and limitations at its late stage. However, the confounding effect of steroid injection and coadjuvant treatments should be critically considered in the evaluation of results. A longer follow-up may not be necessary for the clinical practice, although this would help in providing other relevant evidence in research, especially for the differential functional outcome of the disease with or without non-conservative treatments.

DNL is a safe procedure, free from critical consequences both in shoulder structures (no tendon tear or rupture were observed) and in general condition of patients.

CONCLUSION

Ultrasound-guided percutaneous procedures for RCCT must be safe, effective and with prompt pain relief and function restoration. This study shows which clinical picture is more favourable to this purpose in DNL. The success of the procedure with quick improvement in function and symptoms is warranted in soft and middle-sized calcifications, in young adults. Well-designed prospective trials should include more rigorous clinical evaluations (constant shoulder score evaluations, visual analogue scale score etc.), to further address this point as well as those which may help to find the relative “weight” of this procedure in the clinical management of RCCT.

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