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RESEARCH ARTICLE

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Calcific Tendinopathy of the Rotator Cuff. Current Solutions

Rómulo Silva[1]*, Alice Pimentel[2] and Manuel Gutierres[3]

[1]Department of Orthopedics, ULSAM, Viana do Castelo
[2]Department of General Surgery, CHBV, Aveiro
[3]Professor at Faculdade de Medicina da Universidade do Porto Department of Orthopedics, CHSJ, Porto

ABSTRACT

Objective: Systematic review of the current treatment options for Calcific Tendinopathy of the Rotator Cuff

Materials and Methods: The information was obtained using the Pubmed database using the following keywords: "calcific", "tendinopathy", "tendinitis", "rotator", "cuff", "shoulder", "treatment". The search was restricted to articles in English or Portuguese, less than 10 years old. Eight articles were included prior to the date defined by their singular relevance to the topic. After selection, 48 articles were consulted.

Results: The treatment of calcific tendinopathy of the rotator cuff involves several lines of treatment, to be carried out successively. The initial, conservative, non-invasive approach includes the use of non-steroidal anti-inflammatory drugs and oral analgesics, physical therapy (with extra-body shock waves) and corticosteroids (oral or intramuscular), aiming mainly to act in the reduction of symptoms. In the second line of treatment, already invasive, we highlight the infiltration with corticoids (diluted in lidocaine) and the ultrasound-guided "barbotage", which acts not only in the symptoms, but also in the resolution of the underlying pathology, with excellent proven results. Finally, arthroscopic surgery is an approach with good success rates, limited by its invasiveness, cost and possible complications.

Conclusions: Taking into account the self-limited nature of the pathology, conservative treatment is the first choice, having undergone advances with the inclusion of iontophoresis, extracorporeal shock wave therapy and echo-guided needle washing. Arthroscopic treatment is reserved for the failure of other treatments.

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Introduction

Rotator cuff calcific tendinopathy (CTRC) is one of the most frequent causes of shoulder morbidity, with an estimated prevalence of 2.7% to 22% [1-6]. It is responsible for approximately 10% of consultations for shoulder pain [7]. It affects 1.5 times more women, in the age group of 30 to 50 years, with the right shoulder being affected more commonly than the left. The condition is bilateral in 10% of cases [1,2,4,8].

The pathology is caused by the deposition of calcium crystals, consisting mainly of hydroxapatite, in the tendon insertions of the rotator cuff muscles [9]. Of these, the tendon of the supraspinatus is the most affected, in 80% of cases [1,4].

Etiopathogenesis

The etiopathogenesis of CTRC is still uncertain, mainly regarding the stimuli that induce the deposition of crystals, however, several theories have been proposed [1,4,5, 7,9]. Older theories supported a degenerative etiology, however, the most accepted theory today is described by Uhthoff, who describes an interactive cellular environment in which calcification is mediated by cells, usually followed by phagocytic resorption, thus taking into account the self-resolving nature of the pathology [1,4,5,7,9-12]. Uhthoff and colleagues thus describe three main stages of calcification: pre-calcification, calcification and post-calcification [10-12].

The pre-calcification phase is characterized by fibrocartilaginous metaplasia of the tenocytes in the avascular areas of the tendon (critical zone). The stimuli that trigger the metaplasia are not known [1,3,4,7,9-12].

The second phase, calcifying, is subdivided into 3 stages: formation, rest and resorption.

In the formative phase, calcium crystals are deposited in matrix vesicles that coalesce and form calcification deposits separated by fibrocartilage. This fibrocartilage is slowly eroded by expanding deposits [1,3,5,9-12].

The resting phase is characterized by the cessation of calcifying deposition, with the deposits being involved in fibrocartilaginous

Contact Rómulo Moreira Lucas dos Prazeres e Silva ✉ almost_romulo@hotmail.com Department of Orthopedics, ULSAM, Viana do Castelo Rómulo Silva Estrada Exterior da Circunvalação nº7912B 5ºDt Tras 4200-162 Porto Portugal.

tissue. It is a period of variable latency, with little inflammation [1,9-12].

During these first two phases the calcium deposits have a chalk-like appearance. Both are chronic and can last for years and are associated with varying degrees of pain, constant or intermittent, both at rest and with motion, especially with abduction [9,10].

In the final phase of reabsorption, calcium deposits are invaded by macrophages, polymorphs and fibroblasts that perform phagocytosis and remove calcium [1,3,5,9-12]. The stimuli that triggers it is also not known [3,5,9].

At this stage, the deposits resemble toothpaste, but appear poorly defined on radiographs and produce little or no shadow on ultrasound [3,9,10]. It is the most painful phase of the pathology due to vascular invasion and increased phagocytic cells associated with edema and increased intratendinous pressure [13]. It has a typical duration of approximately two weeks with subsequent improvement [9,10].

The last phase called post-calcification consists of replacing the deposits with granulation tissue, thus repairing the tendon via fibroblasts and new vessels, resulting in collagen and scar tissue [1,3-5,9,10,12]. Olivia et al observed an increased expression of transglutaminase 2, cathepsin K and osteopontin in the calcified areas of the supraspinatus tendon, however its role in the pathogenesis is still undetermined [2].

A relationship has been reported between CRCT and endocrine diseases, namely hypothyroidism and Diabetes, noting that the prevalence of endocrine diseases was higher in patients with tendinopathy and that individuals with endocrine diseases developed symptoms earlier, for longer periods and had higher rates of surgical need [1,2,4].

Clinical manifestations

The clinical presentation consists of shoulder pain, with many patients reporting decreased range of motion and mobility in an attempt to prevent the onset of pain [1].

Uhthoff and Sarkar related the symptoms to the pathological mechanisms and phases of the disease, thus associating chronic pain to the formative phase, resting phase and also to the post-calcification phase, with acute pain being more associated to the resorption phase [12]. Osteolysis of the great tuberosity is an uncommon form of CRCT associated with a worse clinical and functional prognosis [4,14].

Diagnostic Methods

A simple anteroposterior radiograph in a neutral position with internal and external rotation is usually sufficient to make the diagnosis [1,4,8]. The deposits are usually 1.5-2 cm from the proximal insertion of the tendon, in the so-called critical zone [1]. In the resorption phase, deposits have poor radiographic visualization [8]. Ultrasound is as sensitive as radiography to locate deposits, which appear hyperechoic [1,4].

Doppler ultrasound is useful to predict the evolution of the pathology as well as the predictament of pain [4,15,16]. In symptomatic patients it reveals large deposits, a positive power doppler signal and enlargement of the capsular subacromial space [1,15].

MRI is rarely indicated, being more used in patients with refractory pain because it helps to identify complications such as cuff tears [1,4,8,14]. There are several classification systems for categorizing deposit types [1,4,7] (Table: 1).

Table: 1

Classificação dos depósitos	Type	Discription
French Society of Arthroscopy (17)	A	Homogeneous, dense, defined contours.
	B	Segmented, dense, defined contours.
	C	Heterogeneous, smooth contours
	D	Dystrophic calcifications in tendon insertions.
Gärtner e Heyer (18)	I	Dense, well circumscribed, formative.
	II	Smooth / dense or defined / transparent outline
	III	Translucent and misty with no defined contour, resorptive
Bosworth(6)	Small	< 0,5cm
	Medium	0,5 – 1,5cm
	Large	> 1,5cm

The French society of arthroscopy defines 4 types of morphological deposits, with deposits C and D being in the resorption phase, therefore being responsible for the periods of greatest pain. Deposits A and B are blocked before this phase, thus associated with chronic CTRC [8,17]. Gärtner and Heyer defined 3 types of calcification - I, II and III - also in relation to the morphological presentation [18]. Bosworth described a classification based on the radiographic size of the calcifications [6].

Treatment

TCCR does not have universally accepted treatment or international protocols defined to address the pathology, resulting in several described techniques with variable results [19-22]. The chosen treatment must take into account the symptoms, the stage of the disease and the patient's response [5,7]. Considering the self-resolving nature of the pathology, calcifications tend to disappear when treated conservatively [3,8,20,23,24].

However, considering the variability in the natural evolution of the disease and that the time until there is spontaneous resolution is often extensive and negatively affects the patient's quality of life, there is often a need to seek another line of treatment, with preference always for the least invasive, safe, cheap and with good results in the short and medium terms [23,25-27].

Conservative Treatment

It is the cornerstone of the treatment, having a wide range of options, mainly involving rest, physiotherapy, oral non-steroidal anti-inflammatory drugs, local injections of corticosteroids, extra-corporal shock waves and ultrasound-guided "barbotage" [1,7,8, 22,24-28]. It is successful in 90% of cases [4,7,22,23]. As such, it should be tried for a long period of time - 6 months - before considering more aggressive therapies [1,22]. Patients in the acute / resorption phase benefit from this treatment, acting on pain and comorbidities [8].

Ogon in a study with the objective of defining prognostic factors for non-surgical treatment in patients with chronic CTRC, defined type III Gärtner deposits and the lack of echographic extinction of the deposits as positive prognostic factors for non-surgical treatment, and the surgery must be contraindicated in these cases [29].

These options each have associated advantages, disadvantages and controversy, factors well summarized by Suzuki [1] in (Table 2).

Table 2

Advanced therapeutic options and their advantages, disadvantages and controversy (1)			
Treatment	**Advantages**	**Disadvantages**	**Controversy**
Extracorporeal shock waves	Non-invasive, high level of evidence when compared to placebo	Painful, requires anesthesia, local adverse reactions, limited availability, special equipment	Density of energy flow, number of pulses, number of sessions
Ultrasound guided needling	Cheap, well tolerated with minimal anesthesia, mechanical destruction of deposits	Operator-dependent, invasive, possible bursitis after the procedure	Size and number of needles, number of perforations, effect of perforations
Arthroscopy	Direct visualization, direct removal of deposits, treats associated pathology	More invasive / expensive option, longer recovery time, associated general anesthetic risks	Residual calcification, subacromial decompression, repair of the rotator cuff

Non-invasive

Physiotherapy

Physiotherapy is the first treatment option, trying to avoid the stiffness that comes from pain [3,19,27]. Applies delicate movements, such as medial and lateral rotation with frontal elevations, and as the pain decreases, the amplitude increases and then the postural exercises are increased [8]. There is a possibility of associating physical therapy with other modalities such as ultrasound, iontophoresis and hyperthermia. The association with ultrasound is particularly effective, and the results with hyperthermia seem to be equally promising [28]. Kachewar states that yoga is a good exercise for increasing joint flexibility and reducing stress [3].

Iontophoresis

Iontophoresis did not prove to be better than placebo [26,27]. Its effectiveness is a matter of disagreement, with studies claiming that the association of iontophoresis and physiotherapy has better results than physical therapy alone while others have not found advantages in adding iontophoresis [3,9].

Oral anti-inflammatories

Oral NSAIDs offer good results in short-term pain relief, but in the long term it has not yet been proven. This option must always have into account the associated risks of prolonged use of these drugs at the gastrointestinal, cardiovascular and renal systems [28].

Hyperthermia

Hyperthermia, using local microwave diathermy, has been described as a safe option, but it still needs long-term studies to establish its effectiveness [4,30]. It works by attenuating symptoms and favoring the resorption of deposits, having already been tested in association with barbotage with good results [3,31].

Therapeutic ultrasound

Ultrasound, widely used as a diagnostic method, can be used for therapeutic purposes, with a still undetermined level of effectiveness [3,4,32]. It has the ability to stimulate the local accumulation of peripheral mononuclear blood cells from the activation of endothelial cells. At higher intensities, it is able to trigger / accelerate the destruction of microcrystals, thus stimulating macrophages to act on calcifications. Finally, due to its ability to increase the temperature of exposed tissues, it can increase blood flow and local metabolism [3]. Good results have

been described regarding pain and the reduction of calcification in the short term [32].

Extracorporeal shock waves

Extracorporeal shock wave therapy - ESWT - is a non-invasive therapy that works by directing shock waves of different degrees of energy in a specific area of the body, promoting the destruction of fibrous tissue and its resorption, promoting revascularization and tissue regeneration. It was also postulated that it would act by mitigating the transmission of painful stimuli [3,7, 24].

It is a technique with proven records of effectiveness, namely in reducing pain and improving the function of the cuff. Its usefulness as a second-line treatment, after failure of the conservative basic treatment, is highly accepted, and there are even records of efficacy similar to surgery [3,4,8,9,24,25,28,33,34]. There is still no consensus or clear evidence in the literature regarding the exact dose, number and frequency of sessions necessary to achieve the best clinical result [7,33].

Farr et al found no clinical or radiological differences between using a single high-energy session and two low-energy sessions, both of which revealed significant improvements in shoulder function, results that coincide with those described by Pleiner [33-35]. Huisstede states that only high energy ESWT is effective, considering that this treatment is associated with few risks and is inexpensive. Rebuzzi in turn states that repeated low-dose sessions are effective and have the advantage of being able to be administered without the need for analgesics, which are often administered to patients, especially when treated with high energy doses [1,24,32,34].

Thus, a single session with high energy seems to be able to achieve good results in relation to clinical restrictions and pain, but it seems to be more painful during the procedure, often requiring sedation [1,8,32-34]. The procedure is not free of complications, namely pain during the procedure, more accentuated and frequent with high energies, local reactions such as petechiae, bruises and erythema. There are also descriptions of cases with osteonecrosis of the humeral head in high energy procedures [1,4,24].

Rebuzzi in his study comparing low-energy shock waves and arthroscopic surgery reports that there are no clinical advantages with arthroscopy. Considering that the costs of surgery are 5-7 times higher, it gives preference to ESWT even for less invasive. With regard to the stage of the disease, this technique showed a better response when administered to patients with refractory pathology outside the acute phase of resorption [1-24].

Electrostimulation

Transcutaneous electrical neurostimulation - TENS - acts to promote anesthesia, having also been used in the chronic phase of the pathology to increase the reabsorption of deposits [5,23]. However, there are studies that observed that only two sessions of extra-corporal shock waves were superior to 12 sessions of electrostimulation in relieving pain and improving the functioning of the shoulder after 2, 4 and 12 weeks of treatment [32].

EDTA

EDTA Disodium is an amino acid that can be used as a chelating agent, being able to bind and remove calcium deposits. It can be administered by iontophoresis or mesotherapy [4,27,32]. Cacchio states that the use of EDTA removes calcifications, being equally effective in safely reducing pain and improving shoulder function, results that have been maintained for one year. This article declares an efficacy similar to ESWT and therefore should be considered a valid, cheaper and more easily available alternative [27].

Invasive

Platelet-rich plasma

The use of platelet-rich plasma is an evolving technique that has been used in the treatment of chronic tendinopathy. A study with human and equine cells supports its use in the treatment of pathology of the tendons, and in shoulder surgeries it has been used only to improve pain after cuff repairs [8].

Local steroid injections and analgesics

Local injections of corticosteroids and analgesics are among the most used treatments [7,36]. The typical intervention is to inject corticosteroids together with local analgesics, both of which have better results than placebo [28]. It is a simple technique, easy to perform, with little risk of complications, cheap and with good availability [36]. It has good results in relieving and controlling mild symptoms, but low evidence of long-term benefits [5,8,13,26,28].

The risk associated with the technique can be minimized by performing the injection with image control, in order to confirm that the injection is paratendinous and non-intratendinous [28].

Barbotage/ “needling”

One of the most used treatments, needling / percutaneous aspiration guided by ultrasound, is often applied when the most conservative treatments are not effective [1,4,36,37]. The purpose of this technique is to reduce local pressure and remove deposits, knowing that partial removal of deposits facilitates the decompression of calcified cavities and promotes spontaneous calcium reabsorption [20].

It can be performed with the patient seated or in the lateral decubitus position, associating non-steroidal anti-inflammatory drugs and local anesthetic, the process being usually guided by ultrasound, which surpassed fluoroscopy as a guide method, as it has better accuracy and clinical response [1,4,7, 9,22,38].

After the procedure, the needle is often removed from the subacromial capsule still under ultrasound guidance and local corticosteroids are injected [1,38]. Patients usually remain under observation for a short period of time and are discharged with optional analgesic medication and criotherapy [1,9,38]. It is typically well tolerated with a decrease in pain within 48 hours [1,9].

The complications described for the procedure are minor, such as vagal reactions, post-procedural pain and a described case of septic bursitis [1,22]. It is one of the only treatments with a high level of success evidence in studies, with several reports of good results in the medium and long term [26,36,39].

The specific technique to be used, however, has different approaches, with no consensus on the importance of the removal of the deposits, as to the number of needles to be used in the procedure and as to drill multiple locations or keep the needle fixed only in one place in an attempt to minimize damage to the

cuff [1,7,20,23,36,39,40].

De Witte in a study comparing needling and percutaneous lavage guided by ultrasound against injection of subacromial corticosteroids, found better clinical and radiographic results in the first group, admitting however that, compared to infiltrations, the needling is more invasive, needs better operator technique and equipment, it takes longer and can be painful during and after the procedure, however reiterating the best results in retrospective and clinical studies. In this study, he also observed that barbotage had better results in patients with Gärtner type II and III calcifications, results that are in line with other older studies, thus defining an advantage of barbotage for certain types of calcifications - II and III of Gärtner - and that these types of calcifications may be resistant to other treatments [36].

Suzuki also states in an article that patients with type B / II calcifications have a better rate of reduction / elimination of deposits than patients with type A / I. Yang-Soo Kim compared this technique with shock waves, concluding that both improved the clinical outcome and eliminated deposits, however the needling was more effective in recovering shoulder function and in relieving pain in short-term [1-20].

Krasny compared the use of the barbotage / ESWT association with extra-body shock waves alone, concluding that the combination was associated with higher statistically significant deposit elimination rates (60% vs 32.5%), less pain during the shock wave procedure (VAS scores of 5.8 vs 8.3) and lower rates of arthroscopic surgery (20% vs 45%) [40].

Scofienza reports improved results by associating a hot saline solution to the procedure with 2 needles, claiming that it reduces the duration of the procedure by 25%, decreases the incidence of post-procedure bursitis and has a better rate of calcification removal [13]. Serafini made an assessment of the effect of barbotage in the short term and after 10 years against placebo, where he obtained better short-term results for the first group, however at 10 years the outcomes were similar [26].

Arthroscopic Surgery

Approximately 10% of patients are resistant to conservative treatment and appear to remain in a prolonged formative phase with chronic symptoms, making surgical intervention necessary [4,7,22,23]. Thus, surgery is the last therapeutic option, being indicated when conservative treatment fails with severe debilitating symptoms lasting more than 6 months [1,4,7,22,36,41,42].

Arthroscopic surgery is currently more used because it is less invasive and has better results than classic open surgery [1,22]. There is controversy about the specific procedure to be used, ranging from removal of calcifications combined with subacromial decompression, subacromial decompression only and removal of calcifications only [1,7,24,25].

Several articles report that subacromial decompression is indicated when there are signs of subacromial irritation, and there are also reports of its effectiveness in improving postoperative pain [1,25,43,44]. Marder in a study comparing acromioplasty combined with subacromial decompression against isolated removal of deposits states that the return to employment was delayed in the first group (18 weeks vs 11 weeks) and that the long-term results were similar [45].

Maier and Porcellini carried out studies in which they removed the calcified deposits without using acromioplasty, having obtained excellent results in 91% of the patients, suggesting that this procedure does not influence the outcome of the patients, results supported by Gosens [8,41,46].

Lam, summarizing the current available evidence, points out the main indications for performing acromioplasty in (Table 4) [7].

Table: 3

Different therapeutic efficacy in the different stages of the pathology				
Treatment	Conservative / non-surgical treatment	Shock waves therapy	Barbotage / Needling	Arthroscopic surgery
Most effective stage	Gärtner III	Outside acute phase	Gärtner II and III	Gärtner I

Table: 4

Indications for performing acromioplasty (7)
Radiological signs of mechanical conflict. (type III acromion, sclerosis of the acromion and greater tuberosity).
Intraoperative signs of mechanical conflict. (kiss lesion - partial rupture of the bursal side of the cuff with changes in the mirror on the acromial side).
Type C calcium deposits with poorly defined contours and heterogeneous appearance on radiography.

Another disagreement in the literature stems from the need to remove all deposits, with some authors supporting the importance of total removal of calcifications and others report that residual calcifications have no negative impact on results [4,7,24,41,46,47]. Seil in a study with 54 patients submitted to arthroscopic removal of calcifications found excellent results in a 2-year follow-up in 92% of patients [7]. Studies comparing extracorporeal shock waves with arthroscopic removal of the deposits have found better results with surgery in patients with type A / I calcifications, with similar efficacy for type B / II calcifications [1,24,25].

Rebuzzi describes success of the arthroscopic procedure in 50-82% of the cases. Despite the proven effectiveness of the procedure, it has a high cost, requires hospitalization, long rehabilitation and possible complications such as rupture of the supraspinatus tendon [23,24,36,43].

Bethune describes a technique that can be useful in the arthroscopic removal of, approximately 18%, cases, in which it

was not possible to visualize the deposits, with the arthroscopic insertion of a mini ultrasound probe that will help in the detection of calcifications, confirming later success with ultrasound and post-op radiography [22].

Cho reports radiographic success rates between the different treatments, with extra-body shock waves between 15-70%, barbotage between 28-76% and arthroscopic surgery of 72% [48].

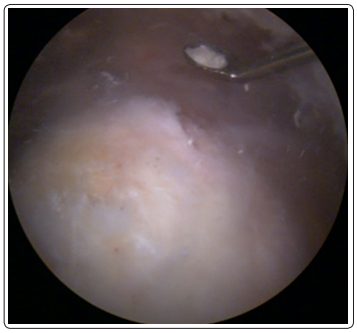

Figure 1: Arthroscopic removal of the calcification through a small opening in the hood and using a curette

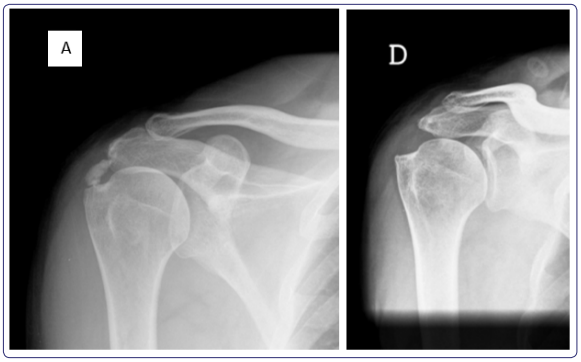

Figure 2: Radiological image of a large calcification of the rotator cuff before (A) and after its arthroscopic removal (B).

Conclusion

Calcifying tendinopathy is a common orthopedic condition and there are several therapeutic options available. Type C and D calcifications, due to their relationship with the reabsorption phase, which is the most painful, are those that require priority treatment. Conservative treatment is the 1st therapeutic choice. The self-resolving nature of the pathology and the good results of these techniques in the short and medium term are the pillars that support such a choice. Thus, physiotherapy and oral non-steroidal anti-inflammatory drugs are the initial options to act in the pathology.

When this 1st line of treatment fails, the second options involve more elaborate treatments, which seek to resolve the symptoms by avoiding surgery. Among them are shock waves, echo-guided barbotage and corticoid infiltrations. They are more invasive techniques, but also well studied and with well-established positive results. Needling / barbotage seems to be more effective in recovering function and relieving pain, however it is more invasive, more technically demanding and more time consuming than shock waves. As for the most suitable approach for each stage of the pathology, barbotage seems to be more appropriate for the resolution of Gardner's type II and III calcifications, while shock waves are more effective in patients with refractory disease, outside the acute phase of resorption.

In case of ineffectiveness of the first two lines of treatment for more than 6 months, the therapeutic option falls on to surgery, which is currently practiced arthroscopically. Calcifications are removed, with bursectomy and subacromial decompression if there are signs of subacromial irritation. This intervention has good success rates and positive results in pain relief described in the bibliography, however, its cost, rehabilitation time and eventual postoperative complications limit its use.

More prospective studies, mainly in the long term, with standardized techniques and methodologies, are needed to establish the best treatment for calcifying tendinopathy of the rotator cuff.

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