Ultrasound-Guided Percutaneous Irrigation of Calcific Tendinopathy

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Abstract

Rotator cuff calcific tendinopathy (RCCT) is a common disease that may cause highly disabling shoulder pain. No treatment is required for asymptomatic calcifications; mild symptoms may be treated conservatively. Among several therapeutic options, ultrasound-guided percutaneous irrigation of calcific tendinopathy (US-PICT) is currently accepted as the first-line safe and effective treatment for RCCT, with significant pain improvement and a very low rate of minor complications. Different approaches have been reported to dissolve calcified deposits, all including the use of a fluid (local anesthetic or saline solution) and the use of one or two needles to inject and retrieve the fluid/dissolved calcium. This review describes both one-needle and two-needle US-PICT techniques, providing technical and practical information that can improve daily clinical practice.

Keywords
- shoulder
- calcific tendinopathy
- rotator cuff
- ultrasound-guided procedures
- ultrasound-guided percutaneous irrigation

Rotator cuff calcific tendinopathy (RCCT), a common disease that occurs in up to 7.5% of asymptomatic adults and up to 20% of painful shoulders, is frequently seen in women in their 40s and 50s.[1–3] Etiopathogenesis of RCCT is still not completely understood. It is believed that a decrease of intratendinous oxygen concentration may promote tendon fibrocartilaginous metaplasia and cellular necrosis, ultimately followed by calcium deposition (mainly hydroxyapatite).[4] All tendons of the body may be affected by RCCT, even though the rotator cuff is the most common site, with the supraspinatus tendon involved in about two thirds of cases.[5,6] RCCT must be differentiated from calcific enthesopathy, a disease characterized by small scattered calcifications located on the insertional portion of the tendons as a result of a degenerative process.[3]

Pathogenesis of RCCT can be divided into four stages: (1) precalcific stage with fibrocartilaginous transformation within the tendon; (2) formative stage with calcium deposition; (3) resorptive phase, characterized by vascular invasion, edema, increased intratendinous pressure with possible extravasation of calcium crystals in the subacromial bursa; and (4) postcalcific phase, in which self-healing and repair of the affected tendon occurs and can last several months. The resorptive phase is usually associated with the development of acute pain that can be highly disabling and unresponsive to common analgesics.[7]

Because RCCT is a self-healing condition with substantial restoration to the original state of the tendon matrix and pain regression, treatment needs to be not only effective but also complication free and minimally invasive. No treatment is required for asymptomatic calcifications detected occasionally, and mild symptoms may be treated conservatively, such as with physical therapy and oral nonsteroidal anti-inflammatory drugs.[6] Therapeutic options include subacromial steroid injections, arthroscopy, and extracorporeal shockwaves. Currently, ultrasound-guided percutaneous irrigation of calcific tendinopathy (US-PICT) is accepted as the first-line safe and effective treatment for RCCT, with significant pain improvement and a very low rate of minor complications (vasovagal reaction, bursitis).[8–10] Compared with arthroscopy, US-PICT is less expensive and invasive, and it requires no hospitalization and little rehabilitation.[6]

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Different approaches have been reported for US-PICT, all including the use of a fluid (local anesthetic or saline solution) to dissolve calcified deposits and one[11–13] or two needles[14–16] to inject and retrieve the fluid/dissolved calcium.[5,17] This review describes both one- and two-needle US-PICT techniques, and it also provides some tips and tricks based on daily routine experience that can improve practical performance.

US-PICT Treatment Procedure

Pretreatment Ultrasound Tendon Evaluation

Rotator cuff tendon evaluation should be performed before beginning the procedure. In fact, US-PICT is immediately indicated in the acute phase of RCCT when calcifications appear as well-demarcated homogeneous hyperechoic foci, with a weak posterior shadow, thus indicating a soft consistency (type II).[18] US-PICT can also be performed in case of semiliquid consistency when the calcification is amorphous and inhomogeneously hyperechoic (type III). In the case of a mildly symptomatic patient with solid calcifications (hyperreflective, strong dorsal acoustic shadow, type I), elective treatment should be considered.[19] Finally, US-PICT is not indicated in patients with very small calcifications (< 5 mm) or fragmented deposits.[20]

Equipment Needed

- One or two 16G needles (depending on the technique chosen: single or double needle)
- Two syringes (20 mL and 3 mL)
- One 10-cm 18/20G spinal needle (optional)
- Bowl (to collect the washing fluid)
- Sterile saline solution (100–200 mL, warmed to $\sim$ 38–40°C)
- Lidocaine (10 mL)
- Steroid (1 mL, 40 mg/mL)
- Plaster
- Ice pack

Patient Positioning

It is prudent to place the patient in a semisupine position, to prevent patient movement during the procedure and the consequences of possible vagal reactions. Also, the arm of the affected shoulder should lie completely extended along the body with a slight internal or external rotation, according to calcification location.

Skin Antisepsis and US Probe Disinfection

Ordinary antisepsis is generally sufficient to guarantee a safe procedure for both the patient and operator. Preliminary disinfection of instruments is mandatory before starting the procedure.[21,22] To our knowledge, no study has investigated the infection rate in US-guided joint procedures; nevertheless, Caturelli et al reported no infection when the US transducer was cleaned with a 70% alcoholic solution prior to each abdominal fine-needle puncture.[23] Thus a cheaper alternative to a sterile probe cover could be the application of sterile gauze soaked with a 2% peracetic acid solution (or 0.25% benzalkonium chloride plus 70% ethylic alcohol) over the probe for at least 5 minutes.[24] The use of a sterile lubricating gel is advisable to optimize the contact between probe and skin.

For skin cleaning, we currently use a two-step antiseptic procedure. A colored disinfectant (i.e., 7.5–10% iodopovidone solution) is used for a first cleaning, followed by an uncolored disinfectant (e.g., benzalkonium chloride solution). Apart from the obvious improvement in skin asepsis, this approach also creates a peripheral ring of colored antiseptic that makes the operator aware of the external borders of the cleaned area. Lastly, if no sterile cover is used, the US probe will remain clean from the colored antiseptic solution.

In our series of 1,651 patients treated with both the single- and double-needle approach, one case of septic bursitis occurred in a patient treated with the single-needle procedure. The cause of this infection was identified as *Staphylococcus aureus* (suggesting a skin origin), although in that case the disinfection protocol was adhered to strictly.

Local Anesthesia

Different anesthetic solutions can be used effectively. Using US guidance with an in-plane approach, we usually inject up to 10 mL lidocaine along the path of the needles into the subacromial-subdeltoid bursa (SASD) and around the calcification (►**Fig. 1**).

Needle Positioning and Irrigation Procedure

The use of one or two needles of different diameters has been reported in the literature, but a recent systematic review showed that no existing evidence favors using a specific size or number of needles.[2] The choice of one needle is justified by the belief that using two needles may be risky to the tendon, but the safety and efficacy of the two-needle technique has been already shown up to 10 years.[9,20,25] Conversely, the two-needle technique allows for creating a continuous inflow and outflow of saline solution to remove calcium and to control the saline pressure inside the calcification. This provides an

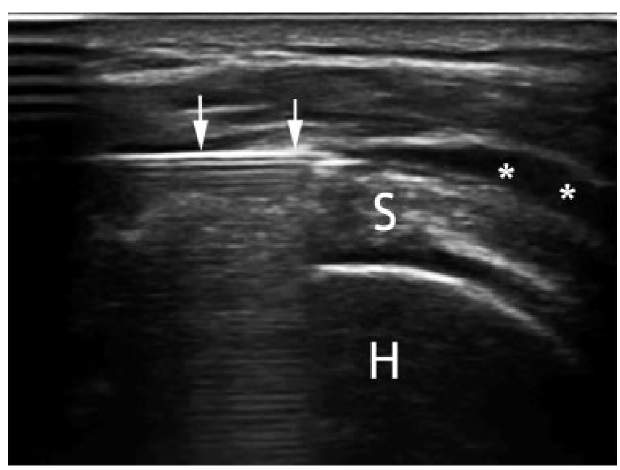

Fig. 1 Ultrasound image showing anesthetic injection in the subacromial-subdeltoid bursa (asterisks). The needle (arrows) is advanced with an in-plane approach. Anesthetic should also be injected in the peribursal space and around the calcification. H, humeral head; S, supraspinatus tendon.

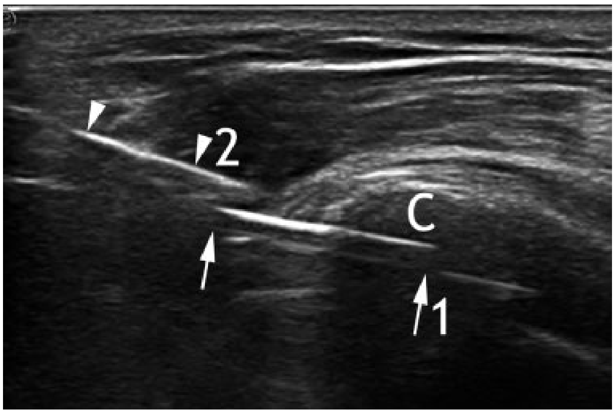

Fig. 2 Ultrasound image of the double-needle technique. The first needle (1, arrows) is inserted with an in-plane approach into the lowest portion of the calcification (C). The second needle (2, arrowheads) is then inserted more superficially, to reach the upper part of the calcification. Importantly, the first needle must be inserted in a deep position because it may cause shadow artifacts that can hidden by the second needle.

Fig. 4 Double-needle technique. When needles are properly positioned, a washing fluid can be seen exiting from the second needle (arrow). The fluid is usually collected in a bowl positioned on the patient's side.

escape for the fluid, avoiding possible disruption of the peripheral calcific rim.[26]

Needles (16G) are inserted into the calcification with a free-hand technique under continuous US monitoring. Correct needle positioning and an adequate visualization of needle tips during the whole procedure are crucial. Also, when performing the double-needle technique, the position of the two needles with respect to each other and to the calcifications must be considered.

Needles must be inserted with an in-plane approach and parallel to the probe surface to achieve optimal visualization under US guidance.[5,19] If a double-needle procedure is performed, the deeper needle has to be inserted first, taking care to preserve the integrity of the calcific shell. The second needle is then inserted into the calcification parallel and superficial to the first one, with the bevel opposite to the first needle with the aim of creating a washing circuit[26] (►**Figs. 2** and **3**). Because the calcific material may obstruct needle tips, the operator can gently insert an 18G spinal needle into each needle to remove calcium and ensure needle patency.[27,28] The calcification is then washed with saline solution, applying gentle and intermittent pressures on the syringe plunger to avoid excessive pressure that could break the calcification shell. It is essential that the solution injected in one needle exits from the other (►**Fig. 4**); if not, small adjustments of the needles are needed until a correct washing circuit is established. Saline solution irrigation should be continued until complete internal emptying is visualized (►**Fig. 5**). Of note, the use of warm saline may shorten the duration of the procedure and improve calcification dissolution.[2] In case of hard calcifications, to improve calcium removal, needles can be gently rotated or displaced while still inside

Fig. 3 Double-needle technique. Image shows the proper position of both needles on shoulder skin surface, with the deeper needle (1) inserted first. Then the second needle (2) is inserted superficial to the first one.

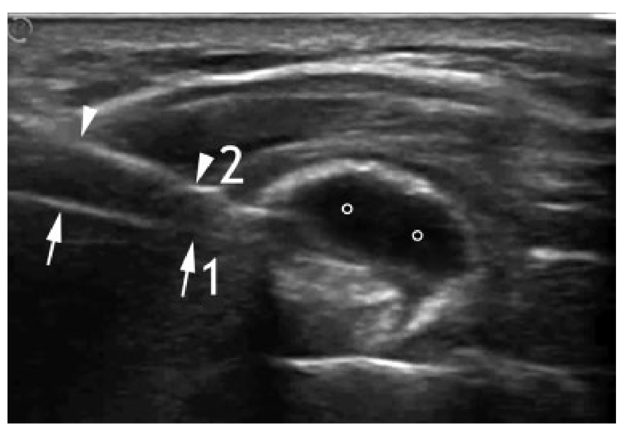

Fig. 5 Ultrasound image of the double-needle technique. Both needles are inserted on the same coronal plane, with their tips very close to each other. When pressure to the syringe is applied, a slight expansion of the calcification can be directly visualized. Saline solution irrigation should be continued until complete emptying of the calcification is visualized (circles). Deeper needle = 1, arrows. Superficial needle = 2, arrowheads.

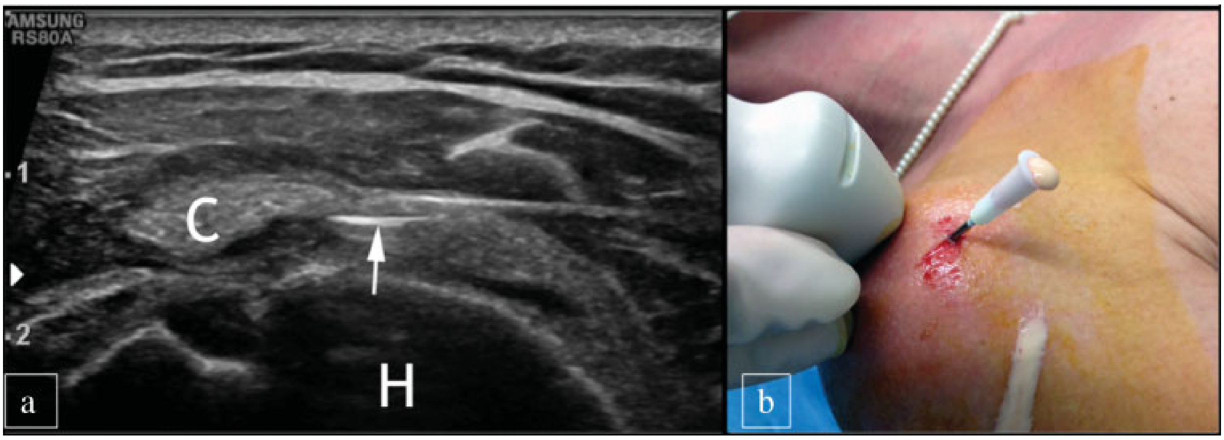

Fig. 6 (**a**) Ultrasound image of a calcification with soft consistency punctured with a single-needle technique. (**b**) Immediately after the insertion of the needle into the calcification, a leakage of white material may be seen from the needle, representing the amorphous content of the calcification. C = calcification, arrow = needle, H = humeral head.

the calcification, always trying not to disrupt the peripheral calcific rim.[15] In another situation, the amorphous content of a soft calcification can leak out from the needle immediately after its insertion into the calcification (►**Fig. 6**).

The single-needle procedure is quite similar to what was just described, except the calcification is only punctured with one needle. Washing is performed by pushing the syringe plunger to hydrate the deposit, with calcium deposits that reflux back in the same syringe when the plunger is released (►**Figs. 7** and **8**).[12]

Subacromial-Subdeltoid Bursa Injection

At the end of the procedure, if no contraindications are present, ultrasound-guided intrabursal injection of slow-release steroids is indicated. This may help reduce the risk of postprocedural bursitis that represents a short- to medium-term (up to 3 months) complication.[15] The approximate duration of the whole procedure is ~ 15 to 20 minutes.

Postprocedural Treatment

There is wide heterogeneity in how patients are managed after treatment. We suggest a short course of nonsteroidal anti-inflammatory drugs and relative rest (i.e., no elevation of the arm over the shoulder) for ~ 15 days. Then, a short treatment of physiokinetic therapy is recommended. Imaging is not routinely used during follow-up, but patients are instructed to call our department if pain persists for more than a few days after treatment or in case of fever, or in case of pain recurrence after 2 months posttreatment. In these cases, we usually perform a US scan of the shoulder to detect the presence of complications. In the case of postprocedural bursitis, we perform an US-guided intrabursal injection of steroid.[2,20]

Clinical Effectiveness

There is a wide variation in the scales used to evaluate the effectiveness of US-PICT among different authors. A recent meta-analysis[2] demonstrated that US-PICT is a safe procedure

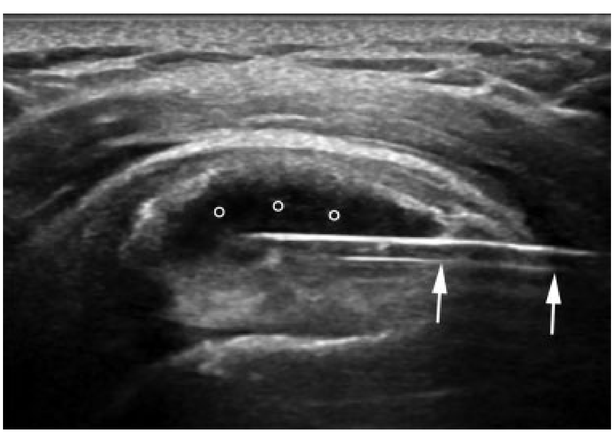

Fig. 7 Ultrasound image of the single-needle technique. The calcification is punctured with just one needle (arrows), and washing is performed by pushing and releasing the syringe plunger. At the end of the procedure, the calcification is almost completely empty (circles).

Fig. 8 Single-needle technique. Image shows a syringe containing saline solution partially filled with the calcium that is being removed from the calcification (arrows). The luer must be is pointed upward so calcium can be deposited at the bottom of the syringe reducing its reinjection during the rest of the procedure.

with an estimated 55% pain reduction at an average time of 11 months, with 10% minor complications. In 2013, a randomized controlled trial with 48 patients by de Witte et al compared two common RCCT treatments: US-PICT combined with subacromial steroid injection versus an isolate injection of corticosteroid in the SASD bursa.[8] After 1 year of follow-up, despite a general improvement in both groups, authors showed that clinical and X-ray results were significantly better in the US-PICT group (with significant major decrease in mean calcification size). Also, when compared with extracorporeal shock wave therapy, US-PICT was shown to be more effective in the short term with regard to function restoration and pain relief.[29]

Conclusion

US-PICT has been shown to be a safe and effective procedure for treating RCCT, regardless of the use of one or two needles to perform the procedure. It is quick, low cost, and minimally invasive. Minor complications occur in a few cases, consisting mainly of bursitis and vagal reactions. The adoption of the step-to-step procedure discussed in this review may improve the execution of US-PICT in daily practice.

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