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Clinical indications for image-guided interventional procedures in the musculoskeletal system: a Delphi-based consensus paper from the European Society of Musculoskeletal Radiology (ESSR)—part I, shoulder

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Abstract

Background Image-guided interventional procedures around the shoulder are commonly performed in clinical practice, although evidence regarding their effectiveness is scarce. We report the results of a Delphi method review of evidence on literature published on image-guided interventional procedures around the shoulder with a list of clinical indications.

Methods Forty-five experts in image-guided musculoskeletal procedures from the ESSR participated in a consensus study using the Delphic method. Peer-reviewed papers regarding interventional procedures around the shoulder up to September 2018 were scored according to the Oxford Centre for Evidence-based Medicine levels of evidence. Statements on clinical indications were constructed. Consensus was considered as strong if more than 95% of experts agreed and as broad if more than 80% agreed.

Results A total of 20 statements were drafted, and 5 reached the highest level of evidence. There were 10 statements about tendon procedures, 6 about intra-articular procedures, and 4 about intrabursal injections. Strong consensus was obtained in 16 of them (80%), while 4 received broad consensus (20%).

Conclusions Literature evidence on image-guided interventional procedures around the shoulder is limited. A strong consensus has been reached for 80% of statements. The ESSR recommends further research to potentially influence treatment options, patient outcomes, and social impact.

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Key Points

- *Expert consensus produced a list of 20 evidence-based statements on clinical indications of image-guided interventional procedures around the shoulder.*
- *The highest level of evidence was reached for five statements.*
- *Strong consensus was obtained for 16 statements (80%), while 4 received broad consensus (20%).*

Keywords Interventional radiology · Shoulder · Ultrasonography · Injections · Platelet-rich plasma

Abbreviations

ACJ	Acromioclavicular joint
CT	Computed tomography
ESSR	European Society of Musculoskeletal Radiology
ESWT	External shockwave therapy
GHJ	Glenohumeral joint
LHBT	Long head of biceps tendon
MA	Methylprednisolone acetate
PRP	Platelet-rich plasma
RCCT	Rotator cuff calcific tendinopathy
SASD	Subacromial–subdeltoid
TA	Triamcinolone acetonide or triamcinolone acetate
US-PICT	Ultrasound-guided percutaneous irrigation of calcific tendinopathy

Introduction

For the musculoskeletal system, the principal areas of image-guided interventional procedures are oncology (e.g., ablation of bone lesions) [1], bone structural stability (e.g., vertebroplasty and cementoplasty) [2], and control of pain originating from joints and soft tissue conditions [3]. In the shoulder, the most common interventional procedures are related to the treatment of tendinopathy, subacromial–subdeltoid (SASD) bursitis, and joint pain [4–7]. Due to the anatomy of the involved structures and aforementioned common conditions, fluoroscopy and ultrasound are the most frequently used guidance techniques, with limited use of computed tomography (CT) and magnetic resonance imaging [4–6, 8, 9].

Most of these interventional procedures are regarded as minimally invasive and are relatively easy to perform; thus, their use is increasing in clinical practice. However, evidence on their effectiveness is limited [10, 11]. Thus, it is difficult to provide guidelines for the application of these procedures in many clinical settings. For this reason, in 2017, the Ultrasound and the Interventional Subcommittees of the European Society of Musculoskeletal Radiology (ESSR) through its Research Committee promoted a collaborative project to review the existing literature on image-guided interventional procedures in the musculoskeletal system to derive a list of clinical indications.

In this article, we report the results of a Delphi method review of evidence on published image-guided interventional procedures around the shoulder listing clinical indications.

Materials and methods

Institutional Review Board approval was not required for the present study as patients are not involved. This paper is a part of a larger collaborative project aimed to the review of image-guided interventional procedures in the upper limb. In this paper, we only report the results regarding tendon, joint, and bursal procedures around the shoulder.

Similar to previous ESSR consensus papers [12, 13], a literature-based Delphic method of review was employed. This method involves a sequence of discussion rounds to determine the opinion of experts on controversial topics, drafted on the basis of the existing literature, to produce a final shared agreement [14]. The AGREE II tool was used to ensure the quality of this work [15, 16]. Full details of the Delphi method, including (1) expert selection; (2) literature search, statement drafting, and level of evidence; (3) questionnaire preparation and consensus; and (4) data analysis and paper drafting are reported as Supplementary material. The Oxford Centre for Evidence-based Medicine evidence levels were employed [17].

Results

Statement no. 1: ultrasound-guided percutaneous irrigation of calcific tendinopathy (US-PICT) is a feasible, safe, and effective procedure for calcific tendinopathy treatment, both when performed with one or two needle techniques

Level of evidence: 1

US-PICT is a safe and effective procedure for treating rotator cuff calcific tendinopathy (RCCT). It provides an estimated average pain improvement of 55% at 1-year follow-up. Complications occur in 10% of treatments and can be regarded as minor [18–20]. In addition, it is suggested that there is no outcome difference in favor of using one or more needles of different sizes [21, 22]. Also, the use of warm saline has been reported to help improve results [23].

Agree, $n = 45$; abstain, $n = 0$; disagree, $n = 0$. Level of agreement = 100%

Statement no. 2: US-PICT is more effective than simple SASD bursa steroid injection in improving symptoms and functional status of rotator cuff tendons

Level of evidence: 2

US-PICT could be considered the treatment of choice for non-surgical options of treatment in RCCT, being more effective than simple SASD bursa steroid injection in terms of pain reduction and functional outcome at 1-year follow-up [24].

Agree, $n = 45$; abstain, $n = 0$; disagree, $n = 0$. Level of agreement = 100%

Statement no. 3: US-PICT reduces risks of adverse events when compared to extracorporeal shockwave therapy (ESWT), US-PICT plus ESWT, ESWT, and SASD corticosteroid injections

Level of evidence: 1

US-PICT, ESWT, and arthroscopy are all treatment options for RCCT. However, US-PICT reduces risks of adverse events when compared to US-PICT plus ESWT, ESWT, and SASD bursa corticosteroid injections. Thus, evidence suggests US-PICT being the treatment of choice for nonsurgical options in RCCT [20].

Agree, $n = 44$; abstain, $n = 1$; disagree, $n = 0$. Level of agreement = 97.2%

Statement no. 4: ultrasound-guided dry needling for supraspinatus tendinopathy is effective in reducing pain but is inferior to platelet-rich plasma (PRP) injection up to 6 weeks

Level of evidence: 3

Dry needling or fenestration disrupts scar tissue causing bleeding, which is considered to promote autonomous healing. Ultrasound-guided dry needling for treating supraspinatus tendinopathy is suggested by a single randomized controlled trial comparing the outcomes of patients treated with dry needling and those treated with PRP injection. The experts concluded that both treatments are effective in improving pain and function, although PRP is superior to dry needling from 2 to 6 weeks after treatment with no long-term complications [25].

Agree, $n = 42$; abstain, $n = 1$; disagree, $n = 2$. Level of agreement = 93.3%

Statement no. 5: ultrasound-guided prolotherapy for supraspinatus tendinopathy can reduce pain and improve function better than placebo or physiotherapy

Level of evidence: 2

Prolotherapy is injection therapy using irritant agents, promoting tendon healing by initiating an inflammatory cascade. Two randomized controlled studies in patients with chronic supraspinatus tendinopathy have shown that ultrasound-guided hypertonic dextrose injection can relieve pain and improve shoulder range of motion [26, 27]. The effects were significantly better that physiotherapy alone for up to 6 weeks [27]. Intratendinous glucose injection has been reported to be inferior to SASD bursal steroid injections [28].

Agree, $n = 41$; abstain, $n = 3$; disagree, $n = 1$. Level of agreement = 91.1%

Statement no. 6: ultrasound-guided injections of steroid in the long head of biceps tendon (LHBT) sheath are more accurate and effective than palpation-guided injections

Level of evidence: 2

Based on a prospective randomized controlled trial, ultrasound guidance leads to significantly more accurate needle placement and symptom reduction compared to palpation guidance. A prospective randomized study comparing palpation-guided to ultrasound-guided injections of contrast media in LHBT sheath using CT for confirmation showed ultrasound guidance provided correct positioning in all cases, while palpation guidance reached the target in one third of cases [29].

Agree, $n = 45$; abstain, $n = 0$; disagree, $n = 0$. Level of agreement = 100%

Statement no. 7: ultrasound-guided injections of steroid in the LHBT sheath are more accurate and equally effective compared to fluoroscopy-guided injections

Level of evidence: 3

Fluoroscopy may be used to guide injections into the LHBT sheath. Based on a 10-year retrospective review comparing fluoroscopy to ultrasound guidance for proximal LHBT injections, the latter had higher initial-pass (90.6 vs 74%, respectively) and final-pass success rates (98.2 vs 92%, respectively) and was slightly cheaper. Ultrasound demonstrated abnormalities prior to injection. Both techniques resulted in similar pain relief and no complications. Ultrasound is more accurate and has greater diagnostic benefits than fluoroscopy-guided LHBT sheath injection [30].

Agree, $n = 45$; abstain, $n = 0$; disagree, $n = 0$. Level of agreement = 100%

Statement no. 8: ultrasound-guided LHBT tenotomy is feasible but clinical value is not yet demonstrated

Level of evidence: 4

Ultrasound-guided proximal percutaneous tenotomy of the LHBT is feasible in every cadaveric study [31–34] without any complications using various approaches (posterior percutaneous, deep to superficial axial, and anterolateral approach) [31–33]. However, in another cadaveric study using an anterolateral superior approach, tendon section was achieved in only 25% of cases [34]. Serious iatrogenic injuries involving the cartilage of the humeral head, the supraspinatus, and the subscapularis tendon were noted, suggesting that although feasible, percutaneous LHBT is not a reliable technique [34]. Clinically, the technique was reported in a single patient with tendinopathy and was found to be feasible, resulting in full return to normal activity at 15 months with evidence of a "Popeye" deformity of the biceps muscle but no other complications [35]. More work in patients is needed to determine the safety and reliability of the technique.

Agree, $n = 42$; abstain, $n = 3$; disagree, $n = 0$. Level of agreement = 93.3%

Statement no. 9: ultrasound-guided PRP injection in rotator cuff tendinopathy or partial tear is safe. It is also effective in improving symptoms in rotator cuff tendinopathy based on preliminary results

Level of evidence: 3

The results of studies using PRP to treat rotator cuff tendinopathy and partial rotator cuff tears are widely variable due to different inclusion criteria, varied types of PRP, and different administration techniques and protocols. Most papers report a small series with favorable outcomes [36–39].There are very few controlled studies of PRP injection in tendinopathy or partial tears [40, 41]. Most papers have a small sample size. Some papers describe injection of PRP into the SASD bursa rather than the tendon. Wesner et al [41] demonstrated that intratendinous ultrasound-guided injection of PRP in patients with tendinopathy or partial thickness tears in the rotator cuff may lead to improvements in pain, function, and MRI appearance. However, the study is limited by the low sample size.

Agree, $n = 44$; abstain, $n = 0$; disagree, $n = 1$. Level of agreement = 97.8%

Statement no. 10: ultrasound-guided PRP injection in patients with arthroscopically repaired rotator cuff tears does not demonstrate conclusive benefit for reducing postoperative pain after arthroscopy compared to placebo

Level of evidence: 2

Some randomized controlled trial studies compared the use of PRP with saline solution [42] or no treatment [43, 44] by measuring the reduction in pain after arthroscopic repair of complete rotator cuff tears. All studies show that image-guided PRP injections do not lead to improved outcomes, early tendon-bone healing, or functional recovery.

Agree, $n = 44$; abstain, $n = 0$; disagree, $n = 1$. Level of agreement = 97.8%

Statement no. 11: ultrasound-guided glenohumeral joint (GHJ) injections are more accurate than palpation-guided injections

Level of evidence: 1

Different papers assessed the accuracy of palpation and ultrasound-guided GHJ injections. Cunnington et al evaluated injections in different joints, reporting no significant difference in the accuracy of needle placement (40% of palpation-guided injections vs 63% of ultrasound-guided injections). However, they compared a sonographer with 1-year experience versus a rheumatologist with 14-year experience [45]. Different papers separately studied the accuracy of palpation-guided injections (ranges 10–99%) [46–53] and ultrasound-guided injections (ranges 92–100%) [54–57]. A comparison between palpation- and ultrasound-guided injections in cadavers showed significantly different accuracy (72.5 vs 92.5%, respectively) [58]. A recent systematic review and meta-analysis showed that ultrasound-guided injections are more accurate than palpation-guided injections [31].

Agree, $n = 45$; abstain, $n = 0$; disagree, $n = 0$. Level of agreement = 100%

Statement no. 12: ultrasound guidance improves the outcome of GHJ injections compared to palpation-guided or sham injections in adhesive capsulitis up to 12 weeks

Level of evidence: 2

Lee et al compared the efficacy of ultrasound-guided versus palpation-guided steroid injections to treat adhesive capsulitis, showing that the former yielded better outcome in terms of pain and function in the first 2 weeks, while results were similar up to 6 weeks [59]. A randomized controlled trial comparing ultrasound-guided GHJ injections of steroids, ultrasound-guided GHJ plus rotator interval injection, and sham injections revealed that ultrasound-guided GHJ injections with or without interval injection are significantly more effective than sham injections up to 12 weeks, while no differences were noted at 26 weeks [60].

Agree, $n = 45$; abstain, $n = 0$; disagree, $n = 0$. Level of agreement = 100%

Statement no. 13: for steroid GHJ injections, ultrasound seems a more cost-effective guidance technique for the initial treatment of patients with adhesive capsulitis compared to palpation and fluoroscopic guidance

Level of evidence: 3

A very recent cost-effectiveness study provided simulation models where ultrasound-guided injections in adhesive capsulitis showed to be the cheapest in 44% of cases compared to palpation- (34%) and fluoroscopy-guided (22%) injections [61].

Agree, $n = 44$; abstain, $n = 1$; disagree, $n = 0$. Level of agreement = 97.8%

Statement no. 14: ultrasound-guided and fluoroscopy-guided acromioclavicular joint (ACJ) injections are significantly more accurate than palpation-guided injections

Level of evidence: 1

Several in vivo and in vitro studies have shown that palpation-guided ACJ injections are frequently misplaced. Reported accuracy had great variability and the studies were inhomogeneous in terms of operators' qualifications and experience and methods of assessing needle placement [62–71]. A meta-analysis concluded that ACJ ultrasound-guided injections were significantly more accurate than palpation-guided injections (93.6 vs 68.2%) [31]. No studies compared ultrasound guidance with fluoroscopy or CT.

Agree, $n = 45$; abstain, $n = 0$; disagree, $n = 0$. Level of agreement = 100%

Statement no. 15: intra-articular ACJ local anesthetic and/or steroid injections produce pain reduction, with imaging guidance improving the outcome compared to palpation

Level of evidence: 2

There is wide variability in pain reduction after ACJ injection, ranging between 14 [72] and 70% [67] for up to 6 months. A study of ACJ injection of lidocaine and betamethasone in 20 patients randomly allocated to ultrasound or palpation guidance found no clinical difference [73]. In another series of 106 ACJ injections, ultrasound-guided intra-articular and peri-articular injections of lidocaine and betamethasone were compared. There was more pain reduction in the intra-articular injection group at 3-week follow-up [74]. Park et al found that ultrasound-guided ACJ injection had better pain and functional improvement compared to palpation-guided injections for up to 6 months. Injection accuracy was the only significant predictor of success [69].

Agree, $n = 45$; abstain, $n = 0$; disagree, $n = 0$. Level of agreement = 100%

Statement no. 16: palpation-guided sternoclavicular joint injections are reported to be 78% accurate, while image-guided injections are reported to be 100% accurate

Level of evidence: 4

There is very little literature on the effectiveness of sternoclavicular joint injections. One paper studied the accuracy of palpation-guided injections in 76 cadavers and found 78% of the injections were intra-articular [75]. A single, small study found 100% accuracy for ultrasound-guided injections [76]. Similarly, 100% accuracy was reported for CT-guided injections, with clinical improvement in 67% of patients irrespective of any abnormalities on the associated CT images [77].

Agree, $n = 45$; abstain, $n = 0$; disagree, $n = 0$. Level of agreement = 100%

Statement no. 17: SASD bursa injections under ultrasound guidance are feasible and tend to be more accurate than palpation-guided injections, although there is conflicting evidence about clinical superiority

Level of evidence: 1

Studies have shown that ultrasound-guided injections of the SASD bursa have the same [31, 56, 78] or higher [79–83] accuracy of drug placement compared to injections performed by palpation guidance. There is conflicting evidence that ultrasound guidance improves clinical outcome after steroid injection to the SASD bursa. Several papers have demonstrated an improvement in terms of pain and/or function by using ultrasound guidance instead of palpation to inject the SASD bursa [29, 31, 79, 80, 82–90]. Other studies were unable to establish a significant impact of ultrasound guidance on clinical outcome [28, 78, 81, 91, 92].

Agree, $n = 45$; abstain, $n = 0$; disagree, $n = 0$. Level of agreement = 100%

Statement no. 18: there is conflicting evidence about the efficacy of triamcinolone acetonide (TA) or methylprednisolone acetate (MA) in ultrasound-guided SASD bursa injections

Level of evidence: 3

A small randomized study found a significant difference in pain response in the MA group at 2 weeks and 2 months, without using lidocaine [93]. Battaglia et al found that bursal treatment after US-PICT is significantly more effective with TA [94]. A randomized, single-blind, multi-arm study showed no difference in outcome at 6 weeks in the use of MA or TA at 20 or 40 mg when used with 2 ml lidocaine and 2 ml of bupivacaine [95].

Agree, $n = 42$; abstain, $n = 2$; disagree, $n = 1$. Level of agreement = 93.3%

Statement no. 19: ultrasound-guided SASD bursa injection of hyaluronic acid is more effective than placebo in patients with painful shoulder

Level of evidence: 2

Ultrasound-guided SASD bursa injection of hyaluronic acid is an option for patients with degenerative rotator cuff tendinopathy. Four randomized controlled trials show that intrabursal hyaluronic acid injection is superior to placebo for pain control and improvement in function at different times up to 1 year [96–99].

Agree, $n = 43$; abstain, $n = 1$; disagree, $n = 1$. Level of agreement = 95.6%

Statement no. 20: ultrasound-guided SASD bursa corticosteroid injection is more effective than hyaluronic acid injection in patients with painful shoulder in the short term

Level of evidence: 2

Three randomized clinical trials have compared SASD ultrasound-guided injection of hyaluronic acid and steroid. Steroid showed better and earlier short-term results up to 12 weeks [100, 101]. At 26 weeks, hyaluronic acid and steroid showed similar results in terms of pain relief and functional improvement [100].

Agree, $n = 45$; abstain, $n = 0$; disagree, $n = 0$. Level of agreement = 100%

Discussion

The level of evidence supporting our statements is highly variable. However, level 1 evidence (systematic review of randomized trials or *n*-of-1 trials [17]) is available for only five statements. The level of evidence is generally low [10, 11, 102]. Despite randomized controlled trials on some topics, the level of evidence was often downgraded by their low quality (e.g., small sample size, inadequate methodology, short follow-up) [17]. Published evidence is invariably biased by the tendency to publish positive results. There is debate whether randomized controlled trials are the best means of testing the effectiveness of a procedure as potentially large, well-designed prospective longitudinal trials may be more representative of real life [103, 104]. We support the role of these procedures in patients not suitable or willing to undergo surgery or in those where conservative treatments have failed. We also consider that patient education, physiotherapy, and activity modification after minimally invasive treatment are important. In addition, we underline a lack of studies about cost/effectiveness of these treatments, as well as very few or no studies comparing them with surgery or other types of treatment (e.g., physiotherapy).

Sixteen statements received a strong consensus, while four statements had a broad consensus. This data probably reflects the existing controversies on some topics of interventional procedures around the shoulder, such as the use of PRP or prolotherapy to treat tendinopathy or of different steroid preparations for SASD injections, or the role of LHBT tenotomy to control pain in patients with complete RC tears.

In conclusion, the ultrasound and interventional subcommittees of the ESSR offer 20 statements regarding image-guided treatment for tendons, joints, and bursae around the shoulder. We critically reviewed the available evidence, highlighting the advantages and limitations of each procedure. The ESSR encourages future studies regarding the role of these treatments and methods of image guidance, which may influence treatment options, patient outcomes, and social impact [105].

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Compliance with ethical standards

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Informed consent Written informed consent was not required for this study because it does not involve patients.

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Methodology
• Literature-based Delphi process

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