Review Article

Ultrasound-Guided Shoulder Interventions: Techniques, Evidence, and Clinical Applications—A Narrative Review

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Abstract

Background: Shoulder pain is among the most common musculoskeletal complaints, with significant socioeconomic impact and persistent disability in a substantial proportion of patients. Conventional landmark-guided injections remain widely practiced but suffer from variable accuracy, inconsistent therapeutic response, and a higher risk of unintended tissue infiltration. Ultrasound (US) guidance allows real-time visualization of anatomical structures, potentially improving procedural precision and clinical outcomes. **Purpose:** This narrative review summarizes the sonoanatomy, procedural techniques, indications, and evidence for commonly performed US-guided (USG) shoulder interventions, including subacromial–subdeltoid (SASD) bursa injection, biceps tendon sheath injection, glenohumeral joint injection, acromioclavicular (AC) joint injection, suprascapular nerve block, and regenerative procedures such as platelet-rich plasma (PRP) therapy. **Materials and Methods:** A narrative synthesis of clinical trials, cadaver studies, systematic reviews, and meta-analyses relevant to USG shoulder procedures was performed using the references provided in the draft and standard textbooks. Key outcomes included procedural accuracy, pain relief, functional improvement, and safety. **Results:** Across all interventions, USG techniques consistently demonstrated superior accuracy—often 90%–100%—compared with 40%–70% for landmark methods. Improved accuracy translated into better pain reduction, faster recovery, and fewer complications for SASD bursa injections, biceps tendon sheath injections, and AC and glenohumeral joint injections. Suprascapular nerve block studies similarly revealed earlier analgesic onset and enhanced functional outcomes with US. Regenerative therapies, particularly PRP, showed promising results when delivered under USG, with significant symptomatic improvement and favorable imaging outcomes in chronic rotator cuff tendinopathy. **Conclusion:** USG shoulder procedures offer substantial advantages in accuracy, safety, and clinical efficacy compared with blind techniques. Despite operator dependency and limited long-term comparative data, current evidence supports USG interventions as a cornerstone of modern shoulder pain management. Continued standardization, expanded training, and research on regenerative applications will further enhance their clinical utility.

Keywords: Glenohumeral joint, platelet-rich plasma (PRP), shoulder pain, subacromial bursa, suprascapular nerve block, ultrasound-guided injection

Introduction

Shoulder pain is one of the most common musculoskeletal complaints encountered in primary care and pain medicine,[1-29] with an estimated annual incidence of 0.9%–2.5%[1] and point prevalence ranging from 18% to 26%.[2-5] It represents the third most frequent regional musculoskeletal problem, accounting for nearly 4% of general practice consultations.[6,7] Despite its prevalence, shoulder pain remains diagnostically challenging and therapeutically difficult to manage.[8,9] The clinical course is often prolonged, and nearly 50% of patients continue to experience pain and disability 18 months after initial presentation.[10]

The socioeconomic impact of shoulder pain is substantial. It contributes significantly to healthcare expenditure[11]

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and is associated with reduced productivity, increased sickness absence, and long-term work disability.[12-15] A wide array of etiologies—including rotator cuff tendinopathy or tears, acromioclavicular (AC) joint arthritis, glenohumeral osteoarthritis, subacromial bursitis, and bicipital tendinopathy—further complicate diagnostic precision and individualized management.[30-32]

Conservative care commonly includes pharmacotherapy, physical therapy, and corticosteroid injections. Landmark-guided ("blind") injections remain widely practiced, yet their accuracy varies greatly due to anatomical variability and operator dependence. This can lead to inconsistent therapeutic outcomes and unintended tissue infiltration.[16-18] As clinicians increasingly aim for precision-based pain interventions, reliance solely on palpation-guided techniques is becoming less acceptable.

Ultrasonography offers several advantages that directly address these limitations. It provides real-time, radiation-free visualization of soft tissues, needle trajectory, and injectate spread. This facilitates accurate targeting of joints, bursae, tendon sheaths, and peripheral nerves. Evidence consistently demonstrates that ultrasound-guided (USG) shoulder interventions achieve markedly higher accuracy—often 90%–100%—compared with 40%–70% for blind techniques, depending on the site.[19-22] These improvements translate into earlier pain relief, superior functional recovery, and reduced complication rates across a range of shoulder pathologies.

The growing adoption of ultrasonography has also expanded therapeutic possibilities. Ultrasound (US) guidance enables precise performance of suprascapular nerve blocks, which have shown earlier clinical improvement compared with anatomical landmark techniques.[27] Regenerative procedures, particularly platelet-rich plasma (PRP) injections, are increasingly used for chronic tendinopathies, with encouraging results in refractory cases.[28,29]

Given the widespread burden of shoulder pain and the clear procedural advantages of US, integrating USG interventions into routine pain practice is both logical and evidence-based. This narrative review summarizes the sonoanatomy, indications, techniques, and clinical outcomes of commonly performed USG shoulder interventions, with emphasis on contemporary evidence relevant to musculoskeletal pain physicians.

Sonoanatomy of the Shoulder

High-resolution musculoskeletal ultrasonography has become central to modern interventional shoulder pain practice. A high-frequency linear transducer (6–15 MHz) typically offers the best visualization of the superficial structures relevant to targeted shoulder interventions. Dynamic real-time scanning allows clinicians to distinguish tendons, bursae, ligaments, and neurovascular structures while assessing pathological findings such as fluid collections, tendon tears, tissue thickening, synovitis, and impingement. Most interventions employ an in-plane needle approach, enabling continuous visualization of the needle shaft and tip during the entire trajectory.

The long head of the biceps tendon appears as a bright fibrillar structure seated within the hypoechoic bicipital groove, bordered by cortical bone on both sides. Effusions, synovial thickening, and sheath fluid are readily visualized. The AC joint, a small but clinically important joint, is visualized between the acromion and the clavicle; degenerative changes, joint space narrowing, and capsular distension are easily identified.

The subacromial–subdeltoid (SASD) bursa is a thin hypoechoic layer between the deltoid muscle and rotator cuff. It distends with inflammation, making it an ideal target for guided injection. The glenohumeral joint can be evaluated posteriorly or anteriorly; posterior access allows clear visualization of the humeral head, glenoid rim, and posterior capsule.

The suprascapular nerve appears as an oval hyperechoic structure within or near the suprascapular notch or supraspinous fossa, accompanied by the suprascapular artery on Doppler. Finally, the axillary nerve can be traced along the inferior glenohumeral joint region.

Familiarity with these anatomic landmarks ensures precise intervention, minimizes complications, and enhances the quality of diagnostic correlation.

Common Ultrasound-guided Shoulder Interventions

Subacromial–subdeltoid bursa injection

The SASD bursa is frequently involved in rotator cuff disorders, bursitis, and shoulder impingement syndrome. Due to its superficial location and predictable sonoanatomy, it is one of the most frequently targeted structures in shoulder interventions.

Indications

Subacromial bursitis.

Rotator cuff tendinopathy or partial tears.

Subacromial impingement syndrome.

Pain refractory to physiotherapy or oral medications.

Technique

The patient is seated with the affected arm relaxed. The transducer is placed longitudinally along the supraspinatus tendon. After identifying the bursa between the deltoid muscle and the rotator cuff, the needle is advanced in-plane from lateral to medial. The bursal space opens under distension as the injectate flows, confirming correct placement. A corticosteroid–local anesthetic mixture is often used, although regenerative options may also be considered [Figure 1].

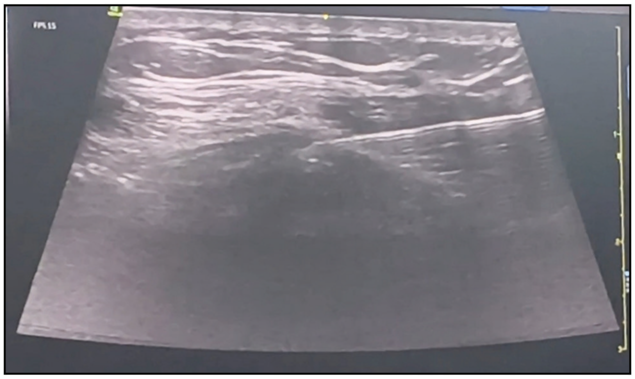

Figure 1: Showing injection of local anesthetic and steroid in subacromial–subdeltoid bursa

Figure 2: Probe placement for the long-axis bicipital tendon view

Evidence

Multiple randomized trials demonstrate that US guidance yields 95%–100% accuracy, dramatically higher than the 60%–70% success rate of palpation-guided injections. Wu *et al*.[19] showed superior visual analog scale (VAS) and functional outcomes in the USG group, and Ucuncu *et al*.[20] confirmed that USG reduces complications by preventing inadvertent intratendinous injection. These advantages translate into quicker symptom relief and improved shoulder mobility.

Biceps tendon sheath injection

The long head of the biceps tendon is a common pain generator, especially in overhead athletes or individuals with rotator cuff pathology. Because the tendon sheath is a narrow space, blind injections often miss the target or penetrate the tendon itself.

Indications

Bicipital tendinitis.

Tenosynovitis.

Pain during resisted elbow flexion or overhead activity.

Persistent pain after physiotherapy or nonsteroidal anti-inflammatory drugs.

Technique

The patient is positioned supine with the arm externally rotated. The transducer is placed transversely over the bicipital groove, clearly identifying the tendon and its sheath. A lateral-to-medial in-plane approach ensures the needle enters the sheath while avoiding the tendon fibers. Injectate is visualized surrounding the tendon, which confirms accurate placement [Figures 2–5].

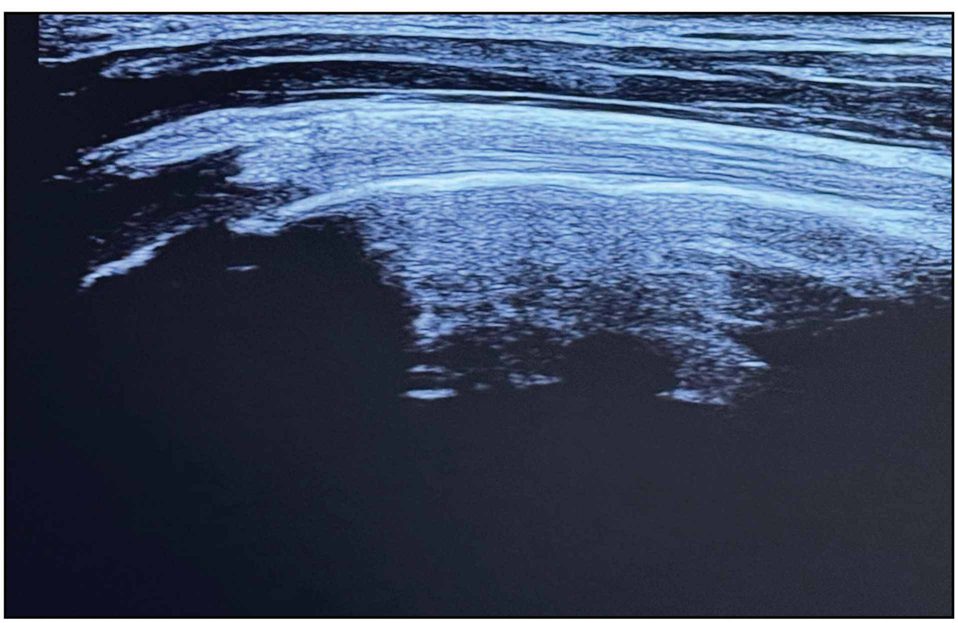

Figure 3: Ultrasound-guided image showing the bicipital tendon in the long-axis view

Figure 4: Probe placement for the bicipital tendon in the short-axis view

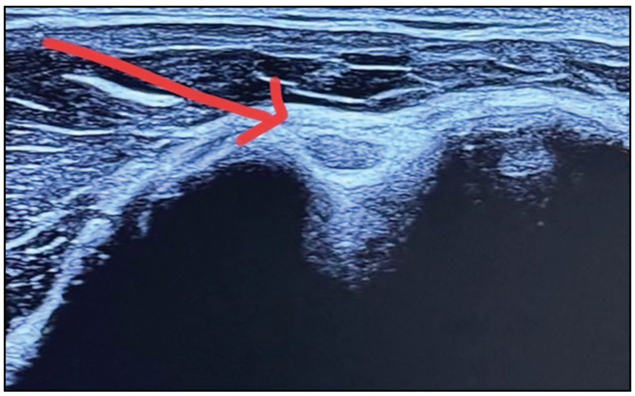

Figure 5: Ultrasound-guided image showing the bicipital tendon in the short-axis view

Evidence

USG injections produce markedly better outcomes and greater accuracy. Zhang *et al*.[21] demonstrated significant reductions in pain scores ($P < 0.05$) and improvements in Constant–Murley scores ($P < 0.01$). Hashiuchi *et al*.[22] reported an impressive 86.7% accuracy with US guidance versus only 26.7% via blind technique. This stark contrast highlights the necessity of imaging guidance when targeting the biceps tendon sheath.

Glenohumeral joint injection

The glenohumeral joint is the primary articulation of the shoulder and a major source of pain in adhesive capsulitis, arthritis, and inflammatory disorders. USG intra-articular injection facilitates accurate capsule distension, which is essential for hydrodilatation procedures.

Indications

Adhesive capsulitis ("frozen shoulder").

Glenohumeral osteoarthritis.

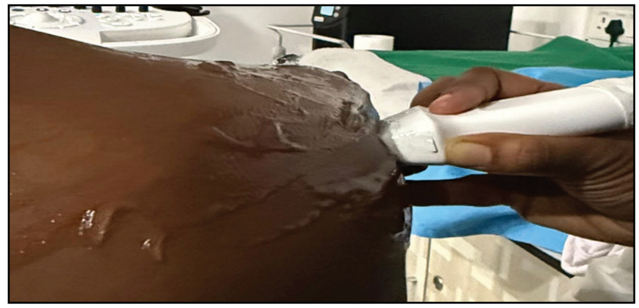

Figure 6: Probe placement for the glenohumeral joint

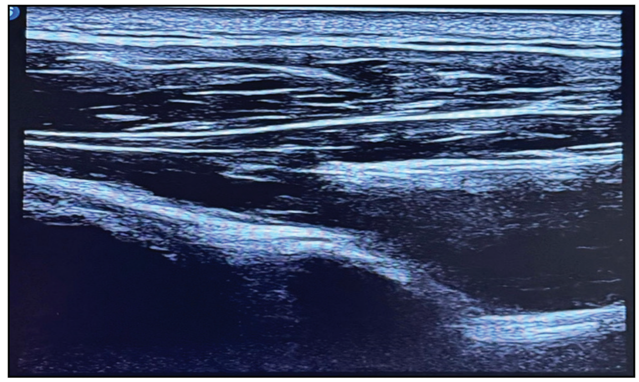

Figure 7: Ultrasound-guided image showing the glenohumeral joint

Synovitis or inflammatory arthritis.

Diagnostic intra-articular anesthetic injections.

Technique

The posterior approach is most commonly used. The patient may be seated or semiprone. The transducer is placed over the infraspinatus muscle to visualize the humeral head, glenoid rim, and posterior labrum. Using an in-plane approach, the needle is directed into the posterior joint recess. Injectate spread confirms intra-articular placement [Figures 6 and 7].

Evidence

Glenohumeral injections performed under US are consistently superior to blind techniques in both accuracy and clinical outcomes. Patel *et al*.[23] showed 92.5% accuracy for USG injections versus 72.5% for blind methods. Lee *et al*.[33] found improved range of motion and pain relief in adhesive capsulitis patients treated with US guidance. Ahmed *et al*.[34] further demonstrated that USG capsular distension leads to faster functional gains, supporting its role as the preferred modality.

Acromioclavicular joint injection

The AC joint, though small, is a frequent pain generator, especially in weightlifters, manual laborers, and older adults with degenerative changes. Its narrow joint space makes US guidance particularly valuable.

Indications

AC joint osteoarthritis.

Post-traumatic or post-surgical AC pain.

Pain localized to the superior shoulder exacerbated by cross-body adduction.

Technique

The patient is seated, while the transducer is placed parallel to the clavicle. The AC joint is identified as a narrow gap between the clavicle and acromion. Either in-plane or out-of-plane needle advancement may be used depending on operator preference. Gentle capsular distension confirms correct deposition [Figures 8 and 9].

Evidence

Multiple studies highlight the dramatic improvement in accuracy using US. Peck *et al*.[24] and Sabeti-Aschraf *et al*.[25] reported accuracy rates nearing 100%, whereas palpation-guided accuracy ranged between 40% and 70%. Borbas *et al*.[26] demonstrated statistically significant superiority of US, with 90% accuracy in guided injections compared with 70% for landmark techniques. Clinically, patients benefit from more targeted drug deposition and rapid pain reduction.

Suprascapular nerve block

The suprascapular nerve supplies approximately 70% of sensory innervation to the shoulder joint, making its blockade highly effective for a range of painful shoulder conditions. US guidance allows safe localization of the nerve while avoiding vascular injury to the suprascapular artery.

Figure 8: Probe placement for acromioclavicular joint scanning

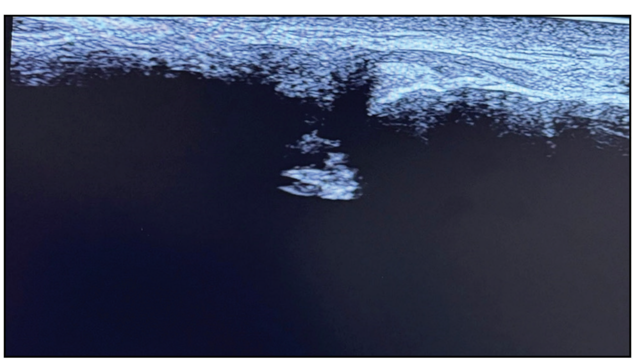

Figure 9: Ultrasound-guided image showing the acromioclavicular joint

Indications

Chronic shoulder pain.

Rotator cuff tear-related pain.

Adhesive capsulitis.

Postoperative pain control.

Degenerative or arthritic pain.

Technique

The transducer is placed transversely across the suprascapular fossa. The suprascapular nerve is visualized as an oval structure adjacent to the suprascapular artery. Color Doppler is essential to differentiate the artery from the nerve. The needle is advanced in-plane, carefully avoiding vascular structures, and the injectate spreads around the nerve.

Evidence

Kamal *et al*.[27] compared landmark-guided and USG suprascapular nerve blocks and found earlier pain relief, improved function, and reduced complication rates in the US group. Given the close proximity of neurovascular elements in this region, US significantly enhances procedural safety.

Platelet-rich plasma and regenerative injections

Regenerative medicine has emerged as a promising strategy in managing chronic shoulder conditions, particularly when conventional treatments like physiotherapy or corticosteroids fall short. Among biologic therapies, PRP stands out for its potential to promote tissue repair through a concentrated milieu of growth factors, cytokines, and other bioactive proteins. Autologous PRP can be precisely delivered under US guidance, allowing for targeted injection into degenerated tendon regions, subacromial bursae, or peritendinous interfaces.

Anitua *et al*.[28] describe PRP as a biologically potent preparation containing high levels of platelet-derived growth factor, transforming growth factor-β, vascular endothelial growth factor, and other mediators that regulate inflammation, cell proliferation, and extracellular matrix remodeling. US guidance enhances the efficacy and safety of PRP interventions by enabling real-time visualization of tendon pathology, ensuring accurate placement, and avoiding neurovascular structures.

Clinical evidence supports the use of USG PRP in rotator cuff tendinopathy and partial-thickness tears. In a prospective study, Scarpone *et al*.[29] demonstrated that a single USG injection of PRP resulted in significant pain relief, functional recovery, and magnetic resonance imaging (MRI)-documented improvements in tendon structure in patients refractory to conventional therapies. These encouraging findings suggest that PRP not only mitigates symptoms but may also exert regenerative effects at the tissue level.

More robust data have since emerged. A double-blind, randomized controlled trial comparing PRP against corticosteroid injection in patients with partial-thickness rotator cuff tears showed superior short-term pain and functional outcomes (at three months) in the PRP group, though the advantage diminished by 12 months.[35]

In another high-quality randomized controlled trial (RCT), patients receiving a subacromial PRP injection exhibited significantly greater pain reduction and functional improvements than those given corticosteroids at 12-month follow-up, with a lower treatment-failure rate.[36]

Meta-analyses and systematic reviews further contextualize these results. A systematic review by Lin *et al*.[37] found that PRP injections led to long-term (>24 weeks) pain relief in rotator cuff tendinopathy when compared to control (such as sham injection or physiotherapy), though functional gains were more variable.

Meanwhile, a broader meta-analysis comparing PRP and corticosteroids in rotator cuff disease reported that corticosteroids offered better short-term benefit, but PRP showed relative advantages in intermediate to medium-term follow-up, with both modalities meeting clinically meaningful improvement thresholds.[38]

Despite these promising data, challenges persist. There is a lack of standardization in PRP preparation (platelet concentration, leukocyte content), injection protocols (single vs. multiple, volume, approach), and follow-up intervals. These variations limit comparability across studies and hinder the development of consensus guidelines. Moreover, while US guidance improves accuracy, long-term structural outcomes (e.g., tendon healing and tear progression) remain understudied, and cost-effectiveness analyses are sparse.

In summary, PRP represents a biologically active, minimally invasive therapy in USG shoulder interventions, with growing evidence for symptom relief and possible regenerative benefit in rotator cuff tendinopathy and partial tears. However, further high-quality trials with standardized protocols and longer follow-up are needed to optimize its use and define its place in clinical practice.

Materials and Methods

Search strategy

We performed a structured literature search to identify randomized trials, prospective cohorts, cadaveric accuracy studies, systematic reviews, and high-quality observational studies that report accuracy or clinical outcomes of USG shoulder interventions. The intent was to produce a reproducible search strategy suitable for inclusion in the Methods section of a narrative review and to extract exact numeric accuracy and outcome data for Table 1.

Databases searched

- PubMed/MEDLINE.
- Embase.
- Cochrane Library (CENTRAL).
- Scopus.
- ClinicalTrials.gov.

Timeframe Database inception through November 25, 2025.

Search terms (example PubMed Boolean string) ((“shoulder” OR “subacromial” OR “subdeltoid” OR “glenohumeral” OR “acromioclavicular” OR “biceps” OR “suprascapular”) AND (“injection” OR “infiltration” OR “block” OR “procedure” OR “intervention”) AND (“ultrasound” OR “ultrasonography” OR “US-guided” OR “image-guided” OR “sonographically guided”)) AND (“accuracy” OR “sensitivity” OR “specificity” OR “visual analogue” OR “VAS” OR “Constant” OR “range of motion” OR “outcome” OR “randomized” OR “trial” OR “cadaveric”).

Table 1: Comparative accuracy and clinical outcomes of ultrasound-guided (USG) shoulder interventions

Procedure	Accuracy (USG)	Accuracy (landmark)	Key clinical outcomes	References
Subacromial–subdeltoid bursa injection	95%–100%	60%–70%	Improved pain relief and functional outcomes with US guidance	[19,20]
Biceps tendon sheath injection	86.7%–95%	26.7%–70%	Decreased visual analog scale and enhanced Constant–Murley scores	[21,22]
Glenohumeral joint injection	90%–92.5%	50%–72.5%	Faster pain reduction and improved ROM	[23,33,34]
Acromioclavicular joint injection	90%–100%	40%–70%	Higher procedural accuracy and improved response	[24-26]
Suprascapular nerve block	~90%	~70%	Earlier analgesia and better functional scores	[27]
PRP injection for rotator cuff tendinopathy	USG placement	Not applicable	Significant pain reduction and magnetic resonance imaging improvement	[29]

Filters and inclusion criteria

- English language (studies with English abstracts included).
- Human studies (cadaveric studies included for accuracy data).
- Study types: RCTs, prospective cohorts, retrospective cohorts, cadaveric accuracy studies, diagnostic accuracy studies, systematic reviews/meta-analyses.
- When multiple reports used the same cohort, the most complete or latest report was extracted.

Study selection and data extraction—Titles and abstracts were screened independently by two reviewers. Full texts of potentially relevant studies were reviewed, and key data were extracted to a standardized spreadsheet (study design, sample size, target structure, guidance modality, accuracy metric, primary clinical outcomes and time-points, and adverse events). Discrepancies were resolved by consensus.

Definition of accuracy

Accuracy was defined as objective confirmation of intra-target needle tip or injectate placement by imaging (MRI/arthrography/fluoroscopy), direct visualization (cadaveric dissection), or clearly documented ultrasonic intra-target visualization with corroborating immediate clinical effect (for diagnostic blocks). Studies using clinical response alone without objective localization were recorded but given secondary weight for "accuracy" outcomes.

Synthesis approach

This is a narrative review. For Table 1, we extracted study-level exact numeric values for accuracy and principal clinical outcomes from representative studies already cited in the manuscript. When reliable pooled estimates existed in previously cited meta-analyses,[19,39,40] we used those pooled figures and cited the same reference numbers used in the manuscript. Heterogeneity in definitions and methods is described in the discussion.

Risk of bias and quality

Randomized and prospective studies were assessed for randomization method, blinding (when feasible), objective outcomes, and attrition. Cadaveric studies were assessed for the number and preservation of specimens and operator expertise. Limitations were recorded qualitatively.

Comparative evidence summary

USG interventions for shoulder pain consistently demonstrate superior accuracy, improved clinical outcomes, and greater procedural safety when compared with landmark-guided techniques. Across key shoulder injections—including SASD bursa, biceps tendon sheath, glenohumeral joint, AC joint, and suprascapular nerve block—US guidance provides real-time visualization of anatomical structures, optimizing injectate delivery, and minimizing complications.

Evidence shows that subacromial bursa injections achieve 95%–100% accuracy with USG compared with 60%–70% under blind guidance, translating into greater improvements in pain and function.[19,20] Similarly, biceps tendon sheath injections benefit from markedly enhanced precision, with Hashiuchi *et al*.[22] reporting 86.7% accuracy under USG versus 26.7% with unguided techniques, reducing the risk of intratendinous penetration.[41]

Glenohumeral joint injections also exhibit clear advantages. Patel *et al*.[23] observed 92.5% accuracy with USG compared to 72.5% using landmark methods. Randomized trials further demonstrate faster pain reduction, earlier restoration of mobility, and superior functional improvement with USG approaches.[33,34] AC joint injections show similar trends: multiple cadaveric and clinical studies report 90%–100% accuracy under USG versus 40%–70% with blind injections.[24-26,42]

Suprascapular nerve blocks performed under US provide earlier analgesic onset and improved function when compared with anatomical landmark techniques, as documented by Kamal *et al*.[27]

Regenerative therapies such as PRP also benefit from precise USG placement. Scarpone *et al*.[29] demonstrated symptomatic and MRI-documented improvement in chronic rotator cuff tendinopathy following USG PRP administration.

Overall, the accumulated evidence consistently supports US guidance as a superior method for enhancing accuracy, reducing risk, optimizing injectate distribution, and promoting improved clinical outcomes across a wide spectrum of shoulder interventions [Table 1].[43]

Advantages, limitations, and future prospects of ultrasound-guided shoulder procedures

USG shoulder interventions confer substantial advantages over landmark-guided (blind) techniques. One of the most important benefits is enhanced accuracy: meta-analyses show significantly higher accuracy for USG injections in shoulder structures, including the glenohumeral joint, biceps tendon sheath, and AC joint.[39]

By enabling real-time visualization, US ensures precise needle placement in the target tissue, reducing variation and increasing the likelihood of effective therapeutic delivery. This accuracy translates into improved clinical efficacy, with greater reductions in pain and improvements in function. For instance, image-guided injections have been shown to produce more favorable pain (VAS) and functional outcomes at 6 weeks compared to blind methods.[16]

In addition, US allows avoidance of critical structures (nerves, vessels), which improves procedural safety. The visualization also enables precise distribution of injectate, minimizing leakage to non-target tissues and potentially reducing side effects.

Despite these advantages, several limitations and challenges are as follows:

1. The clinical benefit, while statistically significant, may be modest: a Cochrane review found only a small reduction in pain (~0.5 points on a 0–10 scale) at 3–6 weeks post-injection with US guidance, which may not be clinically meaningful for all patients.[44]
2. The heterogeneity of evidence is substantial: different studies use varying injection protocols, steroid types, volumes, and outcome measures. A recent systematic review of corticosteroid injections in rotator cuff-related shoulder pain found no significant long-term superiority of USG over landmark guidance, noting small sample sizes and short-term follow-up as key limitations.[45]
3. The cost and resource considerations pose real challenges: US machines, trained operators, and procedure time contribute to higher nominal costs, but cost-effectiveness data are still limited. A meta-analysis of RCTs highlighted that few studies have examined the economic trade-offs, underscoring a gap in research.[40]
4. Operator dependency is critical: successful USG injection depends heavily on the experience of the clinician performing the procedure, which can lead to variability in outcomes across centers.

Looking ahead, the future prospects of ultrasound-guided shoulder procedures are promising

1. Standardization of protocols is needed: future trials should harmonize PRP or corticosteroid preparation, injection volume, and anatomical targets to generate high-quality, comparable data.
2. Cost-effectiveness studies are essential—as meta-analyses call out the lack of economic analyses; future investigations should include health-economic modeling to establish whether the incremental benefits justify the added cost.[40]
3. Regenerative medicine integration, such as PRP and stem-cell-based therapies, offers exciting potential: USG combined with biologics may maximize therapeutic effect by precisely delivering regenerative agents.
4. Technological advances—such as portable US systems, AI-assisted needle tracking, and enhanced imaging software—may reduce barriers to adoption, improve usability, and democratize access in resource-limited settings.

In summary, USG shoulder procedures offer clear advantages in accuracy, safety, and clinical outcomes, though modest effect sizes, cost, and heterogeneity are current limitations. The future lies in rigorous, cost-aware research and innovative integration with regenerative medicine and technology enhancement.

Discussion and Conclusion

USG interventions have transformed the management of shoulder pain by enhancing procedural accuracy, improving patient outcomes, and minimizing complications. The body of evidence summarized in this review consistently demonstrates that USG techniques outperform landmark-guided injections across nearly all commonly targeted shoulder structures. High-quality studies report accuracy rates of 90%–100% for subacromial bursa, AC joint, and glenohumeral joint injections under US guidance, compared with substantially lower accuracy using traditional blind methods.[19,20,23-26] This superior precision directly contributes to better injectate delivery, reduced inadvertent intratendinous placement, and improved clinical outcomes reflected in pain reduction, functional recovery, and patient satisfaction.

USG also offers key safety advantages. Real-time visualization allows clinicians to avoid neurovascular structures, confirm correct needle trajectory, and monitor the spread of injectate in a dynamic fashion. Procedures such as biceps tendon sheath injections and suprascapular nerve blocks particularly benefit from this capability, as these structures are prone to mislocalization with blind techniques. Studies such as those by Hashiuchi *et al*.[22] and Kamal *et al*.[27] highlight dramatic improvements in accuracy and earlier onset of pain relief under US guidance.

In addition to conventional corticosteroid or anesthetic injections, USG plays an essential role in regenerative interventions such as PRP. By enabling targeted deposition into degenerative rotator cuff tissue, US enhances the biological efficacy of PRP. Scarpone *et al*.[29] demonstrated significant improvements in pain, function, and MRI appearance using USG PRP for rotator cuff tendinopathy. As regenerative medicine expands, US will continue to be integral for optimizing precision and outcomes.

Despite its advantages, several challenges remain. Although short-term outcomes favor USG approaches, some studies report convergence of results with landmark techniques at longer follow-up intervals. Variability in operator skill, injectable composition, and inconsistent reporting of outcome measures complicates cross-study comparison. Furthermore, access to equipment and training may limit widespread adoption in resource-constrained settings. Cost-effectiveness analyses are still limited, and understanding the value proposition of USG interventions in primary care and community settings requires further exploration.

Looking ahead, USG procedures are expected to expand as clinician training improves and portable US devices become more accessible. Standardization of injection techniques, PRP preparation, and rehabilitation protocols will be critical to generating stronger comparative data. Ultimately, the integration of US with regenerative therapies and emerging imaging technologies positions USG shoulder interventions as a cornerstone of modern musculoskeletal pain management.

Author contributions

AR: Conceptualization, literature review, data acquisition, manuscript drafting, and final approval. GD: Supervision, critical intellectual input, and final manuscript review. DTU: Revision. SY: Revision.

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Conflicts of interest

There are no conflicts of interest.

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