Ultrasound Guidance for Intra-Articular Knee and Shoulder Injections
A Review

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Abstract
Intra-articular injections have traditionally been performed “blind,” guided only by anatomic palpation. Many may be placed inaccurately, and the use of imaging may significantly improve injection accuracy. This review analyzed the impact of ultrasound-guidance on injection accuracy and clinical efficacy in the knee and shoulder joints. Ultrasound-guided injections were significantly more accurate than blind injections in clinical studies of the knee joint (92.7% vs. 77.9%, p < 0.05). Shoulder injections into the glenohumeral and acromioclavicular joints showed modest benefit in cadaver studies, but improved accuracy has not been demonstrated in clinical studies. Insufficient data was available to show any effect in the subacromial bursa. Preliminary efficacy research shows that ultrasound guidance may modestly improve the subjective pain relief and functional improvement provided by these injections.

Intra-articular injections of corticosteroids, hyaluronic acid, or other agents are commonly used as treatment in various painful and degenerative joint conditions. However, these injections may not be as accurate as previously believed. Intra-articular injections are traditionally performed “blind,” that is guided by palpation, relying on common anatomic landmarks and without the use of any concurrent imaging. Depending on injection site and approach, it has been shown that baseline accuracy may fall as low as the 45% to 85% range. Inaccurate injections represent a clinically significant problem as they may prevent desired symptomatic relief, require repeating the same procedure, or even require avoidable operative treatment.

One approach that has been utilized in order to improve accuracy is that of image-guided injections. Techniques that have been studied and applied include fluoroscopy, MRI, and ultrasound. This review will specifically focus on the use of ultrasound guidance, as it is safe, easy-to-perform, non-invasive, and can be used in an outpatient setting. Due to greater risk and cost, other imaging methods are considered impractical for this particular application.

The purpose of this review is to analyze the multidisciplinary body of literature on ultrasound injections of the knee and shoulder joints. There are two main research questions that guide this investigation. The first is whether ultrasound-needle guidance improves injection accuracy rates. Will an ultrasound guided injection accurately reach the desired intra-articular target more often than a blind one? The second question focuses on clinical outcomes. Is an ultrasound-guided injection more effective than a blind one? Even if an ultrasound-guided injection is more accurate than an unguided one, improved accuracy is only useful if it confers additional clinical benefit such as better pain relief or functional improvement.

Methods
The medical literature was searched using Medline with the goal of comprehensively identifying all peer-reviewed studies of image guided intra-articular injections. Initial searches yielded 5,045 studies related to intra-articular injections using combinations of MeSH terms: intra-articular injections, ultrasonography, arthrography, knee joint, shoulder joint, arthritis, and viscosupplementation. Additionally, reference sections of the articles themselves were searched to identify relevant studies not otherwise
identified. Twelve papers that discussed the first question of injection accuracy were identified and were included.

Included studies were ones that performed injections or aspirations using ultrasound guidance, performed injections in either a real clinical setting or on cadavers, and performed injections on the knee or any of three shoulder targets—glenohumeral joint (GH), acromioclavicular joint (AC), or subacromial bursa (SA).

Excluded studies were those that guided injections by other means (fluoroscopy, MRI, etc.) or injected in a different joint than the knee or any of the three shoulder targets (GH, AC, and SA).

All studies identified that met these criteria were included in the review. The injection accuracy data was analyzed quantitatively and broken down by injection site: knee, glenohumeral, acromioclavicular, and subacromial. Accuracy data in each injection site was analyzed using Fisher’s Exact Test to determine statistical significance. Due to the limitations of the clinical efficacy data—different injectable agents, different pain scoring systems, different measures of functional improvement, and a generally limited number of studies—those studies were reviewed in a qualitative format.

### Results

#### Accuracy

Overall, 12 primary studies were included that addressed the question of injection accuracy. Table 1 provides a concise summary of these 12 papers. Five of the papers studied the knee joint, six studied one of the shoulder joints, and one studied both knee and shoulder. Overall, the data set included 896 injections performed in varying sites: 491 knee, 119 glenohumeral, 220 acromioclavicular, and 66 subacromial. Of these 896 injections, 380 were performed in cadavers and 516 in a clinical setting. Table 2 is a summary of injection data in cadaver studies, and Table 3 is a summary of all injection data in clinical studies. Figures 1 through 4 are a graphical representation of this accuracy data by joint and injection site.

For knee injections, one cadaveric study (N = 80) showed an accuracy improvement from 77.5% to 100% (p = 0.002). Five clinical studies (N = 411) showed an accuracy improvement from 77.9% to 92.7% (p < 0.001) with ultrasound guidance.

### Table 1 Summary of the 12 Studies Included in the Analysis of Injection Accuracy, with 7 Clinical Studies and 5 Cadaver Studies

<table>
<thead>
<tr>
<th>Cadaver Studies</th>
<th>Joint</th>
<th>Injections</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curtiss (2011)⁴</td>
<td>Knee</td>
<td>80</td>
<td>Colored liquid latex injection, superolateral approach, dissected and graded by blinded investigator</td>
</tr>
<tr>
<td>Borbas (2012)¹</td>
<td>Shoulder (AC)</td>
<td>80</td>
<td>Methyl blue injections, dissection, and grading</td>
</tr>
<tr>
<td>Patel (2012)¹²</td>
<td>Shoulder (GH)</td>
<td>80</td>
<td>Contrast agent injected, scored by visible presence of injectate within GH joint on fluoroscopy or ultrasound</td>
</tr>
<tr>
<td>Peck (2010)¹³</td>
<td>Shoulder (AC)</td>
<td>20</td>
<td>Injection of colored latex solution, lateral-to-medial approach, dissected and graded by blinded investigator</td>
</tr>
<tr>
<td>Sabeti-Aschraf (2011)¹⁴</td>
<td>Shoulder (AC)</td>
<td>120</td>
<td>Ventral approach, water injected, scored based on appreciable widening/swelling of the AC joint</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clinical Studies</th>
<th>Joint</th>
<th>Injections</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balint (2002)⁶</td>
<td>Knee</td>
<td>29</td>
<td>Aspiration and subsequent injection of mixed joints with mixed pathology, graded as successful by positive fluid yield</td>
</tr>
<tr>
<td>Cunnington (2010)⁷</td>
<td>Knee</td>
<td>68</td>
<td>Contrast agent injected, immediate radiographs, outcome assessed by blinded radiologist, patient blinded by use of “sham ultrasound”</td>
</tr>
<tr>
<td>Im (2009)⁸</td>
<td>Knee</td>
<td>89</td>
<td>Knee OA, HA injections with contrast, medial patellar approach, verified by radiograph by the non-blinded injector</td>
</tr>
<tr>
<td>Park (2011)⁹</td>
<td>Knee</td>
<td>99</td>
<td>Knee OA, comparison of three different US guided injection approaches, contrast agent injected, radiographs, outcome assessed by blinded radiologist</td>
</tr>
<tr>
<td>Park (2012)¹⁰</td>
<td>Knee</td>
<td>126</td>
<td>Knee OA, HA injections with contrast, radiographs, graded by blinded assessor</td>
</tr>
<tr>
<td>Cunnington (2010)⁷</td>
<td>Shoulder (GH)</td>
<td>39</td>
<td>Contrast agent injected, immediate radiographs, outcome assessed by blinded radiologist, patient blinded by use of “sham ultrasound”</td>
</tr>
<tr>
<td>Dogu (2012)¹⁵</td>
<td>Shoulder (SA)</td>
<td>46</td>
<td>Contrast agent injected, variable approach, MRI and graded by blinded radiologist</td>
</tr>
<tr>
<td>Rutten (2007)¹⁶</td>
<td>Shoulder (SA)</td>
<td>20</td>
<td>Contrast agent injected, MRI and graded by two blinded radiologists</td>
</tr>
</tbody>
</table>

AC = Acromioclavicular, GH = Glenohumeral, SA = Subacromial Bursa, OA = Osteoarthritis, HA = Hyaluronic Acid.
For glenohumeral shoulder injections, one cadaveric study (N = 80) showed an accuracy improvement from 72.5% to 92.5% (p = 0.036), and one clinical study (N = 39) showed an accuracy improvement from 40.0% to 63.2% (p = 0.205).

Table 2  Summary of Injection Accuracy Data in Cadaver Studies

<table>
<thead>
<tr>
<th>Joint</th>
<th>Number of Studies</th>
<th>Blind Accurate/Total (%)</th>
<th>Ultrasound-Guided Accurate/Total (%)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee</td>
<td>1</td>
<td>31/40 (77.5%)</td>
<td>40/40 (100.0%)</td>
<td>0.002*</td>
</tr>
<tr>
<td>Shoulder (GH)</td>
<td>1</td>
<td>29/40 (72.5%)</td>
<td>37/40 (92.5%)</td>
<td>0.036*</td>
</tr>
<tr>
<td>Shoulder (AC)</td>
<td>3</td>
<td>75/110 (68.2%)</td>
<td>103/110 (93.6%)</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>Shoulder (SA)</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

*p < 0.05.

Table 3  Summary of Injection Accuracy Data in Clinical Studies

<table>
<thead>
<tr>
<th>Joint</th>
<th>Number of Studies</th>
<th>Blind Accurate/Total (%)</th>
<th>Ultrasound-Guided Accurate/Total (%)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee</td>
<td>5</td>
<td>106/136 (77.9%)</td>
<td>255/275 (92.7%)</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>Shoulder (GH)</td>
<td>1</td>
<td>8/20 (40.0%)</td>
<td>12/19 (63.2%)</td>
<td>0.205</td>
</tr>
<tr>
<td>Shoulder (AC)</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Shoulder (SA)</td>
<td>2</td>
<td>25/33 (75.8%)</td>
<td>26/33 (78.8%)</td>
<td>0.999</td>
</tr>
</tbody>
</table>

*p < 0.05.

Figure 1  Accuracy of injections at the knee joint.

Figure 2  Accuracy of injections at the glenohumeral joint of the shoulder.

Figure 3  Accuracy of injections at the acromioclavicular joint of the shoulder.

Figure 4  Accuracy of injections at the subacromial bursa of the shoulder.
= 0.205) with ultrasound guidance.

For acromioclavicular shoulder injections, three cadaveric studies (N = 220) showed an accuracy increase from 68.2% to 93.6% (p < 0.001) with ultrasound guidance, and no clinical studies were available.

Finally, for subacromial shoulder injections, no cadaveric studies were available, and two clinical studies (N = 66) showed similar accuracy results of 75.8% with blind injections and 78.8% with ultrasound guidance (p = 0.999).

**Efficacy**

Compared to studies on accuracy, there is a relative paucity of data suggesting that ultrasound-guided injections offer a clinically significant improvement in injection outcomes. Several studies discussed below have looked beyond accuracy, in order to gauge clinical efficacy.

In their first of two papers in 2009, Sibbitt and coworkers compared ultrasound guided versus blind corticosteroid injections in 148 mixed painful joints with varied pathology.17 With ultrasound guided injections, the study found significantly less procedural pain on the VAS scale (43.6% reduction, p = 0.0004), greater relative pain reduction scores 2 weeks post-injection (30.5% greater reduction, p = 0.002), and a reduced non-response rate (defined as a < 50% reduction in pain from baseline 2 weeks post-injection) from 28.4% to 10.1% (p = 0.038).

In 2012, Sibbitt and coworkers conducted a follow-up study comparing ultrasound versus blind aspirations and corticosteroid injections of 64 effusive knees.18 This study found 48% less procedural pain (p = 0.001), 183% increased aspiration yield (12 ml vs. 34 ml, p = 0.0001), and 46% less pain at 2 weeks post injection (VAS pain score 2.8 vs. 1.5, p = 0.034).

Cunnington and associates performed 184 injections in varied joints of patients with inflammatory arthritis.7 The study found no significant difference between blind and ultrasound-guided injections in pain relief on the VAS-pain scale, stiffness, range of motion, or function as measured by Health Assessment Questionnaire (HAQ) or EuroQol 5-domain questionnaire. Notably, the study did find that only clinicians using ultrasound guidance could reliably determine whether their injections were accurate (p < 0.001), whereas clinicians performing blind injections could not reliably make this determination (p = 0.29).

Three studies compared clinical outcomes of blind versus ultrasound corticosteroid injections specifically for shoulder pain. Naredo and colleagues in a study of SA injections in 41 patients found significantly better pain reduction 6 weeks post-injection (0-100 VAS score decrease of 34.9 vs. 7.1, p < 0.001) and a better Shoulder Function Assessment (SFA) score improvement (15 vs. 5.6, p < 0.05).19

Ucuncu and coworkers in a study of mixed shoulder injections in 60 patients also found better pain reduction 6 weeks post-injection (0-10 VAS score decrease of 4.0 vs. 2.2, p < 0.05) and better functional improvements as measured by the Constant score (change of 32.2 vs. 12.2, p < 0.05).20

Finally, Zufferey and associates in a study of SA injections in 67 patients found lower resting pain at 2 weeks post injection (0-10 vocal numerical rating pain scale, 1.6 vs. 3.3, p < 0.005) and at 6 weeks (3.0 vs. 4.2, p < 0.05).21 Changes in pain relief with activity and functional improvement, as measured by the Constant score, both showed no significant difference between the ultrasound and blind injection groups. Additionally, the study found a significantly higher percentage of good responders, as defined by a pain relief of greater than 50%, at both 2 weeks (81% vs. 54%, p < 0.005) and 6 weeks (64% vs. 38%, p < 0.05).

**Discussion**

This review serves to capture and analyze the literature on the highly relevant and clinically applicable problem of the value of ultrasound guidance for intra-articular knee and shoulder injections. According to our analysis, there is sufficient evidence from both cadaveric and clinical studies to conclude that ultrasound injections of the knee joint are more accurate than blind injections.

With regard to glenohumeral injections, there is limited evidence to suggest greater accuracy with ultrasound guidance in a single cadaver study, but there is no data to show that the same effect is significant in the one clinical study. The data suggest that accuracy may be improved, but this cannot be conclusively demonstrated based on the available studies. For acromioclavicular joint injections, we see a similar pattern. Cadaver studies suggest significantly increased accuracy, but this has not been demonstrated in a clinical setting. At this time, we cannot draw any strong conclusions about the accuracy of acromioclavicular joint injections with or without ultrasound guidance. Finally, there is insufficient data on subacromial shoulder injections to draw any conclusions either way.

Generally, more research needs to be conducted to establish the value of ultrasound guidance in improving accuracy of shoulder injections. The conclusions drawn from this analysis were also limited by the varying methodology used in the reviewed studies. Standardized protocols, blinding of the outcome assessor, the use of “sham ultrasound” (as done by Cunnington and colleagues7 to blind the patient), and a standardized definition of what marks an accurate injection could all help to strengthen future accuracy data.

As far as our analysis on clinical efficacy, it has been suggested in the literature that ultrasound guidance may improve outcomes, measured by pain relief and functional improvement, of both knee and subacromial shoulder injections. Several studies offer modest support for this idea. However, early results are equivocal, and there is insufficient literature on this topic to draw any firm conclusions. Pain relief scores are largely based on subjective, self-reported pain scores, which can carry a significant amount of bias. Future studies should preferentially focus on this question, as any improved accuracy of guided injections is not valuable unless it results in concurrent, objectively measured clinical benefits. Pain relief measures, scores of functional
improvement, and the timeline of the studies all need to be more standardized before any useful review of that evidence can be performed. Additionally, in this age of cost-conscious medicine, researching the cost-effectiveness of this intervention is critical. The possibility of less repeat injections and avoidable operations must be weighed against the additional costs of using ultrasound for these injections.

This review serves to both confirm and focus the research of Daley and coworkers, which establishes improved injection accuracy with concurrent guidance, but does not restrict the analysis to ultrasound nor discussed the clinical efficacy of guided injections. Additionally, it serves to confirm and build upon the conclusions of Berkoff and associates by updating their analysis and broadening the focus to review more literature on the shoulder joint. Generally, much of the literature on this topic comes from foreign sources and rheumatology journals, suggesting that ultrasound guidance for intra-articular injections has yet to be broadly adopted by the American orthopaedic community.3

In summary, ultrasound guidance for knee and shoulder injections is a promising yet still not fully evidence-supported method for improving care in many painful joint conditions. It improves the accuracy of knee injections, and may mildly improve the accuracy of glenohumeral and acromioclavicular shoulder injections as well. With greater accuracy, there may be theoretically greater improvements in pain relief, functional improvement, and overall clinical utility of these injections.

Disclosure Statement
Neither author has a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

References