

Existing Evidence on Ultrasound-Guided Injections in Sports Medicine

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Office-based ultrasonography has become increasingly available in many settings, and its use to guide joint and soft tissue injections has increased. Numerous studies have been conducted to evaluate the use of ultrasound-guided injections over traditional landmark-guided injections, with a rapid growth in the literature over the past few years. A comprehensive review of the literature was conducted to demonstrate increased accuracy of ultrasound-guided injections regardless of anatomic location. In the upper extremity, ultrasound-guided injections have been shown to provide superior benefit to landmark-guided injections at the glenohumeral joint, the subacromial space, the biceps tendon sheath, and the joints of the hand and wrist. Ultrasound-guided injections of the acromioclavicular and the elbow joints have not been shown to be more efficacious. In the lower extremity, ultrasound-guided injections at the knee, ankle, and foot have superior efficacy to landmark-guided injections. Conclusive evidence is not available regarding improved efficacy of ultrasound-guided injections of the hip, although landmark-guided injection is performed less commonly at the hip joint. Ultrasound-guided injections are overall more accurate than landmark-guided injections. While current studies indicate that ultrasound guidance improves efficacy and cost-effectiveness of many injections, these studies are limited and more research is needed.

Keywords: musculoskeletal ultrasonography; ultrasound-guided injection; joint injection; osteoarthritis; tendinopathy; sports medicine

Since 1957, ultrasonography has been used to evaluate the musculoskeletal system. The first report of musculoskeletal ultrasonography was published by Dussik et al,¹⁴ who measured the acoustic attenuation of articular and periarticular tissues. Since that time, the use of musculoskeletal ultrasonography has increased substantially. Ultrasonography is a useful tool because it is a repeatable, noninvasive imaging modality that is capable of providing real-time dynamic tissue assessment.³⁰ The term *sports ultrasound* was introduced in 2015 by the American Medical Society of Sports Medicine (AMSSM) and includes the diagnosis and treatment of both musculoskeletal and nonmusculoskeletal conditions applicable to the field of sports medicine.¹⁶ Ultrasonography has become more widely used in sports

medicine during procedures to assist with needle guidance and to visualize surrounding anatomic structures, thereby minimizing risk of injury to adjacent structures.¹⁷ In this article, we review the existing evidence on ultrasound-guided injections in sports medicine.

UPPER EXTREMITY INJECTIONS

Conflicting studies have been published regarding the effectiveness of ultrasound-guided injections at the shoulder. A Cochrane Review published in 2012 stated there was not enough evidence to recommend ultrasound-guided injections over landmark-guided injections at the shoulder.⁶ A 2015 meta-analysis, however, showed that ultrasound-guided glenohumeral and biceps tendon injections were not only more accurate but also more efficacious in providing relief.² Evidence on ultrasound-guided injection of other upper extremity joints is based on smaller studies. Current evidence is reviewed here and summarized in Table 1. The criteria used to assign level of evidence are derived from Wright et al⁵² consistent with those used in a recent position statement by Finnoff et al.¹⁷

Glenohumeral Joint

The glenohumeral joint is frequently injected with corticosteroids for osteoarthritis and adhesive capsulitis.

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TABLE 1
Summary of Upper Extremity Studies^a

Anatomic Feature Studied	Author	Type of Study	Sample Size	Accuracy, %		Efficacy	Level of Evidence
				USGI	LMGI		
Glenohumeral joint	Patel et al ²⁹	RCT	80	92.5	72.5	—	2
	Lee et al ²⁴	RCT	43	—	—	USGIs were more efficacious than LMGIs.	2
Acromioclavicular joint	Peck et al ³¹	RCT	20	100	40	—	2
	Rho et al ³⁶	Cohort	24	—	16.7	—	4
	Sabeti-Aschraf et al ³⁷	RCT	120	95	72	—	2
	Sabeti-Aschraf et al ³⁸	RCT	20	—	—	No difference in efficacy was found between USGIs and LMGIs.	2
Subacromial space	Borbas et al ⁷	RCT	80	90	70	—	2
	Aly et al ²	SR	220	93.6	68.2	—	2
	Ucuncu et al ⁴⁶	RCT	60	—	—	USGIs were more efficacious than LMGIs.	2
	Chen et al ⁸	RCT	40	—	—	USGIs were more efficacious than LMGIs.	2
Biceps tendon	Zhang et al ⁵⁴	RCT	98	—	—	USGIs were more efficacious than LMGIs.	2
	Hashiuchi et al ²⁰	RCT	30	86.7	26.7	—	1
Elbow joint	Lopes et al ²⁶	Cohort	31	—	100	—	1
	Cunnington et al ⁹	RCT	22	91	64	—	1
Hand and wrist joints	Smith et al ⁴³	Cohort	10	100	—	—	2
	Smith et al ⁴²	RCT	20	100	80	—	2
	Umphrey et al ⁴⁷	Cohort	17	94	—	—	2
	Pollard et al ³²	Cohort	10	100	81.8	—	2
	Goncalves et al ¹⁸	CS	27	—	—	USGIs were efficacious.	4
	Raza et al ³⁴	RCT	53	96	59	—	3

^a—, not reported; cohort, cohort study; CS, case series; LMGI, landmark-guided injection; RCT, randomized controlled trial; SR, systemic review; USGI, ultrasound-guided injection.

Injections into the glenohumeral joint have been studied for both accuracy and efficacy. Patel et al²⁹ compared the accuracy of landmark-guided versus ultrasound-guided glenohumeral injections by injecting 80 cadaveric shoulders. Results of the study favored ultrasound-guided over landmark-guided injections, with accuracy being 92.5% for ultrasound-guided injections compared with 72.5% for landmark-guided injections. Lee et al²⁴ evaluated the clinical effect of ultrasound-guided intra-articular injections compared with a landmark-guided technique for the treatment of adhesive capsulitis. The visual analog scale for pain intensity, range of motion of the shoulder, and general shoulder function during daily activities were measured at preinjection as a baseline and then every week after injection for 6 weeks for each patient. The improvements in pain intensity, range of motion, and shoulder function score were significantly greater in the ultrasound-guided injection group than in the landmark-guided injection group by the second week after injection ($P < .05$). However, no further significant differences were found in improvement between the 2 groups beyond the third week. Results from these studies demonstrate that ultrasound-guided injections are more accurate and efficacious than landmark-guided injections.

Acromioclavicular Joint

The acromioclavicular (AC) joint is a saddle joint at the articulation of the clavicle and acromion process. The AC is commonly affected by osteoarthritis and can be a source of pain. Corticosteroid injection into the AC joint

is a common treatment. Until recently, the AC joint was thought easy to palpate and inject using landmark guidance. However, Rho et al³⁶ found that accuracy of landmark-guided palpation of the AC joint was only 16.7% among physiatry residents.

Peck et al³¹ performed a study in which 20 unembalmed cadaveric AC joints were injected. All ultrasound-guided injections were successfully placed into the AC joint (10/10, 100%), whereas only 4 of 10 (40%) landmark-guided AC joint injections were accurate ($P = .0054$). Sabeti-Aschraf et al³⁷ conducted a prospective, randomized, observer-blinded study in which 120 AC joints of 60 cadavers were injected by use of an ultrasound-guided method or a landmark-guided method. The landmark-guided injection was inaccurate 25% of the time compared with 3% inaccuracy when ultrasound guidance was used ($P = .009$). Borbas et al⁷ also evaluated the accuracy of ultrasound-guided injection versus landmark-guided injection of the AC joint. Those investigators showed 90% accuracy for ultrasound-guided injections compared with 70% accuracy for landmark-guided injections ($P = .025$). A review by Aly et al² in 2015 showed that the accuracy of ultrasound-guided versus landmark-guided injections was 93.6% versus 68.2%, respectively ($P < .0001$).

Another study analyzed 20 patients who were assigned to either an ultrasound-guided or a landmark-guided group. Clinical examinations were performed before treatment and at 1 hour, 1 week, and 3 weeks after an injection into the AC joint.³⁸ Both groups had improvement in pain and function; however, no significant difference was found between the two groups. To date, although ultrasound-guided injections are clearly

more accurate than landmark-guided injections, it is yet to be determined whether ultrasound-guided injections to the AC joint are more efficacious than landmark-guided injections.

Subacromial Space

Mixed evidence is available on the benefits of ultrasound-guided subacromial injections. Several studies have revealed no significant difference in accuracy between ultrasound-guided and landmark-guided injections of the subacromial space.^{8,17,19} Some limited evidence is available for increased pain relief after ultrasound-guided subacromial-subdeltoid bursal injections.¹⁷

Ucuncu et al⁴⁶ evaluated 60 patients with shoulder pain due to soft tissue disorders who were randomly assigned to receive triamcinolone 40 mg by either landmark-guided or ultrasound-guided injection. The patients were evaluated on admission and at 6 weeks after the injection. Clinical assessment included a visual analog scale for pain, the Constant scale for function, passive and active shoulder range of motion, and postinjection adverse effects. Those patients receiving an ultrasound-guided injection showed statistically significant improvements in visual analog scale for pain and Constant scores for function at 6 weeks after injection when compared with the landmark-guided group. Improvement in active and passive range of motion was observed in both groups, with the ultrasound-guided group showing superior improvement. Of the patients with limited shoulder range of motion, 50% who underwent ultrasound-guided injections returned to normal motion, while only 33% of those who underwent landmark-guided injection returned to normal ($P < .05$). Range of motion in abduction of the shoulder in the landmark-guided injection group improved from $71.03^\circ \pm 12.38^\circ$ prior to injection to $100^\circ \pm 18.18^\circ$ at 1 week after the injection. The range of motion in the ultrasound-guided injection group improved to $139.29^\circ \pm 20.14^\circ$ after 1 week, from initial range of motion of $69.05^\circ \pm 14.72^\circ$ ($P < .05$).

The currently available evidence indicates that ultrasound-guided subacromial injections may be superior to landmark-guided injections. Most of the studies completed to this point used small sample sizes and did not evaluate cost-effectiveness. Larger studies are needed to determine the true efficacy of ultrasound-guided injection into the subacromial space.

Long Head of the Biceps Tendon

Zhang et al⁵⁴ conducted a randomized prospective study of 98 patients with tendinopathy of the long head of the biceps tendon. The patients were randomized to receive either an ultrasound-guided injection or landmark-guided injection into the biceps tendon sheath. In the ultrasound-guided group, the visual analog scale score significantly decreased ($P < .05$) and the Constant-Murley score improved ($P < .01$).

Hashiuchi et al²⁰ studied 30 patients with reported anterior shoulder pain with a primary diagnosis of tenosynovitis, tendinitis of the biceps tendon, or both. Shoulders were randomly allocated into ultrasound-guided and landmark-

guided injection groups. Computed tomography (CT) imaging was performed immediately after a contrast agent was injected into the biceps tendon sheath. Ultrasound guidance resulted in 86.7% of injections into the tendon sheath, whereas landmark guidance resulted in 26.7% into the tendon sheath, which was a significant difference ($P < .05$).

The results demonstrate that ultrasound-guided injections of the biceps tendon sheath are more accurate and efficacious than landmark-guided injections.

Elbow Joint

Few studies have evaluated ultrasound-guided injection of the elbow joint. Lopes et al²⁶ conducted a prospective study to evaluate the accuracy of intra-articular injections in peripheral joints. Within this study, 31 elbows were injected by use of landmark guidance only, and 100% were successfully injected. Cunnington et al⁹ conducted a double-blinded, randomized controlled study of ultrasound-guided corticosteroid joint injections in patients with inflammatory arthritis. Twenty-two elbows were injected, and ultrasound guidance was accurate 91% of time compared with landmark guidance at 64%; however, this was not statistically significant ($P = .100$). Data on efficacy of ultrasound-guided injections of the elbow joint are quite limited at this time.

Hand and Wrist Joints

Multiple small studies have evaluated accuracy of aspiration and injection of various joints in the wrist and hand. Smith et al⁴² performed a randomized controlled trial comparing the accuracy of ultrasound-guided versus landmark-guided injection at the scaphotrapezotrapezoid joint in cadaveric models. Accuracy of ultrasound-guided injections was 100%, whereas accuracy of landmark-guided injections was 80%. Another study evaluated ultrasound-guided distal radioulnar joint injections, reporting 100% accuracy.⁴⁵ Umphrey et al⁴⁷ performed ultrasound-guided injections of the trapeziometacarpal joint and reported that 94% of injections were successful. Pollard et al³² investigated the accuracy of intra-articular injection of the basal joint; the success rate was 100% for the ultrasound-guided group compared with 81.8% for the landmark-guided group. Goncalves et al¹⁸ conducted a case series demonstrating that ultrasound-guided injections of the metacarpophalangeal joint were efficacious and visual analog scale scores were improved. Raza et al³⁴ assessed the accuracy of proximal interphalangeal (PIP) and metacarpophalangeal (MCP) joint injections: Palpation-guided injections were intra-articular 59% of the time (6/12 PIP and 4/5 MCP joints) compared with 96% (24/26 PIP and 27/27 MCP joints) for ultrasound guidance.

LOWER EXTREMITY INJECTIONS

The use of ultrasound guidance for lower extremity joints is supported by a recent position statement published by AMSSM.¹⁷ Available evidence is reviewed here and summarized in Table 2.

TABLE 2
Summary of Lower Extremity Studies^a

Anatomic Feature Studied	Author	Type of Study	Sample Size	Accuracy, %		Efficacy	Cost-Effectiveness	Level of Evidence
				USGI	LMGI			
Hip joint	Ziv et al ⁵⁵	Cohort	40	—	77.5	—	—	2
	Diracoglu et al ¹²	Cohort	16	—	66.7	—	—	2
	Levi ²⁵	Retrospective review	11	100	—	—	—	4
	Micu et al ²⁷	Case control	61	—	—	USGIs were more efficacious than no injection.	—	3
	Smith et al ⁴²	Cohort	28	97	—	—	—	1
	Pourbagher et al ³³	Case series	10	100	—	80% of patients had less pain and improved function at 6 months.	—	1 for accuracy; 4 for efficacy
	Yoong et al ⁵³	Prospective cohort	138	—	—	93% of USGI patients had reduced pain and positive surgical outcome.	—	4
	Migliore et al ²⁸	Retrospective	2343	—	—	—	NSAID use decreased 48.2% after USGI.	4
Knee joint	Lopes et al ²⁶	Case series	37	—	100	Pain improvement was noted.	—	1 for accuracy; 4 for efficacy
	Jackson et al ²²	Cohort	240	—	71, 75, 93, approach dependent	—	—	1
	Esenyel et al ¹⁵	Cohort	39	—	56, 73, 76, 85, approach dependent	—	—	2
	Hermans et al ²¹	Systematic review	9 studies	—	67, 72, 85, 91, approach dependent	—	—	1
	Daley et al ¹¹	Systematic review	27 studies	99	70, 83, 85, approach dependent	—	—	1
	Curtiss et al ¹⁰	Cohort	20	100	55-100, injector dependent	—	—	2
	Berkoff et al ⁴	Meta-analysis	5 studies	95.8	77.8	USGIs were more efficacious.	—	2
	Sibbitt et al ³⁹	RCT	94	—	—	USGIs entailed less procedural pain and more improvement and were longer lasting.	—	2
Foot and ankle	Sibbitt et al ⁴⁰	RCT	64	—	—	USGIs entailed less procedural pain and better outcomes.	Health care costs were reduced.	2
	Smith et al ⁴³	Cohort	12	100	58	—	—	2
	Wisniewski et al ⁵¹	Cohort	20	100	85	—	—	2
	Khosla et al ²³	Cohort	14	100 (ST/TT)	100 (ST/TT)	—	—	2
	Goncalves et al ¹⁸	Cohort	31	100	—	All patients improved.	—	4
	Wempe et al ⁵⁰	Cohort	5	100 (MTP)	—	—	—	2
	Reach et al ³⁵	Cohort	10	100 (MTP/TT)	—	—	—	2

^a—, not reported; cohort, cohort study; CS, case series; LMGI, landmark-guided injection; MTP, metatarsophalangeal joint; NSAID, nonsteroidal anti-inflammatory drug; RCT, randomized controlled trial; SR, systemic review; ST, subtalar joint; TT, tibiotalar joint; USGI, ultrasound-guided injection.

Hip Joint

Only 2 studies have assessed the accuracy of landmark-guided hip joint injections. Ziv et al⁵⁵ and Diracoglu et al¹² separately studied landmark-guided hip joint injections in a total of 56 patients and showed an accuracy of 77.5% and 66.7%, respectively. Studies of ultrasound-guided injections have reported 100% accuracy^{25,27} with the exception of Smith et al,⁴⁴ who reported 97% accuracy in a group of 28 patients. In this study, the one injection that was not intra-articular was due to a single episode of inadvertent needle withdrawal during attachment of extension tubing for contrast administration.⁴⁴ The efficacy of ultrasound-guided injection has been evaluated in patients with hip pain related to osteoarthritis. A case series (N = 10) by Pourbagher et al³³ in 2005 found that 80% of patients had improved function and less pain at 6 months postinjection. Micu et al²⁷ compared ultrasound-guided injections versus no injection in a group of 61 patients; at 1- and 3-month follow-ups, the authors noted reduction in pain in those patients receiving injections but no change in pain in the group that did not receive injections. Yoong et al⁵³ evaluated the utility of ultrasound-guided hip joint injection in predicting surgical outcomes. In that study, 138 patients underwent ultrasound-guided injection with local anesthetic to aid in diagnosis of hip disease prior to surgical hip arthroscopy. Yoong et al⁵³ found that 93% of patients who had pain relief after injection had successful surgical outcomes, compared with 63% of patients with partial relief; 44 of 49 patients who had no relief from the injection ultimately did not have hip surgery.

A retrospective study by Migliore et al²⁸ in 2011 involving 2343 patients showed that ultrasound-guided intra-articular hip joint injection with hyaluronic acid for hip osteoarthritis decreased consumption of nonsteroidal anti-inflammatory drugs (NSAIDs). Consumption was decreased 48.2% at the 3-month follow-up, followed by a 50% decrease at the 12-month follow-up and a 61% decrease at the 24-month follow-up. This could lead to significantly decreased long-term health care costs as a result of a reduction in NSAID-induced complications.

Iliopsoas Bursa Injection

Anterior hip pain is commonly encountered by the orthopaedic and sports medicine provider. Snapping hip is a cause of anterior hip pain and affects 5% to 10% of the general population. Snapping hip syndrome can be caused by tightness and inflammation of the iliopsoas tendon leading to an audible or palpable snap as the hip moves from flexion to extension. When painful, this condition can respond to injection.

Few studies have been completed assessing pain relief of snapping hip with image-guided injections. In 2005, Adler et al¹ completed a retrospective review of ultrasound-guided injections into the iliopsoas bursa. The investigators enrolled 39 patients and injected an 8-mL solution of anesthetic and corticosteroid into the iliopsoas bursa. They conducted telephone follow-up to assess pain, with a mean follow-up period

of 13.5 months. The investigators showed that 44% of the patients had continued relief of symptoms at 1 year after the injection. No major complications were reported.

In 2006, Blankebaker et al⁵ conducted a retrospective study to assess pain relief achieved from anesthetic injection of the iliopsoas bursa and also assessed the effectiveness of Kenalog injection into the iliopsoas bursa for long-term pain relief. For this study, long-term pain relief was interpreted as improvement of pain for 4 months following injection. Forty patients were enrolled: 22 received ultrasound-guided injection of the iliopsoas bursa with a 7-mL mixture containing lidocaine and bupivacaine, while 18 received ultrasound-guided injection with an 8-mL mixture containing lidocaine, bupivacaine, and Kenalog-40. Injection response was monitored using an 11-point pain scale that was assessed 2 days after the procedure. Those patients undergoing injection with Kenalog were observed for an additional 4 months after injection. Twenty-nine patients had complete or partial relief of pain (>50% pain reduction) from iliopsoas bursal injection 2 days after the injection. Sixteen of the 18 patients (89%) who underwent Kenalog injection had improvement of pain after 4 months.

In 1989, Silver et al⁴¹ reported a single case where the patient had complete relief of symptoms related to snapping hip 2 months after image-guided injection with solution of anesthetic and corticosteroid (Depo-Medrol). In a case series of 3 athletes published in 2004, Wahl et al⁴⁹ showed that ultrasound-guided injection with anesthetic and corticosteroid provided short-term relief for all patients up to 2 weeks after the injection. Two of the 3 patients experienced long-term relief of symptoms for more than 2 years. In 1995, Vaccaro et al⁴⁸ showed a similar response in 8 patients undergoing ultrasound-guided injection of anesthetic and corticosteroid into the iliopsoas bursa. Those 8 patients had relief of symptoms for periods ranging from 2 weeks to 2 years.

The above studies show that ultrasound-guided injection into the iliopsoas bursa is well tolerated and does not have significant adverse complications.^{48,49} Landmark-guided injections are generally not performed at this location because of the proximity to the femoral vascular structures.⁵ A low risk of infection and vascular injuries is found with ultrasound-guided iliopsoas bursa injection.

Knee

Osteoarthritis is a common condition affecting the knee and is often treated with corticosteroid injections. Accuracy of landmark-guided injections is somewhat variable but generally good. Studies from 1993 onward demonstrate a wide margin of accuracy with respect to landmark-guided injection, ranging from 55% to 100%, which is often dependent on the approach taken. A case series by Lopes et al²⁶ in 2008, comprising 37 patients, appears to be the only landmark-guided injection study to report 100% accuracy as well as efficacy. In 2002, Jackson et al²² showed 93% accuracy for lateral midpatellar, 75% for anteromedial, and 71% for anterolateral landmark-guided approaches.

In 2007, Esenyel et al¹⁵ showed 85% accuracy for an anterolateral approach and 56% for medial midpatellar

tendon, with 73% and 76% for anteromedial and lateral midpatellar, respectively. Systematic reviews of landmark-guided injections of the knee conducted by Daley et al¹¹ and Hermans et al,²¹ both published in 2011, reported accuracy rates from 67% to 91% based on approach, with a superolateral approach being most accurate (91%). Daley et al¹¹ did not find statistically significant differences in approach.

Curtiss et al,¹⁰ in a cadaveric ultrasound-guided versus landmark-guided study published in 2011, showed a range of accuracy of 55% to 100% in the landmark-guided group. The results for landmark-guided injections were dependent upon the injector, while the ultrasound-guided injections were 100% accurate regardless of injector.

In other head-to-head studies, ultrasound-guided injections were universally found to be more accurate than landmark-guided injection. In a 2012 review, Berkoff et al⁴ examined 13 relevant studies, with ultrasonography used in 5 studies and the remaining studies using air arthrography, fluoroscopy, magnetic resonance arthrography, or magnetic resonance imaging. The accuracy of injection ranged from 63% to 100% with ultrasonography, while the accuracy ranged from 39% to 100% with landmark guidance. Accuracy was 95.8% with ultrasound guidance versus 77.8% without ultrasound guidance.

Sibbitt et al^{39,40} examined both efficacy and cost-effectiveness of knee injections in patients with inflammatory arthropathy. First, in 2011, in a prospective, randomized controlled trial of 94 patients, the investigators showed greater accuracy with ultrasound-guided injection.³⁹ This study also concluded that ultrasound guidance improves clinical outcomes by increasing therapeutic duration. The increased therapeutic duration leads to less utilization of health care resources and overall reduction in yearly health care costs. Similar findings were achieved in the 2012 study by Sibbitt et al⁴⁰ of 64 patients. These studies were performed in patients with inflammatory arthropathy, and one should be cautious extrapolating these data to noninflammatory arthropathies.

Foot and Ankle

Several studies have examined the accuracy of landmark-guided and ultrasound-guided foot and ankle joint injections. Accuracy in these studies ranged from 58% to 85% for landmark-guided injections, while ultrasound-guided injections were universally 100% accurate in each study.^{18,23,35,43,50,51} Of note, Khosla et al²³ showed 100% accuracy in a head-to-head cadaveric study of both ultrasound-guided and landmark-guided injections (N = 14) for the tibiotalar joint and subtalar joints, suggesting that either modality would be sufficient. With tarsometatarsal joint injections, ultrasound-guided injections were vastly more accurate than landmark-guided injections, at 64% versus 24%, respectively. Reach et al³⁵ (N = 10) and Wempe et al⁵⁰ (N = 5) in 2009 and 2012, respectively, both showed 100% accuracy in cadaveric ultrasound-guided injection of the metatarsophalangeal joints. Goncalves et al¹⁸ found excellent efficacy in both tibiotalar joint and tarsometatarsal joint injections, with 100% of patients

showing clinical improvement following the procedure. In addition, Drakonaki et al¹³ showed that a majority of patients with midfoot degenerative disease experienced relief up to 3 months following ultrasound-guided injection.

SUMMARY

As technology improves and the availability of ultrasonography increases, ultrasound-guided procedures for musculoskeletal abnormalities are becoming more popular. Many of the studies on corticosteroid injections using ultrasound guidance have shown accuracy superior to that of landmark-guided injections. Research on the efficacy and cost-effectiveness of ultrasound-guided injections is less conclusive. This may be due in part to a lack of high-quality research proving the effectiveness of corticosteroids or other modalities to treat many of the conditions for which they are used.³ Evidence also shows that less experienced providers can be more accurate with ultrasound guidance, potentially affecting the future of medical education.¹³ Continued study of ultrasound-guided injections will be helpful in guiding practice. In the meantime, given the improvements in accuracy, ultrasound-guided injections certainly have a role for deeper anatomic structures, for injecting targets that are close to large vascular structures, and for patients in whom nonguided injections have failed.

REFERENCES

1. Adler RS, Buly R, Ambrose R, Sculco T. Diagnostic and therapeutic use of sonography-guided iliopsoas peritendinous injections. *AJR Am J Roentgenol.* 2005;185:940-943.
2. Aly AR, Rajasekaran S, Ashworth N. Ultrasound-guided shoulder girdle injections are more accurate and more effective than landmark-guided injections: a systematic review and meta-analysis. *Br J Sport Med.* 2015;49:1042-1049.
3. Bellamy N, Campbell J, Robinson V, et al. Intraarticular corticosteroid for treatment of osteoarthritis of the knee. *Cochrane Database Syst Rev.* 2006;(2):CD005382.
4. Berkoff DJ, Miller LE, Block JE. Clinical utility of ultrasound guidance for intra-articular knee injections: a review. *Clin Interv Aging.* 2012;7: 89-95.
5. Blankebaker DG, De Smet AA, Kee JS. Sonography of the iliopsoas tendon and injection of the iliopsoas bursa for the diagnosis and management of the painful snapping hip. *Skeletal Radiol.* 2006;35(8): 565-571.
6. Bloom JE, Rischin A, Johnston RV, et al. Image-guided versus blind glucocorticoid injection for shoulder pain. *Cochrane Database Syst Rev.* 2012;(8):CD009147.
7. Borbas P, Kraus T, Clement H, et al. The influence of ultrasound guidance in the rate of success of acromioclavicular joint injection: an experimental study on human cadavers. *J Shoulder Elbow Surg.* 2012;21:1694-1697.
8. Chen MJ, Lew HL, Hsu TC, et al. Ultrasound-guided shoulder injections in the treatment of subacromial bursitis. *Am J Phys Med Rehabil.* 2006;85:31-35.
9. Cunningham J, Marshall N, Hide G, et al. A randomized, double-blind, controlled study of ultrasound-guided corticosteroid injection into the joint of patients with inflammatory arthritis. *Arthritis Rheum.* 2010;62: 1862-1869.
10. Curtiss HM, Finnoff JT, Peck E, et al. Accuracy of ultrasound-guided and palpation-guided knee injections by an experienced and less-experienced injector using a superolateral approach: a cadaveric study. *PM R.* 2011;3:507-515.

11. Daley EL, Bajaj S, Bisson LJ, et al. Improving injection accuracy of the elbow, knee, and shoulder: does injection site and imaging make a difference? A systematic review. *Am J Sports Med.* 2011;39:656-662.
12. Diracoglu D, Alptekin K, Dikici F, et al. Evaluation of needle positioning during blind intra-articular hip injections for osteoarthritis: fluoroscopy versus arthrography. *Arch Phys Med Rehabil.* 2009;90:2112-2115.
13. Drakonaki EE, Kho JS, Sharp RJ, et al. Efficacy of ultrasound guided steroid injections for pain management of midfoot joint degenerative disease. *Skeletal Radiol.* 2011;40:1001-1006.
14. Dussik KT, Fritch DJ, Kyriazidou M, et al. Measurements of articular tissues with ultrasound. *Am J Phys Med.* 1958;37:160-165.
15. Esenyel C, Demirhan M, Esenyel M, et al. Comparison of four different intra-articular injection sites in the knee: a cadaver study. *Knee Surg Sports Traumatol Arthrosc.* 2007;15:573-577.
16. Finnoff JT, Berkoff D, Brennan F, et al. American Medical Society for Sports Medicine recommended sports ultrasound curriculum for sports medicine fellowships. *Clin J Sport Med.* 2015;25:23-29.
17. Finnoff JT, Hall MM, Adams E, et al. American Medical Society for Sports Medicine position statement: interventional musculoskeletal ultrasound in sports medicine. *Clin J Sport Med.* 2015;25:6-22.
18. Goncalves B, Ambrosio C, Serra S, et al. US-guided interventional joint procedures in patients with rheumatic diseases—when and how we do it? *Eur J Radiol.* 2011;79:407-414.
19. Hall MM. The accuracy and efficacy of palpation versus image-guided peripheral injections in sports medicine. *Curr Sports Med Rep.* 2013;12:296-303.
20. Hashiuchi T, Sakurai G, Morimoto M, et al. Accuracy of the biceps tendon sheath injection: ultrasound-guided or unguided injection? A randomized controlled trial. *J Shoulder Elbow Surg.* 2011;20:1069-1073.
21. Hermans J, Bierma-Zeinstra SM, Bos PK, et al. The most accurate approach for intra-articular needle placement in the knee joint: a systematic review. *Semin Arthritis Rheum.* 2011;41:106-115.
22. Jackson DW, Evans NA, Thomas BM. Accuracy of needle placement into the intra-articular space of the knee. *J Bone Joint Surg Am.* 2002;84-A:1522-1527.
23. Khosla S, Thiele R, Baumhauer JF. Ultrasound guidance for intra-articular injections of the foot and ankle. *Foot Ankle Int.* 2009;30:886-890.
24. Lee HJ, Lim KB, Kim DY, et al. Randomized controlled trial for efficacy of intra-articular injection for adhesive capsulitis: ultrasonography-guided versus blind technique. *Arch Phys Med Rehabil.* 2009;90:1997-2002.
25. Levi DS. Intra-articular hip injections using ultrasound guidance: accuracy using a linear array transducer. *PM R.* 2013;5:129-134.
26. Lopes RV, Furtado RN, Parmigiani L, et al. Accuracy of intra-articular injections in peripheral joints performed blindly in patients with rheumatoid arthritis. *Rheumatology (Oxford).* 2008;47:1792-1794.
27. Micu MC, Bogdan GD, Fodor D. Steroid injection for hip osteoarthritis: efficacy under ultrasound guidance. *Rheumatology (Oxford).* 2010;49:1490-1494.
28. Migliore A, Granata M, Tormenta S, et al. Hip viscosupplementation under ultra-sound guidance reduces NSAID consumption in symptomatic hip osteoarthritis patients in a long follow-up: data from Italian registry. *Eur Rev Med Pharmacol Sci.* 2011;15:25-34.
29. Patel DN, Nayyar S, Hasan S, et al. Comparison of ultrasound-guided versus blind glenohumeral injections: a cadaveric study. *J Shoulder Elbow Surg.* 2012;21:1664-1668.
30. Patel Y, Scillia A, Festa A, et al. The role of ultrasound-guided injections in orthopaedic sports medicine: upper extremity. *AAOS Now.* January 9, 2015:14.
31. Peck E, Lai JK, Pawlina W, et al. Accuracy of ultrasound-guided versus palpation-guided acromioclavicular joint injections: a cadaveric study. *PM R.* 2010;2:817-821.
32. Pollard MA, Cermak MB, Buck WR, et al. Accuracy of injection into the basal joint of the thumb. *Am J Orthop.* 2007;36:204-206.
33. Pourbagher MA, Ozalay M, Pourbagher A. Accuracy and outcome of sonographically guided intra-articular sodium hyaluronate injections in patients with osteoarthritis of the hip. *J Ultrasound Med.* 2005;24:1391-1395.
34. Raza K, Lee CY, Pilling D, et al. Ultrasound guidance allows accurate needle placement and aspiration from small joints in patients with early inflammatory arthritis. *Rheumatology.* 2003;42:976-979.
35. Reach JS, Easley ME, Chuckpaiwong B, et al. Accuracy of ultrasound guided injections in the foot and ankle. *Foot Ankle Int.* 2009;30:239-242.
36. Rho ME, Chu SK, Yang A, et al. Resident accuracy of joint line palpation using ultrasound verification. *PM R.* 2014;6:920-925.
37. Sabeti-Aschraf M, Lemmerhofer B, Lang S, et al. Ultrasound guidance improves the accuracy of the acromioclavicular joint infiltration: a prospective randomized study. *Knee Surg Sports Traumatol Arthrosc.* 2011;19:292-295.
38. Sabeti-Aschraf M, Ochsner A, Schueller-Weidekamm C, et al. The infiltration of the AC joint performed by one specialist: ultrasound versus palpation a prospective randomized pilot study. *Eur J Radiol.* 2010;75:e37-e40.
39. Sibbitt WL Jr, Band PA, Kettwich LG, et al. A randomized controlled trial evaluating the cost-effectiveness of sonographic guidance for intra-articular injection of the osteoarthritic knee. *J Clin Rheumatol.* 2011;17:409-415.
40. Sibbitt WL Jr, Kettwich LG, Band PA, et al. Does ultrasound guidance improve the outcomes of arthrocentesis and corticosteroid injection of the knee? *Scand J Rheumatol.* 2012;41:66-72.
41. Silver SF, Connell DG, Duncan CP. Case report 550. *Skeletal Radiol.* 1989;18:327-328.
42. Smith J, Brault JS, Rizzo M, et al. Accuracy of sonographically guided and palpation guided scaphotrapezotrapezoid joint injections. *J Ultrasound Med.* 2011;30:1509-1515.
43. Smith J, Finnoff JT, Levy BA, et al. Sonographically guided proximal tibiofibular joint injection: technique and accuracy. *J Ultrasound Med.* 2010;29:783-789.
44. Smith J, Hurdle MF, Weingarten TN. Accuracy of sonographically guided intra-articular injections in the native adult hip. *J Ultrasound Med.* 2009;28:329-335.
45. Smith J, Rizzo M, Sayeed YA, et al. Sonographically guided distal radioulnar joint injection: technique and validation in a cadaveric model. *J Ultrasound Med.* 2011;30:1587-1592.
46. Ucuncu F, Capkin E, Karkucak M, et al. A comparison of the effectiveness of landmark-guided injections and ultrasonography guided injections for shoulder pain. *Clin J Pain.* 2009;25:786-789.
47. Umphrey GL, Brault JS, Hurdle MF, et al. Ultrasound-guided intra-articular injection of the trapeziometacarpal joint: description of technique. *Arch Phys Med Rehabil.* 2008;89:153-156.
48. Vaccaro JP, Sauser DD, Beals RK. Iliopsoas bursa imaging: efficacy in depicting abnormal iliopsoas tendon motion in patients with internal snapping hip syndrome. *Radiology.* 1995;197(3):853-856.
49. Wahl CJ, Warren RF, Adler RS, et al. Internal coxa saltans (snapping hip) as a result of overtraining—a report of 3 cases in professional athletes with a review of causes and the role of ultrasound in early diagnosis and management. *Am J Sports Med.* 2004;32(5):1302-1309.
50. Wempe MK, Sellon JL, Sayeed YA, et al. Feasibility of first metatarsophalangeal joint injections for sesamoid disorders: a cadaveric investigation. *PM R.* 2012;4:556-560.
51. Wisniewski SJ, Smith J, Patterson DG, et al. Ultrasound-guided versus nonguided tibiotalar joint and sinus tarsi injections: a cadaveric study. *PM R.* 2010;2:277-281.
52. Wright J, Swionkowski MF, Heckman JD. Introducing levels of evidence to the journal. *J Bone Joint Surg Am.* 2003;85:1-3.
53. Yoong P, Guirguis R, Darrach R, et al. Evaluation of ultrasound-guided diagnostic local anaesthetic hip joint injection for osteoarthritis. *Skeletal Radiol.* 2012;41:981-985.
54. Zhang J, Ebraheim N, Lause GE. Ultrasound-guided injection for the biceps brachii tendinitis: results and experience. *Ultrasound Med Biol.* 2011;37:729-733.
55. Ziv YB, Kardosh R, Debi R, et al. An inexpensive and accurate method for hip injections without the use of imaging. *J Clin Rheumatol.* 2009;15:103-105.