Clinical Applications of Ultrasonography in the Shoulder and Elbow

Abstract

In the past 30 years, the use of ultrasonography in the field of orthopaedics has evolved. As ultrasonography has been refined, smaller machines with higher fidelity and better transducers have become available at a lower cost. Diagnostic and therapeutic applications of ultrasonography in the shoulder and elbow have expanded imaging options and provided alternatives to surgical management. Ultrasonography is a dynamic tool that affords immediate diagnostic assessment for clinical correlation and can be used for serial examinations and image guidance during therapeutic procedures. This imaging modality is highly reliable and accurate and may limit the need for costly imaging referrals, particularly in geographic areas where advanced imaging is not readily available. However, clinical expertise is paramount for ultrasonography, which is an operator-dependent modality. Ultrasonography is an effective educational resource; therefore, the curriculum in orthopaedic residency training programs should include education on this modality as the use of ultrasonography increases among orthopaedic surgeons.

The first report of musculoskeletal sonography was published in 1958 by Dussik et al.1 in a study that measured acoustic attenuation of articular and periarticular tissues. Technical advances and expanding indications in the 1970s popularized the use of ultrasonography in athletes.2 In the 1980s and early 1990s, Middleton et al3 and Harryman et al4 first evaluated rotator cuff pathology using ultrasonography. In a more recent study, Yamaguchi et al5 performed a longitudinal analysis of rotator cuff tears (RCTs) detected on sonograms. Ultrasonography is an operator-dependent imaging modality, and clinical expertise in its use is paramount. Even with the use of well-defined protocols, substantial interobserver variability is associated with ultrasonography, and ultrasonography performed by clinicians rather than radiologists has led to debates with regard to training and level of competence.6 Published training guidelines indicate that clinicians must perform 150 to 300 scans under the supervision of a qualified ultrasonographer or radiologist to develop proficiency.6

In general, MRI is the preferred imaging modality for evaluation of the shoulder and elbow. In most patients, MRIs are comprehensive; however, arthrography often is required to improve the diagnostic accuracy of MRI for labral assessment. MRI is not well tolerated by some patients, may lead to incidental findings, and may be costly. In contrast, ultrasonography allows for rapid,
dynamic examination, immediate clinical correlation, and image guidance during therapeutic procedures. Ultrasonography can be used for serial examination of soft tissues and affords real-time tissue elastography, which is a technique that allows for close monitoring of tendon and tissue quality with various muscle contraction conditions and joint positions.7

Ultrasonography is an excellent educational tool for orthopaedic residency training, and interest in the use of this modality as an adjunct for physical examination of the shoulder and elbow has increased in the past two decades. Other benefits of ultrasonography include portability, decreased artifact from metal hardware, and contrast-enhanced Doppler applications that allow for real-time assessment of soft-tissue vascularity.2,8 In addition, ultrasonography is less expensive than MRI. In 2007, >80 million MRIs were performed in the United States, with a cost to the healthcare system of >$120 billion.9

In a recent study of 146 patients who underwent ultrasonographic evaluation of shoulder pathology, Adelman and Fishman9 reported that 35 MRIs were avoided with the use of ultrasonography, saving a predicted $17,603, which represented a 50% 1-year return on investment ($34,897) for the ultrasonography machine and equipment.

Office-based musculoskeletal ultrasonography became possible as the quality of portable ultrasonography improved. Newer generation machines, which currently are the size of a laptop computer, replaced the large ultrasonography units typically used in hospitals. The ability to own and maneuver an ultrasonography machine in a clinic in combination with higher quality sonograms allowed for increased office-based musculoskeletal ultrasonography. The processing power, transducer capabilities, and software advances of newer ultrasonography machines also played an important role in the increased office-based use of the modality. Various ultrasonography machines are available for clinicians who desire an-office musculoskeletal ultrasonographic capability. Almost all modern models meet high-quality and function standards. Selection of an appropriate machine for a clinic requires consideration of the desired capabilities of interchangeable probes, desired image resolution, ease of use, comfort with the machine/interface, and cost. To become familiar with various ultrasonography machines, clinicians can contact manufacturers to test their machines and/or attend expositions to observe demonstrations of the newest features. Clinicians can contact colleagues and/or attend educational courses to determine the advantages and disadvantages of various ultrasonography machines.

Diagnostic Applications in the Shoulder

Rotator Cuff

Ultrasonography is an accurate and cost-effective imaging modality for detection of partial- and full-thickness RCTs, demonstrating no statistically significant difference in sensitivity or specificity for detection of RCTs compared with arthrography or MRI.5,10 Murphy et al6 reported on the learning curve among orthopaedic surgeons without prior experience who used ultrasonography for the detection of full-thickness supraspinatus tears. Arthroscopy was used as the standard of care for assessment of rotator cuff integrity. The authors found that orthopaedic surgeons had high levels of proficiency for the detection of RCTs during the first 50 scans performed. Notably, orthopaedic surgeon proficiency for the detection of RCTs during the second 50 scans performed was comparable with published data for surgeons with experience in shoulder ultrasonography and musculoskeletal radiologists.6

Ultrasonographic examination of the shoulder is performed in the longitudinal and transverse planes (see Video, Supplemental Digital Content 1, Comprehensive Ultrasound Examination of the Shoulder, http://links.lww.com/JAAOS/A91). The supraspinatus tendon is examined with the patient’s arm in internal rotation, which exposes the footprint beneath the acromion. On longitudinal sonogram views, the supraspinatus tendon appears as a convex, hyperechoic, fibrillar layer deep to the deltoid that tapers as it inserts onto the greater tuberosity. The infraspinatus and teres minor tendons are examined with the patient’s hand on the contralateral shoulder. Superficial to the rotator cuff and deep to the deltoid, the subacromial and subdeltoid bursae appear as a hypoechoic line with variable amounts of echogenic fat. The subscapularis tendon, which is best examined with the patient’s arm in external rotation, can be traced from the lesser tuberosity medially until it courses deep to the coracoid process.

Dynamic postoperative ultrasonographic evaluation of the shoulder is useful to obtain information that is difficult to interpret with static imaging modalities and/or if MRIs and CT scans are obscured by normal postoperative changes or metal artifact. In a prospective comparative study of 61 patients who underwent rotator cuff repair, Collin et al11 compared evidence of healing 6 months postoperatively using MRI and ultrasonography. Two independent observers analyzed the findings of the imaging studies, and the authors reported that ultrasonography was 80% sensitive and 98% specific for detection of rotator cuff healing if MRI was used as the reference standard.11 Rotator cuff repair technique also has been evaluated via ultrasonography. In a recent randomized controlled trial of the structural outcomes of 40 patients who
underwent single-row rotator cuff repair and 43 patients who underwent double-row suture bridge fixation rotator cuff repair, Gartsman et al\textsuperscript{12} performed diagnostic ultrasonography 3 months, 6 months, and 1 year postoperatively. The authors reported rotator cuff healing, which required visualization of normal thickness, convexity, and length, in 30 of the patients who underwent single-row repair and 40 of the patients who underwent double-row repair.\textsuperscript{12} Contrast-enhanced ultrasonography has been used to evaluate the rotator cuff vascularity after repair. Cadet et al\textsuperscript{8} used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair.\textsuperscript{12} Sassas et al\textsuperscript{8} also used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair and 43 patients who underwent single-row repair.\textsuperscript{11} Contrast-enhanced ultrasonography has been used to evaluate the rotator cuff vascularity after repair. Cadet et al\textsuperscript{8} used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair.\textsuperscript{12} Sassas et al\textsuperscript{8} also used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair and 43 patients who underwent single-row repair.\textsuperscript{11} Contrast-enhanced ultrasonography has been used to evaluate the rotator cuff vascularity after repair. Cadet et al\textsuperscript{8} used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair.\textsuperscript{12} Sassas et al\textsuperscript{8} also used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair and 43 patients who underwent single-row repair.\textsuperscript{11} Contrast-enhanced ultrasonography has been used to evaluate the rotator cuff vascularity after repair. Cadet et al\textsuperscript{8} used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair.\textsuperscript{12} Sassas et al\textsuperscript{8} also used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair and 43 patients who underwent single-row repair.\textsuperscript{11} Contrast-enhanced ultrasonography has been used to evaluate the rotator cuff vascularity after repair. Cadet et al\textsuperscript{8} used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair.\textsuperscript{12} Sassas et al\textsuperscript{8} also used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair and 43 patients who underwent single-row repair.\textsuperscript{11} Contrast-enhanced ultrasonography has been used to evaluate the rotator cuff vascularity after repair. Cadet et al\textsuperscript{8} used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair.\textsuperscript{12} Sassas et al\textsuperscript{8} also used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair and 43 patients who underwent single-row repair.\textsuperscript{11} Contrast-enhanced ultrasonography has been used to evaluate the rotator cuff vascularity after repair. Cadet et al\textsuperscript{8} used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair.\textsuperscript{12} Sassas et al\textsuperscript{8} also used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair and 43 patients who underwent single-row repair.\textsuperscript{11} Contrast-enhanced ultrasonography has been used to evaluate the rotator cuff vascularity after repair. Cadet et al\textsuperscript{8} used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair.\textsuperscript{12} Sassas et al\textsuperscript{8} also used perflutren to assess real-time blood flow in 30 patients who underwent double-row repair and 43 patients who underwent single-row repair.\textsuperscript{11}

**Long Head of the Biceps Tendon**

Anterior shoulder pain may be difficult to diagnose based on patient history and physical examination alone. The differential diagnosis for anterior shoulder pain includes tenosynovitis or tendinitis of the long head of the biceps, subacromial bursitis, rotator cuff tendinitis, impingement syndrome, calcific tendinitis, and superior labrum anterior to posterior tears. Physical examination findings, such as tenderness to palpation within the intertubercular groove and a positive Yergason and/or Speed test, may improve diagnostic accuracy; however, the specificity, sensitivity, positive predictive value, and negative predictive value of these physical examination findings range from 32% to 79%.\textsuperscript{17} Therefore, ultrasonography-guided lidocaine injection, which can be performed in an outpatient setting, may be a minimally invasive, accurate, and rapid method to diagnose anterior shoulder pain and aid in preoperative planning.

The long head of the biceps tendon is examined with the patient’s arm in a neutral position and the elbow flexed to 90\textdegree. The long head of the biceps tendon courses along the intertubercular groove on the anterolateral humerus and appears as an oval-shaped echogenic structure surrounded by 1 to 2 mm of synovial fluid. In a controlled trial of 30 patients with tendosynovitis and/or tendinitis of the biceps tendon who were randomized to diagnostic injection of 0.2 mL of 1% lidocaine with or without ultrasonographic guidance, Hashiuchi et al\textsuperscript{17} reported that the lidocaine injections were more accurately delivered into the biceps tendon sheath in the patients who underwent ultrasonography-guided injection compared with the patients who underwent unguided injection. Accurate localization of anterior shoulder pain not only guides diagnosis and management but also decreases the risk of iatrogenic biceps tendon tears as a result of intrasubstance injection.

**Capsulolabral Complex**

MRI with intra-articular contrast is the preferred imaging modality for diagnosis of labral pathology; paralabral cysts; capsular damage; and superior, middle, or inferior glenohumeral ligament disruption.\textsuperscript{18} Since the early 1980s, studies conducted in Europe have emphasized the usefulness of ultrasonographic evaluation of the labrum, which appears as a hyperechoic triangular structure adjacent to the glenoid.\textsuperscript{18} In a study of 20 shoulder cadaver models (80 labral quadrants) that were assessed using ultrasonography and arthroscopy, Taljanovic et al\textsuperscript{18} reported 86%
concordance between ultrasonography and arthroscopy with regard to classification of the labra as normal, degenerative, or torn. The authors reported 95% concordance between ultrasonography and arthroscopy in the anteroinferior quadrants (6-o’clock to 9-o’clock position) and 100% concordance between ultrasonography and arthroscopy in the posteroinferior quadrants (3-o’clock to 6-o’clock position).

Dynamic ultrasonography aids in the detection of Hill-Sachs lesions, glenoid rim fractures, labral tears, and capsuloligamentous injuries. In a study of 22 patients with anterior shoulder instability who underwent preoperative ultrasonography and intraoperative arthroscopy, Hammar et al19 reported that ultrasonography correctly detected 95% of labral tears, the presence of glenoid rim fractures in 10 patients, and the absence of glenoid rim fractures in 9 patients. Labral tear detection was aided by labral movement during dynamic ultrasonography.19

Studies on the validity of ultrasonography for diagnosis of shoulder instability are limited because of small sample sizes and because ultrasonography requires a high level of operator expertise. In addition, ultrasonography may result in incomplete preoperative assessment of the shoulder, whereas MRI may afford a more comprehensive evaluation of the shoulder. Regardless, the clinical applications of ultrasonography in patients with capsulolabral complex disease continue to increase and may supplement current imaging modalities.

Diagnostic Applications in the Elbow

Common Flexor and Extensor Tendons

Typically, medial epicondylitis (golfer’s elbow) and lateral epicondylitis (tennis elbow) are repetitive-use injuries of the common flexor and extensor tendons. Diagnostic ultrasonography may be considered in patients with epicondylitis in whom the diagnosis is unclear, in the setting of injuries that are refractory to nonsurgical treatment, and during preoperative assessment. To prevent anisotropy during ultrasonographic evaluation, the probe should be held parallel to the tendon in the longitudinal plane and perpendicular to the tendon in the transverse plane20 (Figure 1). Epicondylitis is diagnosed via detection of an anechoic or hypoechoic area, an area of thickening or nonvisualization, an area of increased vascularity with color Doppler, or intratendinous calcification.20 In a prospective, single-blind study of 21 elbows with clinical medial epicondylitis and 25 elbows without medial epicondylitis, Park et al20 reported that ultrasonography was 95.2% sensitive and 92% specific for diagnosis of medial epicondylitis compared with clinical diagnosis. In a case-controlled study of 27 patients with clinical lateral epicondylitis and 27 patients without lateral epicondylitis who underwent ultrasonography, Noh et al21 reported that tenderness must be elicited at anechoic or hypoechoic sites within the extensor carpi radialis brevis tendon to improve diagnostic accuracy and prevent misinterpretation of anisotropy.

Ulnar Collateral Ligament

Ulnar collateral ligament (UCL) injuries most commonly occur in baseball pitchers because of chronic valgus stress on the elbow during the late cocking and early acceleration phases of throwing.22 Ultrasonography can be used to evaluate the integrity of the UCL and allows for dynamic assessment of tear severity by uniquely demonstrating medial joint instability22 (Figure 2). In a prospective study of 22 high school baseball pitchers who underwent...
preseason and postseason ultrasound, Keller et al.23 reported adaptive changes to the medial soft-tissue structures of the elbow, including UCL heterogeneity and thickening, increased ulnohumeral joint space laxity, and an enlarged ulnar nerve cross-sectional area.

**Distal Biceps Tendon**

Distal biceps tendon rupture is rare and generally diagnosed via physical examination. However, in patients with a partial distal biceps tendon tear or rupture without retraction because of an intact aponeurosis, ultrasonography is a valid alternative to MRI for diagnosis.24 (Figure 3). Ultrasonographic features of complete distal biceps tendon rupture include the absence of the distal biceps tendon from its insertion site, with various amounts of tendon retraction and fluid in the gap.24 Discontinuity is best observed via longitudinal ultrasonographic probe orientation, allowing for estimation of the amount of tendon retraction, with >8 cm of tendon retraction indicating aponeurosis disruption.24 Ultrasonographic features of partial distal biceps tendon tears include thickening and altered echogenicity, with irregular contour observed on longitudinal views.24

**Therapeutic Applications in the Shoulder**

**Suprascapular Nerve**

Suprascapular neuropathy is a rare and often overlooked cause of chronic shoulder pain. Nerve injury as a result of traction or compression at the suprascapular or spinoglenoid notch can be elucidated via physical examination of the supraspinatus and infraspinatus as a guide for therapeutic localization. In patients in whom physical examination, nerve conduction velocity studies, or...
electromyography are equivocal or negative for suprascapular nerve injury, ultrasonography-guided suprascapular notch injection may be therapeutic and diagnostic if pain relief is achieved and may predict response to arthroscopic suprascapular nerve decompression. In a recent meta-analysis of 11 randomized controlled trials that included 591 patients with chronic shoulder pain, Chang et al reported that suprascapular nerve block resulted in better 12-week pain relief compared with physical therapy and placebo injection. Ultrasonography-guided injections were more effective than fluoroscopy-guided injections and injections performed via identification of surface landmarks. Ultrasonography also allows for identification and avoidance of the suprascapular artery. Preoperative ultrasonography-guided suprascapular nerve block has been reported to reduce postoperative pain and decrease narcotic consumption during the first 3 days after arthroscopic acromioplasty. Paralabral cyst formation is associated with acute or degenerative tears of the glenoid labrum, often superiorly, allowing for fluid collection outside the glenohumeral joint. Large cysts may localize over the scapular neck and extend toward the suprascapular or spinoglenoid notch, leading to suprascapular neuropathy. Case reports and small case series have described ultrasonography-guided cyst decompression using at least an 18-gauge needle with or without corticosteroid injection. In general, cysts are well defined and homogeneously hypoechoic before aspiration and are less well defined and hyperechoic after drainage. Acromioclavicular Joint

The acromioclavicular joint is a common site of isolated pain or pain associated with rotator cuff disease. Acromioclavicular joint injection for diagnostic and therapeutic purposes has been well described; however, localization, even among experienced surgeons, is successful in only 40% to 60% of patients. In a recent study of 50 patients who underwent ultrasonography-guided acromioclavicular joint injection, Edelson et al reported that the anterosuperior aspect of the acromioclavicular joint was the preferred entry point and that localization was successful (confirmed via arthrography) in 96% of the patients (Figure 4). Successful intra-articular localization may not provide a clear benefit to patients with a symptomatic acromioclavicular joint. In a multicenter, prospective, controlled trial of 101 patients with a symptomatic acromioclavicular joint who were randomized to ultrasonography-guided intra-articular or periarticular injection of 1 mL of betamethasone with local anesthetic, Sabeti-Aschraf et al reported a significant clinical improvement in all the patients at 1 hour, 1 week, and 3 weeks postoperatively. At 3 weeks postoperatively, the authors reported no significant differences in visual analog scale pain scores, Constant-Murley scores, and local tenderness to palpation between the patients in the two groups; however, better pain reduction based on the crossover arm test was reported in the patients in the intra-articular injection group.

Rotator Cuff

Subacromial bursitis frequently is managed in an outpatient setting via local anesthetic and corticosteroid injection. In a recent meta-analysis of four cadaver model studies and nine live human studies on the accuracy and efficacy of ultrasonography-guided shoulder girdle injection, Aly et al reported that the accuracy of ultrasonography-guided subacromial space injection and landmark-guided subacromial space injection was 65% and 70%, respectively. The authors reported that the subacromial space was the only anatomic site in the shoulder girdle that did not benefit from ultrasonography-guided injection; however, ultrasonography-guided injection was associated with better pain reduction and functional improvement at 6 weeks postinjection. Subacromial high-volume ultrasonography-guided injection of 20 mL of 0.5% bupivacaine with 50 mg of hydrocortisone in patients with rotator cuff tendinopathy also has
been reported to substantially reduce pain and improve function based on validated outcome questionnaire scores. High-volume ultrasonography-guided injection is believed to result in local mechanical effects that cause neovessels to stretch, break, or occlude, and these effects damage the accompanying nerve supply via trauma or ischemia, leading to pain reduction.

Platelet-rich plasma (PRP) injection has increased in popularity for the management of tendinopathies because the growth factor and cytokine content in PRP is believed to stimulate healing. In a recent controlled trial of 40 patients with chronic rotator cuff tendinopathy, Kesikburun et al randomized patients to ultrasonography-guided subacromial injection of 5 mL of PRP prepared from autologous venous blood or 5 mL of saline. All patients underwent a 6-week standard exercise program, and validated outcome measures were assessed 3, 6, 12, 24, and 52 weeks postinjection. The authors reported that ultrasonography-guided subacromial PRP injection was no more effective than ultrasonography-guided subacromial saline injection with regard to improvement in quality of life, disability, or shoulder range of motion.

Ultrasonography-guided needling and lavage (barbotage) has been reported to be an effective method for management of calcific tendinitis. In a double-blind controlled trial of 48 patients with rotator cuff tendinopathy, de Witte et al randomized patients to barbotage and ultrasonography-guided subacromial injection of 5 mg of bupivacaine and 40 mg of methylprednisolone or ultrasonography-guided subacromial injection of 5 mg of bupivacaine and 40 mg of methylprednisolone alone. Under ultrasonographic guidance, barbotage was performed by introducing a 55-mm, 18-gauge needle into the calcification and flushing the calcification with saline, after which repeated perforation of the calcification was performed. The authors reported better 1-year outcomes, including improved Constant shoulder scores and decreased calcification size, in the patients who underwent barbotage and subacromial injection compared with those who underwent subacromial injection only.

**Glenohumeral Joint**

In a study of 80 cadaver shoulder specimens in which posterior glenohumeral joint injection was performed via ultrasonographic guidance or a freehand technique, Patel et al reported that ultrasonography-guided subacromial injection was accurate in 92.5% of cadaver shoulders and that freehand injection was accurate in 72.5%. The mean time for ultrasonography-guided injection and freehand injection was 166 seconds and 52 seconds, respectively. The authors concluded that ultrasonography is an effective tool for glenohumeral joint injection after surgeons are familiar with the technique (Figure 7). Glenohumeral joint injections are most commonly used for nonsurgical management of osteoarthritis, rheumatoid arthritis, and adhesive capsulitis.

**Therapeutic Applications in the Elbow**

**Common Extensor Tendon**

PRP injection has been reported to be effective for the management of lateral epicondylitis, and ultrasonography guidance can be used to improve the accuracy of PRP injection (Figure 8). In a double-blind controlled trial of 100 patients with lateral epicondylitis who were randomized to corticosteroid or PRP injection, Goens et al reported more successful treatment, which was defined as a reduction of 25% on visual analog scale and Disabilities of the Arm, Shoulder and Hand questionnaire scores, in the patients in the PRP group at a follow-up of 2 years. Corticosteroid injection resulted in short-term pain relief; however, pain relief declined 1 year postinjection.

Other injection therapies also have been described for the management of lateral epicondylitis. In a study of 16 patients with severe chronic, resistant lateral epicondylitis who underwent ultrasonography-guided...
autologous tenocyte injection at the origin of the extensor carpi radialis brevis, Wang et al.\(^{37}\) reported improved pain, activity, and grip strength, as well as signs of structural repair on MRI at a follow-up of 12 months. The FDA recently approved the use of TX1 technology (Tenex Health) for the management of tendinopathy. TX1 technology involves the use of ultrasonic energy to rapidly oscillate a hollow 18-gauge needle tip and emulsify tissue, which is removed via an inflow-outflow fluid circuit.\(^{38}\) In a recent case series of 19 patients with medial or lateral elbow tendinopathy refractory to nonsurgical treatment who underwent tenotomy with the use of TX1 technology, Barnes et al.\(^{38}\) reported no procedural complications, a mean total treatment time of 15 minutes, and improved 1-year outcome scores.

**Distal Biceps Tendon**

In a recent multicenter, prospective, cohort study of 12 patients with refractory distal biceps tendinitis who underwent ultrasonography-guided PRP injection, Sanli et al.\(^{40}\) performed the injections with the patients in the supine position and the ultrasonographic probe in orientation with the longitudinal axis of the tendon. They did not report whether the injection was localized in the tendon sheath or in the intrasubstance of the tendon. The authors reported improved pain and functional resting and activity outcome scores in all the patients at a mean follow-up of 47 months.\(^{40}\)

**Summary**

Given the current emphasis on quality and objective outcome measures, it is important to recognize that diagnostic ultrasonography is an effective, dynamic, portable, low-cost imaging modality that can improve the management of several common musculoskeletal disorders. New noninvasive imaging modalities that aid in the management of shoulder and elbow pathology are under development and continue to emerge in clinical practice. The curriculum in orthopaedic residency training programs should include additional education on ultrasonography as its use increases among orthopaedic surgeons.

**References**

*Evidence-based Medicine:* Levels of evidence are described in the table of contents. In this article, references 6, 26, 27, 31, 33, 34, and 36 are level I studies. References 12, 17, 20, 23, and 30 are level II studies. References 11, 15, 16, 19, 21, and 40 are level III studies. References 1, 3-5, 8-10,
13, 14, 22, 24, 28, 29, 32, and 37-39 are level IV studies. References 2 and 5 are level V expert opinion.

References printed in bold type are those published within the past 5 years.


