

# American Medical Society for Sports Medicine Position Statement: Interventional Musculoskeletal Ultrasound in Sports Medicine

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**Abstract:** The use of diagnostic and interventional ultrasound has significantly increased over the past decade. A majority of the increased utilization is by nonradiologists. In sports medicine, ultrasound is often used to guide interventions such as aspirations, diagnostic or therapeutic injections, tenotomies, releases, and hydrodissections. This American Medical Society for Sports Medicine (AMSSM) position statement critically reviews the literature and evaluates the accuracy, efficacy, and cost-effectiveness of ultrasound-guided injections in major, intermediate, and small joints, and soft tissues, all of which are commonly performed in sports medicine. New ultrasound-guided procedures and future trends are also briefly discussed. Based on the evidence, the official AMSSM position relevant to each subject is made.

**Key Words:** ultrasonography, diagnostic imaging, injections

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## INTRODUCTION

The use of diagnostic and interventional musculoskeletal ultrasound (MSK US) in sports medicine has increased over the past several decades for a variety of reasons, including decreased equipment costs, increased educational opportunities, expanded research, patient safety initiatives, and technological advances leading to higher resolution images.<sup>1</sup> Between 2000 and 2009, there was a 71.7% increase in the number of outpatient diagnostic MSK US studies, a majority of which were performed by nonradiologists.<sup>2</sup> Ultrasound can be used to diagnose disorders of bone, joints, tendons, muscles, ligaments, blood vessels, and nerves as well as guide interventions such as aspirations, diagnostic or therapeutic injections, tenotomies, releases, hydrodissections, and biopsies.<sup>3</sup>

As the utilization of MSK US within sports medicine increases, it is important to critically review the existing literature and, based on the available evidence, make recommendations for its appropriate use. The purpose of this position statement is to evaluate the accuracy, efficacy, and cost-effectiveness of ultrasound-guided injections (USGIs) in major, intermediate, and small joints, and soft tissues, all of which are commonly performed in sports medicine. New procedures and future trends will also be briefly discussed.

## MATERIALS AND METHODS

Relevant English language articles through November 2013 were identified by searching Cochrane Database of Systematic Reviews and PubMed with the search terms injection, accuracy, efficacy, ultrasonography, fluoroscopy, joint, and arthrography. The references of the articles were subsequently reviewed to identify additional articles not found in the original literature search. Articles that studied the accuracy, efficacy, or cost-effectiveness of ultrasound-guided (USG) or landmark-guided injections (LMGIs) were included in the analysis for this position statement. Accuracy was defined as being able to place the injectate or needle tip in the intended structure. Studies that evaluated efficacy were defined as studies that evaluated a change in an outcome measure such as pain, range of motion, mobility, function, or patient satisfaction following the procedure. Cost-effectiveness studies were defined as studies that evaluated the health care cost of the procedure relative to another treatment. The literature search was performed by a single researcher. An

initial review of each study was subsequently performed by a separate researcher, and the level of evidence for each article was ranked according to the scale published by the *Journal of Bone and Joint Surgery*.<sup>4</sup> For accuracy studies, the level of evidence was determined as follows: level 1—injections performed on live subjects with accuracy confirmed using gold standard diagnostic imaging [ie, arthrogram for joints, magnetic resonance imaging (MRI) for soft tissues] or systematic review of level 1 studies; level 2—injections performed on live subjects using non-gold standard imaging for accuracy confirmation, injections performed on cadaveric specimens with accuracy confirmed using gold standard diagnostic imaging or dissection, or systematic review of level 2 studies; level 3—injections performed on cadaveric specimens with accuracy confirmed using non-gold standard diagnostic imaging; level 4—injections performed on a small number ( $\leq 10$ ) of live subjects or cadaveric specimens, injections performed on live subjects with accuracy confirmed by clinical outcome, or retrospective case series; level 5—case study or expert opinion. The literature was then distributed to the remaining authors for review and analysis. Disputes on classification were resolved through discussion and consensus. The literature was divided into the following categories for analysis: major joints, intermediate joints, small joints, multiple joints, and soft tissues.

## RESULTS

The initial literature search identified 216 potential articles. Of these, 124 met the inclusion criteria for the position statement.

### Major Joints

Fifty seven studies assessing injections in major joints were identified (see **Appendix, Supplemental Digital Content 1**, <http://links.lww.com/JSM/A53>).<sup>5–61</sup> A majority of the studies [49/57 (86%)]<sup>6,7,9,11–13,15,17–25,27–30,32–51,53–61</sup> evaluated injections in a single joint, whereas 14% (8/57)<sup>5,8,10,16,26,31,52,55</sup> assessed injections in more than 1

joint. Thirty-five percent (20/57) of the studies evaluated knee injections,<sup>8–10,13,15,16,19–23,26,31,32,36,37,48,52,56,57</sup> 46% (26/57) evaluated glenohumeral (GH) joint injections,<sup>5,7,8,10,11,15–17,24–26,28,29,31,38–40,42,43,46,47,49,52,54,60,61</sup> 21% (12/57) evaluated hip injections,<sup>8,12,27,30,33,35,41,44,45,50,52,59,62</sup> and 4% (2/57) evaluated sacroiliac (SI) joint injections.<sup>18,34</sup> Four studies (7%) assessed injections in the “shoulder,” but did not specify which shoulder structure or joint they were injecting.<sup>6,53,55,58</sup>

The results of the studies investigating major joint injection accuracy are summarized in Table 1. The level of evidence for a majority of the studies evaluating major joint USGI accuracy [15/23 (65%)]<sup>5,8,9,15,16,18,20,21,23,27,30,32,34,36–39,41,42,44–46,49</sup> or LMGI accuracy [28/28 (100%)]<sup>5,7,9–13,17,19,21–26,28,31,32,36–38,40,43,47,48,50,60,61</sup> was level 1 or 2. The mean accuracy of GH, hip, and knee joint USGIs in studies with level 1 or 2 evidence ranged from 91% to 100%,<sup>5,8,9,15,18,21,23,32,36–39,42,46,49</sup> whereas the mean accuracy of LMGI were between 64% and 81%.<sup>5,7,9–13,17,19,21–26,28,31,32,36–38,40,43,47,48,50,60,61</sup> These findings provide strong evidence that USGIs in the GH, hip, and knee joints are more accurate than LMGI.

Only 2 studies investigated the accuracy of SI joint injections,<sup>18,34</sup> and both studies only evaluated the accuracy of USGIs. While USG SI joint injections were 100% accurate in one of the studies,<sup>34</sup> the other study reported an accuracy rate of only 40%.<sup>18</sup> The discrepancy between the 2 studies may be due to a number of factors such as differences in accuracy assessment (color Doppler-US vs MRI arthrogram), patient population, equipment variability, injector experience, and injection technique. No studies were identified that evaluated the accuracy of landmark-guided (LMG) SI joint injections. Further studies are required to determine the accuracy of USG and LMG SI joint injections.

Nine studies with level 1 or 2 evidence investigated the efficacy of USGIs in major joints relative to LMGI (Table 2).<sup>5,6,29,51,54–58</sup> The joints evaluated in the studies included the GH joint (3 studies),<sup>29,51,54</sup> shoulder [joint unspecified (3 studies)],<sup>6,55,58</sup> and knee joint (3 studies).<sup>5,56,57</sup> Eighty-nine percent (8/9) of these studies found that USGIs were more efficacious than LMGI,<sup>5,29,51,54–58</sup> whereas the remaining study found

**TABLE 1.** Major Joint Injection Accuracy

	Level of Evidence				
	Level 1, Mean (Range), %	Level 2, Mean (Range), %	Level 3, Mean (Range), %	Level 4, Mean (Range), %	Level 5, Mean (Range), %
GH joint					
USGI	100 (97–100) <sup>8,15,39,42,46,49</sup>	91 (89–93) <sup>5,38</sup>	—	100 <sup>16</sup>	—
LMGI	64 (27–100) <sup>7,10,24,31,40,43,47</sup>	73 (10–100) <sup>5,11,17,25,26,28,38,60,61</sup>	—	—	—
Hip joint					
USGI	99 (97–100) <sup>8,27,41,44,45</sup>	—	—	100 <sup>30</sup>	100 <sup>44</sup>
LMGI	—	73 (67–78) <sup>12,50</sup>	—	—	—
Knee joint					
USGI	95 (75–100) <sup>8,21,23,32,36,37</sup>	98 (96–100) <sup>59</sup>	—	100 <sup>16</sup>	100 <sup>20</sup>
LMGI	81 (62–100) <sup>10,19,21–23,31,32,36,37,48</sup>	74 (55–100) <sup>5,9,10,13,26</sup>	—	—	—
SI joint					
USGI	40 <sup>18</sup>	—	100 <sup>34</sup>	—	—
LMGI	—	—	—	—	—

**TABLE 2.** Major Joint Injection Efficacy

	Level of Evidence				
	Level 1	Level 2	Level 3	Level 4	Level 5
GH joint	—	3 studies: USGIs are more efficacious than LMGI <sup>29,51,54</sup>	—	1 study: LMGI <sup>31</sup> are efficacious	—
Hip joint	—	—	1 study: USGIs are more efficacious than no injection <sup>33</sup>	3 studies: USGIs are efficacious, <sup>35,41</sup> and pain reduction from injection predicts better surgical outcome <sup>59</sup>	—
Knee joint	1 study: accurate injections are more efficacious than inaccurate injections <sup>48</sup>	3 studies: USGIs less painful and more efficacious than LMGI <sup>5,56,57</sup>	—	1 study: LMGI <sup>31</sup> are efficacious	—
SI joint	—	—	—	1 study: USGIs are efficacious <sup>34</sup> 1 study: USGIs no better than LMGI <sup>18</sup>	—
Shoulder*	2 studies: image-guided injections are more efficacious than LMGI <sup>55,58</sup> 1 study: no significant difference between USGIs and LMGI <sup>6</sup> efficacy	—	1 study: USGIs no better than LMGI <sup>53</sup>	—	—

\*Shoulder refers to studies in which the “shoulder” was injected, but the location of the injection was not further specified.

no difference in efficacy between the 2 injection techniques.<sup>6</sup> A single study with level 1 evidence demonstrated no difference in efficacy between corticosteroid knee injections that were accurate versus those that were inaccurate.<sup>48</sup> Based on the available research, in major joints, the majority of studies with level 1 or 2 evidence indicate that USGIs are more efficacious than LMGI<sup>5</sup>.

Only 2 studies compared the cost-effectiveness of USGIs versus LMGI<sup>56,57</sup> (Table 3). Both of the studies were performed by the same group of researchers and evaluated the cost-effectiveness of USGIs and LMGI<sup>5</sup> in the knee. Although both studies provided level 2 evidence suggesting that USGIs were more cost-effective than LMGI<sup>5</sup>, further research is required to corroborate their findings.

In summary, USGIs in major joints other than the SI joint are more accurate than LMGI<sup>5</sup>. Further research is required to determine the accuracy of USG and LMG SI joint injections. The majority of evidence indicates USGIs in major joints are more efficacious than LMGI<sup>5</sup> in major joints. Although the preliminary research suggests that USGIs are more cost-effective than LMGI<sup>5</sup>, further research is required before making a final determination on the cost-effectiveness of USGIs.

**TABLE 3.** Major Joint Injection Cost-Effectiveness

	Level of Evidence				
	Level 1	Level 2	Level 3	Level 4	Level 5
Knee joint	—	2 studies: USGIs are more cost-effective than LMGI <sup>56,57</sup>	—	—	—

## Intermediate Joints

Twenty-three studies assessing injections into intermediate sized joints were identified (see **Appendix, Supplemental Digital Content 2**, <http://links.lww.com/JSM/A54>).<sup>8,16,26,31,52,63–80</sup> Seventy-four percent (17/23) of the studies evaluated injections into a single joint<sup>8,63–65,67–70,72–80</sup> and 26% (6/23) assessed injections into multiple joints.<sup>16,26,31,52,66,71</sup> Injections into the following joints were evaluated: sternoclavicular (SC) [1/23 (4%)],<sup>79</sup> acromioclavicular (AC) [7/23 (30%)],<sup>26,63,69,70,72,73,78</sup> elbow [3/23 (13%)],<sup>16,26,31</sup> wrist [4/23 (17%)],<sup>8,16,26,31</sup> distal radioulnar (RU) [1/23 (4%)],<sup>77</sup> scapho-trapezio-trapezoidal (STT) [1/23 (4%)],<sup>74</sup> proximal tibiofibular (TF) [1/23 (4%)],<sup>76</sup> tibiotalar (TT) [7/23 (30%)],<sup>16,26,31,65,66,71,80</sup> subtalar (ST) [5/23 (22%)],<sup>66–68,71,75</sup> and midfoot [1/23 (4%)].<sup>64</sup>

Twenty-one of the 23 studies (91%) assessed intermediate joint injection accuracy (Table 4).<sup>8,16,26,31,52,63,65–72,74–80</sup> Their findings are summarized in Table 4. Similar to the injection accuracy studies in major joints, a majority [20/21 (95%)] of the intermediate joint injection accuracy studies provided either level 1 or level 2 evidence.<sup>8,26,31,52,63,65–72,74–80</sup> In the studies with level 1 or 2 evidence, the mean accuracy of USGIs into intermediate joints ranged from 95% to 100%.<sup>8,52,63,66,70,71,74–77,80</sup> The mean accuracy of LMGI<sup>5</sup> into intermediate joints with level 1 or 2 evidence was between 0% and 92%.<sup>26,31,52,63,65–70,72,74,76,78–80</sup> The accuracy of LMGI<sup>5</sup> varied widely by joint and approach.

The only study that evaluated injection accuracy into the SC joint used a landmark-guided approach, and reported a mean accuracy of 78%.<sup>79</sup> Because no USGI studies into the SC joint have been performed, a comparison of SC joint injection accuracy between the 2 techniques cannot be made.

**TABLE 4.** Intermediate Joint Injection Accuracy

	Level of Evidence				
	Level 1, Mean (Range), %	Level 2, Mean (Range), %	Level 3, Mean (Range), %	Level 4, Mean (Range), %	Level 5, Mean (Range), %
SC joint					
USGI	—	—	—	—	—
LMGI	—	78 (74-82) <sup>79</sup>	—	—	—
AC joint					
USGI	—	95 (90-100) <sup>63,70</sup>	—	—	—
LMGI	—	52 (33-72) <sup>63,69,70,72,78</sup>	—	—	0 <sup>26</sup>
Elbow joint					
USGI	—	—	—	100 <sup>16</sup>	—
LMGI	97 (83-100) <sup>26,31</sup>	—	—	—	—
Distal RU joint					
USGI	—	100 <sup>77</sup>	—	—	—
LMGI	—	—	—	—	—
Wrist joint					
USGI	100 <sup>8</sup>	—	—	100 <sup>16</sup>	—
LMGI	74 (50-97) <sup>26,31</sup>	—	—	—	—
STT joint					
USGI	—	100 <sup>74</sup>	—	—	—
LMGI	—	80 <sup>74</sup>	—	—	—
Proximal TF joint					
USGI	—	100 <sup>76</sup>	—	—	—
LMGI	—	58 <sup>76</sup>	—	—	—
TT joint					
USGI	—	100 (100) <sup>66,71,80</sup>	—	100 <sup>16</sup>	—
LMGI	64 (50-77) <sup>26,31</sup>	87 (78-100) <sup>65,66,80</sup>	—	—	—
ST joint					
USGI	—	97 (90-100) <sup>66,71,75</sup>	—	—	—
LMGI	—	89 (68-100) <sup>66-68</sup>	—	—	—
Elbow, wrist, TT joint					
USGI	—	100 <sup>52</sup>	—	—	—
LMGI	—	29 <sup>52</sup>	—	—	—

Two level 2 studies evaluated USGI accuracy into the AC joint and reported mean accuracy of 95%.<sup>63,70</sup> Five level 2 studies<sup>63,69,70,72,78</sup> evaluated the accuracy of LMG AC joint injections and reported a mean accuracy of 52%. In addition to accuracy, the results presented by Sabeti-Aschraf<sup>72</sup> looked at USGI and LMGI accuracy of 3 subgroups: physician specialist, physician nonspecialist, and student. As expected, the student's LMGI accuracy was the lowest (60%) and the physician specialist's LMGI accuracy was the highest (80%). When the same providers used USG, accuracy improved to 90% to 100% with the students being the highest of the 3 subgroups. Based on the available evidence, USGIs into the AC joint are significantly more accurate than LMGI.

Two level 1 studies evaluated LMGI accuracy into the elbow joint.<sup>26,31</sup> The mean accuracy of these studies was 97%. The only study evaluating the accuracy of USGIs into the elbow joint provided level 4 evidence that elbow joint USGI accuracy was 100%. The current research suggests that elbow joint LMGI are quite accurate, and although preliminary findings imply that elbow joint USGIs are also accurate, further research is required to corroborate these data.

The accuracy of injections into 3 different sites about the wrist has been studied. The first is the distal RU joint (DRUJ). A single level 2 study reported the accuracy of USGIs into the DRUJ to be 100%.<sup>77</sup> No DRUJ LMGI accuracy studies were identified. A single level 1 study demonstrated 100% accuracy of wrist joint USGIs.<sup>8</sup> The mean accuracy of wrist joint LMGI reported by 2 level 2 studies was 74%.<sup>26,31</sup> A single level 2 study demonstrated the accuracy of STT joint injections using USG to be 100%, whereas LMGI accuracy was 80%.<sup>74</sup> Therefore, initial findings indicate USGI accuracy into the distal RU, wrist, and STT joints is 100% accurate, but further research is required to confirm these conclusions. The current evidence suggests that LMGI into the wrist and STT joints are less accurate than USGIs (74% and 80%, respectively, vs 100%), and no research is available regarding the accuracy of DRUJ LMGI. However, because of the paucity of research on injections in the wrist region, further research is required before definitive conclusions can be drawn.

The accuracy of injections into 3 intermediate sized, lower extremity joints (proximal TF, TT, and ST joints) has been studied. A level 2 study reported proximal TF joint

USGIs to be 100% accurate, whereas LMGI into the same joint were 58% accurate.<sup>76</sup> Tibiotalar joint USGIs were found to be 100% accurate in 3 level 2 studies.<sup>66,71,80</sup> The mean TT joint LMGI accuracy was 64% in 2 level 1 studies<sup>26,31</sup> and 87% in 3 level 2 studies.<sup>65,66,80</sup> The mean ST joint USGI accuracy of 3 level 2 studies was 97%,<sup>66,71,75</sup> whereas 3 level 2 studies reported the accuracy of LMGI to be 89%.<sup>66–68</sup> These findings suggest that proximal TF, TT, and ST joint USGIs are highly accurate, whereas LMGI into the same regions have variable accuracy, with the highest level of accuracy found in the ST joint (89%).

Finally, 1 level 2 study evaluated the accuracy of USGIs and LMGI into multiple joints (elbow, wrist, and TT joints).<sup>52</sup> Balint et al reported 100% accuracy of USGIs into the elbow and TT joints, whereas the mean accuracy of LMGI into the elbow, wrist, and TT joints was only 29%. However, the conclusions of this study are significantly limited based on the small number of injections performed.

Four studies evaluated the efficacy of intermediate joint USGIs versus LMGI (Table 5).<sup>16,26,64,73</sup> One was a level 2 study,<sup>73</sup> another was a level 3 study,<sup>26</sup> and the remaining 2 were level 4 studies.<sup>16,64</sup> Sabeti-Aschraf et al<sup>73</sup> found no difference in efficacy between AC joint USGIs and LMGI. Jones et al<sup>26</sup> found no difference in efficacy between accurate and inaccurate injections into the AC, elbow, wrist, and ankle joints, but the conclusions of this study are limited because of the study design. Both level 4 studies demonstrated that USGIs were efficacious into intermediate joints.<sup>16,64</sup>

No studies evaluated the cost-effectiveness of USG versus LMG intermediate joint injections.

In summary, USGIs into a majority of intermediate joints are more accurate than LMGI, although LMGI into the ST joint were relatively accurate (mean accuracy of 89%). However, most joints only had 1 or 2 studies evaluating injection accuracy. Therefore, further USG and LMG intermediate joint injection accuracy studies are necessary to make definitive conclusions regarding intermediate joint injection accuracy. Despite the difference in accuracy between USG and LMG intermediate joint injections, the only study that evaluated the difference in efficacy between the 2 injection techniques did not find a difference.<sup>73</sup> Interestingly, the joint

evaluated in this study (AC joint) was one of the joints with a fairly large difference in accuracy between USG and LMG injections (95% vs 52%). Because they did not evaluate the accuracy of their injections, it is difficult to determine whether the lack of difference in efficacy between the 2 techniques is because they had similar accuracy rates between the 2 techniques, or because efficacy is not related to accuracy in this particular joint. Because of the paucity of research, a definite conclusion regarding whether or not USG improves the efficacy of intermediate joint injections cannot be made.

## Small Joints

Nine studies assessing injections in small joints were identified (see **Appendix, Supplemental Digital Content 3**, <http://links.lww.com/JSM/A55>).<sup>16,26,31,52,66,71,81–83</sup> A small majority of these studies [5/9 (56%)]<sup>31,66,71,82,83</sup> evaluated injections into a single type of small joint [eg, metacarpophalangeal (MCP) joint], whereas the remainder [4/9 (44%)]<sup>16,26,52,81</sup> evaluated injections into multiple small joints. Sixty-seven percent (6/9)<sup>16,26,31,52,81,82</sup> of the studies assessed small joint injections in the hands and 56% (5/9)<sup>16,52,66,71,83</sup> evaluated small foot joint injections. Of those studies assessing hand procedures, 3 studies (50%) included the carpometacarpal (CMC) joint,<sup>26,52,82</sup> 2 (33%) the proximal interphalangeal joint (PIP) joints,<sup>52,81</sup> and 1 (17%)<sup>26</sup> the distal interphalangeal joints. Among the studies of foot procedures, 4 (60%)<sup>16,52,71,83</sup> were directed at the metatarsophalangeal (MTP) joints and 1 (20%)<sup>66</sup> the tarsometatarsal (TMT) joints.

The results of the studies investigating small joint accuracy are summarized in Table 6. The majority [5/8 (63%)] of small joint injection accuracy studies provided level 1 or 2 evidence.<sup>31,66,71,82,83</sup> The remaining studies provided level 3 or 5 evidence.<sup>26,52,81</sup> In the hand, a single level 2 study reported the mean USGI accuracy of the CMC joint to be 94%.<sup>82</sup> There were no level 1 or 2 studies for LMGI accuracy of the CMC joint. A single level 3 study compared the accuracy of USG and LMG CMC joint injections and found the mean accuracy of USGI to be 100% and of LMGI to be 0%.<sup>52</sup> No study was identified that addressed the accuracy of USG MCP joint injections, but a single level 1 study reported the mean accuracy of LMGI to be 97%.<sup>31</sup> No level 1

**TABLE 5.** Intermediate Joint Injection Efficacy

	Level of Evidence				
	Level 1	Level 2	Level 3	Level 4	Level 5
AC joint	—	1 study: no difference in efficacy between USGIs and LMGI <sup>73</sup>	—	—	—
Elbow joint	—	—	—	1 study: USGIs are efficacious <sup>16</sup>	—
Wrist joint	—	—	—	1 study: USGIs are efficacious <sup>16</sup>	—
TT joint	—	—	—	1 study: USGIs are efficacious <sup>16</sup>	—
Midfoot joint	—	—	—	1 study: USGIs are efficacious <sup>64</sup>	—
AC, wrist, elbow, and TT joints	—	—	1 study: no difference in efficacy between accurate and inaccurate injections <sup>26</sup>	—	—

**TABLE 6.** Small Joint Injection Accuracy

	Level of Evidence				
	Level 1, Mean (Range), %	Level 2, Mean (Range), %	Level 3, Mean (Range), %	Level 4, Mean (Range), %	Level 5, Mean (Range), %
CMC joint					
USGI	—	94 <sup>82</sup>	100 <sup>52</sup>	—	—
LMGI	—	—	0 <sup>26,52</sup>	—	—
MCP joint					
USGI	—	—	—	—	—
LMGI	97 <sup>31</sup>	—	—	—	0 <sup>26</sup>
IP joint					
USGI	—	—	100 <sup>52</sup>	—	—
LMGI	—	—	0 <sup>52</sup>	—	0 <sup>26</sup>
TMT joint					
USGI	—	64 <sup>66</sup>	—	—	—
LMGI	—	25 <sup>66</sup>	—	—	—
MTP joint					
USGI	—	100 <sup>71,83</sup>	100 <sup>52</sup>	—	—
LMGI	—	—	0 <sup>52</sup>	—	—
MCP and PIP joints					
USGI	—	—	96 <sup>81</sup>	—	—
LMGI	—	—	59 <sup>81</sup>	—	—

or 2 studies evaluated the accuracy of interphalangeal (IP) joint injections. One level 3 study compared the accuracy of USG versus LMG IP joint injections and found the mean accuracy of USGI to be 100%, whereas the accuracy of LMGI was 0%.<sup>52</sup> Another level 3 study reported the accuracy of USG MCP and PIP joint injections to be 96% and LMGI to be 59%.<sup>81</sup>

Regarding small joint injections in the feet, a single level 2 study compared the accuracy of USG and LMG TMT joint injections and found the USGIs to be more accurate (64% accurate) than LMGI (25% accurate).<sup>66</sup> Three studies (2 with level 2 evidence<sup>71,83</sup> and 1 with level 3 evidence<sup>52</sup>) found 100% accuracy for USGI of the MTP joints with 1 of the 3<sup>52</sup> noting poor accuracy (0% accurate) with LMGI.

Only a single level 4 study addressed the efficacy of USGI of the small joints (Table 7).<sup>16</sup> This case series demonstrated that USGI of the MCP and MTP joints were efficacious, but the strength of their findings are limited by the study design.<sup>16</sup> No studies were identified that compared the cost-effectiveness of USGI versus LMGI of the small joints. Thus, it is unclear from the available literature whether the superior accuracy suggested by the available studies translates into improved outcomes or cost savings.

In summary, current research suggests that USGIs in small joints are more accurate than LMGI. However, because of the paucity of high-quality research evaluating

small joint injection accuracy, further research is required to confirm these initial findings before drawing final conclusions. There is insufficient evidence at this time to determine whether USG small joint injections are more efficacious or cost-effective than LMGI.

## Soft Tissues

Forty-nine studies assessing injections into soft tissues were identified (see **Appendix, Supplemental Digital Content 4**, <http://links.lww.com/JSM/A56>).<sup>17,51,52,54,69,71,80,84–125</sup> Most studies evaluated injections into a single structure [42/49 (86%)],<sup>17,51,54,69,80,84–87,90–95,97–101,103–113,115–125</sup> but 7 studies (14%) investigated injections into more than 1 structure.<sup>52,71,88,89,96,102,114</sup> In decreasing frequency, studies evaluated injections into bursae [19/49 (39%)],<sup>17,51,52,54,69,87,91–93,95,97,100,101,103,105,110,115,121,123</sup> tendon sheaths [9/49 (18%)],<sup>71,89,102,106,108,111–113,116</sup> tendons or fascia [8/49 (16%)],<sup>96,102,107,112,119,120,124,125</sup> perineural regions [6/49 (12%)],<sup>85,88,94,104,109,122</sup> muscles [5/49 (10%)],<sup>86,97,114,117,118</sup> cysts [2/49 (4%)],<sup>84,90</sup> peritendinous regions [2/49 (4%)],<sup>71,102</sup> wounds [1/49 (2%)],<sup>52</sup> and periarticular spaces [1/49 (2%)].<sup>80</sup>

Soft tissue injection accuracy studies are summarized in Table 8. Four level 1 or 2 studies evaluating the accuracy of tendon sheath or peritendinous injections were identified.<sup>71,99,113,116</sup> Multiple regions were evaluated including the Achilles peritendinous region,<sup>71</sup> and the tendon sheaths of the long head biceps,<sup>99</sup> first dorsal wrist compartment, flexor hallucis longus,<sup>71</sup> tibialis posterior,<sup>71</sup> popliteus,<sup>116</sup> and peroneal (fibularis) tendons.<sup>113</sup> Although the criteria used to define “accurate injections” were different in the various studies, the mean reported accuracy of USGIs into tendon sheaths or peritendinous regions ranged from 87% to 100%, whereas the mean accuracy of LMGI ranged from 27% to 60%. Thus,

**TABLE 7.** Small Joint Injection Efficacy

	Level of Evidence				
	Level 1	Level 2	Level 3	Level 4	Level 5
MCP and MTP	—	—	—	1 study: USGIs are efficacious <sup>16</sup>	—

**TABLE 8.** Soft Tissue Injection Accuracy

	Level of Evidence				
	Level 1, Mean (Range), %	Level 2, Mean (Range), %	Level 3, Mean (Range), %	Level 4, Mean (Range), %	Level 5, Mean (Range), %
SA-SD bursa					
USGI	100 <sup>115</sup>	65 <sup>91</sup>	—	—	—
LMGI	82 (69-100) <sup>101,115</sup>	78 (29-90) <sup>17,69,91,93,95,105,110,123</sup>	—	—	—
BT sheath					
USGI	87 <sup>99</sup>	—	—	—	—
LMGI	27 <sup>99</sup>	—	—	—	—
FFT sheath					
USGI	—	—	—	100 <sup>89</sup>	—
LMGI	—	—	—	—	—
FET sheath					
USGI	—	—	—	85 (70-0) <sup>89,108</sup>	—
LMGI	—	—	—	15 <sup>108</sup>	—
ECUT sheath					
USGI	—	—	—	100 <sup>89</sup>	—
LMGI	—	—	—	—	—
Obturator internus					
USGI	—	100 <sup>118</sup>	—	—	—
LMGI	—	—	—	—	—
Piriformis					
USGI	—	95 <sup>97</sup>	—	USGIs are accurate (rate not reported) <sup>117</sup>	USGIs with EMG assistance are 100% accurate <sup>88</sup>
LMGI	—	—	—	—	—
Pes anserinus bursa					
USGI	—	92 <sup>98</sup>	—	—	—
LMGI	—	17 <sup>98</sup>	—	—	—
Popliteus tendon sheath					
USGI	—	92 (83-100) <sup>116</sup>	—	—	—
LMGI	—	—	—	—	—
Achilles region					
USGI	—	100 <sup>71</sup>	—	—	—
LMGI	—	—	—	—	—
Peroneal tendon sheath					
USGI	—	100 <sup>113</sup>	—	100 <sup>89</sup>	—
LMGI	—	60 <sup>113</sup>	—	—	—
FHL tendon sheath					
USGI	—	100 <sup>71</sup>	—	—	—
LMGI	—	—	—	—	—
TP tendon sheath					
USGI	—	100 <sup>71</sup>	—	100 <sup>89</sup>	—
LMGI	—	—	—	—	—
SPC					
USGI	—	100 <sup>114</sup>	—	—	—
LMGI	—	100 <sup>114</sup>	—	—	—
DPC					
USGI	—	88 <sup>114</sup>	—	—	—
LMGI	—	90 <sup>114</sup>	—	—	—
Sinus tarsi					
USGI	—	90 <sup>80</sup>	—	—	—
LMGI	—	35 <sup>80</sup>	—	—	—
Morton neuroma					

**TABLE 8.** (Continued) Soft Tissue Injection Accuracy

	Level of Evidence				
	Level 1, Mean (Range), %	Level 2, Mean (Range), %	Level 3, Mean (Range), %	Level 4, Mean (Range), %	Level 5, Mean (Range), %
USGI	—	100 <sup>94,104</sup>	—	—	—
LMGI	—	—	—	—	—
Bursa, tendon sheath, cyst, wound					
USGI	—	—	—	USG aspirations are 100% accurate <sup>52</sup>	—
LMGI	—	—	—	—	—

BT, biceps tendon; DPC, deep posterior compartment; ECUT, extensor carpi ulnaris tendon; FET, finger extensor tendon; FFT, finger flexor tendon; FHL, flexor hallucis longus; SPC, superficial posterior compartment; TP, tibialis posterior.

there is strong evidence that USG tendon sheath or peritendinous injections are more accurate than LMGI.

Ten level 1 or 2 studies examined the accuracy of subacromial–subdeltoid (SA-SD) bursa injections.<sup>17,69,91,93,95,101,105,110,115,123</sup> As with peritendinous injections, the definition of an “accurate injection” was not uniform among the studies. Accuracy rates for LMG SA-SD bursa injections ranged from 24% to 100%, whereas USGI accuracy ranged from 65% to 100%. Although USG SA-SD bursa injections were more consistently accurate than LMGI, because of the highly variable results reported across different studies, a definite conclusion regarding whether or not USG SA-SD bursa injections are more accurate than LMGI cannot be made at this time. Further research is required to clarify this question.

A single level 2 study evaluated the accuracy of LMGI versus USGI into the pes anserinus bursa.<sup>98</sup> The accuracy rate for LMG pes anserinus bursa injections was 17%, whereas USGI accuracy was 92%. These preliminary findings suggest that USG pes anserinus bursa injections are more accurate than LMGI.

One level 2 study compared the accuracy of USG piriformis injections with fluoroscopically guided injections.<sup>97</sup> Ultrasound guidance provided accurate injections in 95% of cases, whereas fluoroscopically guided injections were accurate only 30% of the time. Furthermore, one of the fluoroscopically guided injections placed the injectate into the sciatic nerve. Another level 2 study reported the accuracy of USG obturator internus injections to be 100%.<sup>118</sup> Although preliminary, these findings suggest that US guidance enables accurate injections into the deep gluteal musculature, is more accurate than fluoroscopically guided injections into this region, and minimizes the potential for complications associated with inadvertent needle placement into adjacent neurologic structures.

A level 1 study evaluated the accuracy of placing the needle tip of a compartment pressure monitor into the deep and superficial posterior leg compartments using landmark or US guidance in cadavers.<sup>114</sup> The accuracy was similar between the 2 techniques. This was likely due to the relatively superficial location and large size the 2 posterior leg compartments. Therefore, based on the current evidence, USG is not

recommended for routine compartment pressure testing of the posterior leg compartments.

Two level 2 studies evaluated the accuracy of USGI into Morton neuromas.<sup>94,104</sup> Both reported 100% accuracy. No studies were identified that evaluated the accuracy of LMG Morton neuroma injections. Based on the available evidence, USG Morton neuroma injections are highly accurate and the accuracy of LMG Morton neuroma injections is unknown.

The final soft tissue injection accuracy study was a level 2 study that evaluated the accuracy of LMG sinus tarsi injections versus USGI.<sup>80</sup> Wisniewski et al reported the accuracy of USG sinus tarsi injections to be 90%. Landmark-guided injections were only 35% accurate. These findings suggest that USG sinus tarsi injections are more accurate than LMGI.

Regarding efficacy, only 1 study was identified with level 1 or 2 evidence that directly compared LMGI with USGI for the treatment of a tendon disorder (Table 9).<sup>106</sup> Kume et al demonstrated significantly more pain reduction from USGI than LMGI in patients with septation between the extensor pollicis brevis and abductor pollicis longus tendons in the first dorsal compartment. Septation is present in the first dorsal compartment in greater than 50% of patients.<sup>111</sup> Although further studies are needed, USGI for the treatment of De Quervain tenosynovitis may be superior to LMGI, particularly in the setting of a septated first dorsal compartment.

Two level 2 studies compared the efficacy of USG plantar fascia injections with LMGI.<sup>119,125</sup> Neither of the studies found any difference in efficacy between USG plantar fascia injections and LMGI, although one of the studies reported less recurrent pain after USGI.<sup>119</sup> In addition, one of the studies evaluated the efficacy of scintigraphically guided plantar fascia injections compared with USGI and LMGI.<sup>125</sup> No difference in outcomes was found between the 3 groups. Interestingly, “scintigraphic guidance” was actually an unguided injection since the injector performed an LMGI in the region where the scintigram was positive. There is currently insufficient evidence to support routine US guidance for plantar fascia injections. Further studies are needed to determine whether USG plantar fascia injections



**TABLE 9.** Soft Tissue Injection Efficacy

	Level of Evidence				
	Level 1	Level 2	Level 3	Level 4	Level 5
SA-SD bursa	—	4 studies: USGIs are more efficacious than LMGI <sup>54,87,103,121</sup> 1 study: USGIs produces more pain relief with local anesthetic injection than LMGI <sup>100</sup> 1 study: USGIs more efficacious than LMGI in some but not all outcome measures <sup>51</sup> 1 study: USGIs more efficacious than oral steroids in some but not all outcome measures <sup>92</sup> 1 study: accurate injections are more efficacious than inaccurate injections <sup>93</sup> 2 studies: accurate injections no more efficacious than inaccurate injections <sup>91,105</sup>	—	—	—
Rotator cuff	—	—	—	1 study: USG lavage and aspiration of calcific tendinopathy is efficacious <sup>124</sup>	—
Lateral elbow common extensor tendon	—	—	—	1 study: USG needle tenotomy is efficacious <sup>112</sup>	—
De Quervain tenosynovitis	—	1 study: USGIs more efficacious than LMGI <sup>106</sup>	—	1 study: USGIs are efficacious <sup>111</sup>	—
Carpal Tunnel Syndrome	—	3 studies: USGIs more efficacious and less painful than LMGI <sup>85,109,122</sup>	—	—	—
Gluteus medius tendon	—	—	—	1 study: USGIs are efficacious <sup>107</sup>	—
Baker cyst	—	1 study: USGIs' Baker cyst aspiration and injection more efficacious than Baker cyst aspiration and knee injection <sup>84</sup>	—	1 study: USG aspiration and injection are efficacious <sup>90</sup>	—
Plantar fascia	—	1 study: no difference in efficacy between USGIs 1 study: no difference in efficacy between USGIs and LMGI	—	1 study: USGIs are efficacious <sup>120</sup>	—
Morton neuroma	—	—	—	2 studies: USGIs are efficacious <sup>94,104</sup>	—
FFT, FET, ECUT, TP tendon, and peroneal tendon sheath	—	—	—	1 study: USGIs are efficacious <sup>89</sup>	—
Patellar, Achilles, gluteus medius, ITB, hamstring, lateral elbow, rectus femoris	—	—	—	1 study: USG needle tenotomies are efficacious <sup>102</sup>	—
Multiple upper and lower extremity tendons	—	—	—	1 study: USG needle tenotomies with PRP injections are efficacious <sup>96</sup>	—
Post-upper extremity amputation neuromas	—	—	—	—	1 study: USGIs are efficacious <sup>88</sup>

ECUT, extensor carpi ulnaris tendon; FET, finger extensor tendon; FFT, finger flexor tendon; SGI, scintigraphy-guided injection; TP, tibialis posterior; USG, ultrasound guided.

**TABLE 10.** Soft Tissue Injection Cost-Effectiveness

	Level of Evidence				
	Level 1	Level 2	Level 3	Level 4	Level 5
Carpal tunnel syndrome		1 study: USGIs are more cost-effective than LMGI <sup>85</sup>			

reduce recurrence rates, which may decrease the costs associated with treating this condition. Finally, research is also required to determine whether US guidance reduces complications associated with plantar fascia injections (eg, plantar fascia rupture, calcaneal fat pad atrophy).

Five level 2 studies evaluated the efficacy of USG SA-SD bursa injections versus LMGI<sup>51,54,87,103,121</sup>. All 5 studies demonstrated better outcomes following USG SA-SD bursa injections compared with LMGI. Three level 2 studies assessed the efficacy of accurate versus inaccurate SA-SD bursa injections.<sup>91,93,105</sup> Two of the studies concluded that there was no difference in efficacy between accurate and inaccurate injections,<sup>91,105</sup> and 1 study reported that accurate injections are more efficacious than inaccurate injections.<sup>93</sup> A single level 2 study demonstrated more pain relief after USG SA-SD bursa local anesthetic injections than LMGI, suggesting USG SA-SD bursa injections may provide more diagnostic information regarding the etiology of shoulder pain than LMGI.<sup>100</sup> A final level 2 study demonstrated more improvement in a majority of outcome measures after USG SA-SD bursa injections than oral steroids for shoulder pain.<sup>92</sup> Therefore, current studies indicate USG SA-SD bursa injections are more efficacious than LMGI or oral steroids for shoulder pain. Furthermore, USGIs provide more diagnostic information regarding the etiology of shoulder pain than LMGI.

Three level 2 studies compared the efficacy of USG carpal tunnel injections with LMGI.<sup>85,109,122</sup> All 3 studies reported that USG carpal tunnel injections were less painful and more efficacious than LMGI. Furthermore, one of the studies performed a cost analysis and concluded that USG carpal tunnel injections were also more cost-effective than LMGI (Table 10).<sup>85</sup> However, the cost analysis only included those who responded to the injection. When all patients were included in the cost analysis (responders and nonresponders), the cost was higher for USGIs than for LMGI when the procedure was performed in a physician's office and was equivalent when performed in a hospital-based setting. The findings of these studies provide strong evidence

that USG carpal tunnel injections are more efficacious than LMGI. However, further research is required to determine whether USG carpal tunnel injections are more cost-effective than LMGI.

In summary, USGIs into tendon sheaths, peritendinous regions, deep gluteal muscles (eg, piriformis and obturator internus), the pes anserinus bursa, and sinus tarsi are all more accurate than LMGI. Ultrasound-guided Morton neuroma injections are highly accurate, but the accuracy of LMGI into Morton neuromas is unknown at this time. Although USG SA-SD bursa injections seem to be more accurate than LMGI, the wide range of reported accuracy limits the ability to draw a definitive conclusion at this time. Ultrasound-guided SA-SD bursa, carpal tunnel, and first dorsal wrist compartment injections are more efficacious than LMGI. Ultrasound-guided plantar fascia injections seem to have equivalent outcomes to LMGI. Finally, further research is required to determine whether USGIs into soft tissues are more cost-effective than LMGI.

## Multiple Joints

Three studies were identified that evaluated joint injections in multiple locations (see **Appendix, Supplemental Digital Content 5**, <http://links.lww.com/JSM/A57>).<sup>126–128</sup> None of the 3 studies specified which joints were assessed. The accuracy, efficacy, and cost-effectiveness data from these studies are summarized in Tables 11–13. The first study evaluated the efficacy and cost-effectiveness of USG versus LMGI injections into joints with inflammatory arthritis.<sup>127</sup> This level 2 study found that USGIs into joints with inflammatory arthritis produced less procedural pain, more pain relief, more responders, and less nonresponders to the injection, and was less expensive than LMGI. In a study with level 1 evidence, Cunningham et al<sup>126</sup> determined that the mean accuracy of USGIs into joints with inflammatory arthritis were 83% accurate, whereas LMGI injections were only 66% accurate. Their study also provided level 2 evidence that USGIs into joints with inflammatory arthritis resulted in more clinical improvement and pain reduction at 6 weeks follow-up than those who received an LMGI. The final multiple joint injection study performed by Sibbitt et al<sup>128</sup> provided level 2 evidence that subjects with painful joints who received USGIs experienced less procedural pain and more pain relief than those who received LMGI. Moreover, when compared with LMGI, USGIs resulted in a larger number of responders, less nonresponders, and an improved ability to detect and aspirate joint effusions.

**TABLE 11.** Multi-Joint Injection Accuracy

	Level of Evidence				
	Level 1, Mean (Range)	Level 2, Mean (Range)	Level 3, Mean (Range)	Level 4, Mean (Range)	Level 5, Mean (Range)
Joints with inflammatory arthritis					
USGI	83 <sup>126</sup>	—	—	—	—
LMGI	—	—	—	—	—

**TABLE 12.** Multi-Joint Injection Efficacy

	Level of Evidence				
	Level 1	Level 2	Level 3	Level 4	Level 5
Joints with inflammatory arthritis	—	2 studies: USGIs are more efficacious than LMGIs <sup>126,127</sup>	—	—	—
Painful joints	—	1 study: USGIs are more efficacious than LMGIs <sup>128</sup>	—	—	—

In summary, these findings suggest that USGIs into inflamed or painful joints are more accurate, less painful, more efficacious, and are less expensive than LMGIs. However, further research is required to confirm these findings due to the limited number of studies.

### New Procedures and Future Trends

As the field of MSK US has continued to mature, practitioners from multiple disciplines have capitalized on US's powerful combination of high (submillimeter) resolution and real-time imaging capability to expand the applications of interventional MSK US in clinical practice. These applications can be considered in 3 broad categories, or generations.

First-generation techniques apply US guidance to improve the accuracy of established procedures such as joint injections, peritendinous injections, and perineural injections, and are the focus of the current position statement. The use of first-generation techniques has continued to expand as additional therapeutic and regenerative agents have been introduced into clinical practice, including but not limited to dextrose, autologous blood, and platelet-rich plasma (PRP).<sup>129–139</sup> This trend will continue as practitioners use US guidance as the primary deployment mechanism to deliver an increasing repertoire of drugs, cell-based therapeutic-regenerative agents and tissue scaffolds to soft tissues, and accessible joint regions.<sup>62,140–143</sup>

Second-generation techniques have predominately emerged during the past decade and can be generally considered to be advanced procedures performed with commonly available needles. However, in contradistinction to first-generation techniques, most of the second-generation techniques were developed primarily as a result of the availability of US guidance. Common examples include needle tenotomy/fasciotomy for chronic tendinosis/fasciosis, fenestration of the transverse carpal ligament to treat carpal tunnel syndrome, neovessel ablation through sclerosing agent injection or mechanical disruption to treat chronic tendinosis, needle release of the A1 pulley for trigger finger, needle aponeurotomy for Dupuytren contracture, and hydrodissection to treat peripheral neuritis due to mild compression or adhesions.<sup>62,96,140,141,143–153</sup> Before the widespread

adoption of US guidance, these procedures either did not exist or were performed relatively rarely due to the inability to directly visualize target tissues and subsequent safety concerns. Currently, many of these procedures are being increasingly used on a regular basis in diverse clinical practices. Percutaneous US-guided fenestration and aspiration (ie, barbotage) of calcific tendinosis can also be considered to be a second-generation procedure. Although originally described as a fluoroscopic procedure, the role of fluoroscopy has largely been supplanted by US guidance due to US's excellent safety profile and clinical efficacy.<sup>154–157</sup>

Third-generation techniques are perhaps the most exciting for the field and are characterized by the use of preexisting, specialized surgical tools or specially designed devices to perform a specific US-guided procedure. Many of these techniques duplicate well-accepted surgical procedures using percutaneous US guidance to improve safety and reduce morbidity. Recently described techniques include A1 pulley release using hook knives, carpal tunnel release using hook knives, arthroscopic equipment, or specially designed devices, and tenotomy/fasciotomy using specialized devices that not only cut but also debride damaged tissue.<sup>158–166</sup> The integration of these techniques into clinical practice represents a major advancement in the field of musculoskeletal medicine. In the near future, it is likely that additional USG surgical procedures will be adopted with advanced US imaging techniques and/or specialized equipment.

In summary, the current trend toward expanded applications of interventional MSK US can be expected to continue for decades, driven by advances in US technology, practitioner expertise with US guidance, and the development of specialized tools. Many traditional surgical procedures will become office-based, lower cost procedures performed by skilled practitioners, and some will be combined with precise delivery of therapeutic-regenerative agents.

### DISCUSSION AND RECOMMENDATIONS

The purpose of this position statement was to determine the accuracy, efficacy, and cost-effectiveness of USGIs in joints and soft tissues. A brief discussion of new USG

**TABLE 13.** Multi-Joint Injection Cost-Effectiveness

	Level of Evidence				
	Level 1	Level 2	Level 3	Level 4	Level 5
Joints with inflammatory arthritis	—	1 study: USGIs are more cost-effective than LMGIs <sup>127</sup>	—	—	—

procedures and future trends was also conducted. During the following discussion, the American Medical Society for Sports Medicine position on each topic will be stated, and the strength of the evidence associated with the position will be graded using the following strength of recommendation taxonomy (SORT):

- A. Consistent good-quality evidence.
- B. Inconsistent or limited-quality evidence.
- C. Consensus, disease-oriented evidence, usual practice, expert opinion, or case series.

## Accuracy

American Medical Society for Sports Medicine Position: USGIs are more accurate than LMGI (SORT Evidence Rating = A).

A majority of the relevant research investigated USGI accuracy. There is evidence that USGIs into large, intermediate, and small joints; tendon sheaths, peritendinous regions, deep gluteal muscles, pes anserinus bursa, sinus tarsi, and inflamed joints are more accurate than LMGI. The preponderance of studies evaluated the accuracy of large joint injections followed by intermediate joints with the minority of studies evaluating the accuracy of small joint injections. Because of the limited number of small and intermediate joint injection accuracy studies, further research in these areas is warranted.

Preliminary research suggests that USGIs into Morton neuromas are highly accurate, but no LMGI accuracy studies have been performed so a comparison between the 2 techniques cannot be made. Similarly, no LMGI accuracy studies have been performed in the SI joint and the 2 USG SI joint injection studies that have been published reported conflicting accuracy rates. Therefore, further research is required to determine whether USG SI joint and Morton neuroma injections are more accurate than LMGI.

The soft tissue structure with the most injection accuracy studies was the SA-SD bursa. Although a majority of research suggested that USG SA-SD bursa injections are more accurate than LMGI, the reported accuracy rates for both USG and LMGI were highly variable. This may have been due to several factors. First, USGIs are only accurate if the injector can correctly identify the target and guide the needle into the target. Therefore, the variability of the USGI accuracy results suggests that the injectors in some USG SA-SD bursa injection studies were either unable to accurately identify the SA-SD bursa or correctly guide the needle into the target. Because the injector's ability to correctly identify the SA-SD bursa was not assessed, nor was their ability to guide a needle into a specific target, the influence of the injector's technical abilities on the studies outcome is unknown. The technique by which accuracy is confirmed may also have influenced the study outcomes. For instance, in the study by Mathews et al,<sup>110</sup> 20 cadaveric shoulders were injected with radiocontrast into the subacromial bursa using 2 different approaches, and the accuracy of the injections was initially determined by fluoroscopy to be 90%. However, after dissecting the shoulders, the actual accuracy rate was determined to be 60%. This demonstrates that imaging modalities cannot always be relied on to provide correct information

regarding injection accuracy, particularly into soft tissues. The heterogeneity of accuracy confirmation techniques (CT, CT arthrography, MRI, MR arthrography, standard radiographic arthrography, intraoperative confirmation, and cadaveric dissection) used by different researchers contributes to the difficulty of interpreting the injection accuracy literature. Further research in which the injector's technical abilities are confirmed and the correct imaging technique is used to grade accuracy are required to definitively answer the question of whether or not USG SA-SD bursa injections are more accurate than LMGI.

## Efficacy

American Medical Society for Sports Medicine Position: USGIs are more efficacious than LMGI (SORT Evidence Rating = B).

There is evidence that USGIs are more efficacious than LMGI in large joints, inflamed joints, SA-SD bursa, carpal tunnel, and first dorsal wrist compartment tendon sheath. Only 1 study evaluated the efficacy of USG intermediate joint injections (AC joint) relative to LMGI and found no difference in efficacy between the 2 techniques, but the study's design limits the strength of their conclusions. No studies have been performed comparing the efficacy of USG small joint injections to LMGI. Therefore, although a majority of studies suggest that USGIs are more efficacious than LMGI, further research is required to fully answer this question.

There are some difficulties with performing efficacy research that warrant mention. The most commonly injected substance to treat musculoskeletal conditions is corticosteroids. There is limited evidence that the systemic effects of corticosteroids provide similar therapeutic benefits to localized injections.<sup>92</sup> In the study by Ekeberg et al,<sup>92</sup> a corticosteroid injection in the gluteal region was compared with a USG SA-SD bursa injection for patients with rotator cuff disease. Although their conclusions need to be interpreted with caution due to significant study limitations (eg, heterogeneity of shoulder pathology in the study subjects, lack of control group, soft tissue corticosteroid injections in both groups, which may result in larger systemic effects than intra-articular injections, etc), both groups showed similar improvements in their primary outcome measures although there were some secondary outcome measures that were better in the USGI group than the gluteal (systemic) injection group. Therefore, it is possible that the systemic effects of corticosteroids may make it difficult to detect a difference in efficacy between an accurately and inaccurately placed corticosteroid injection. Despite this possibility, it is important to remember that several studies have been able to demonstrate greater efficacy with accurately placed corticosteroids than inaccurately placed corticosteroids. This may be due to the type of pathology that is being treated. Specifically, although corticosteroids have been demonstrated to provide short-term therapeutic benefits for arthritis,<sup>167</sup> it can be argued that corticosteroid injections may not be an effective treatment for some conditions such as rotator cuff tendinopathy.<sup>168</sup> So, the issue of injection accuracy and efficacy may be irrelevant if the injected agent (eg, corticosteroids) is inappropriate for the pathology being treated. Certainly one could

postulate that injectable therapeutic agents that do not have demonstrable systemic therapeutic benefits (eg, viscosupplements, PRP) would be ineffective if placed in the wrong region. Therefore, therapeutic benefit would be dependent on correct injectate placement for these compounds. However, further research is required to determine whether this hypothesis is correct.

Although the difference in efficacy between USGIs and LMGI is important, because it has been established that LMGI is less accurate than USGI, it is also important to consider the nontherapeutic ramifications of inaccurate injectate placement. If an injectate is misplaced, it may lead to complications such as skin depigmentation, subcutaneous fat atrophy, tendon rupture, neurovascular injury, increased procedural and postprocedural pain, or intra-articular injection.<sup>99,108</sup> In addition, correct injectate placement can provide useful diagnostic information regarding the location of a pain generator. All of these factors must be taken into consideration when choosing which injection technique to use.

### Cost-Effectiveness

American Medical Society for Sports Medicine Position: USGIs are more cost-effective than LMGI (SORT Evidence Rating = B).

The area with the least research is cost-effectiveness. Only 4 studies were identified that compared the cost-effectiveness of USGIs with LMGI. The preliminary findings of these studies suggest that USGIs are more cost-effective than LMGI for large joints, inflamed joints, and carpal tunnel syndrome since more people responded to the USGIs, their improvement was greater and lasted longer than those who received LMGI, and they used health care services less often after USG than LMGI. However, because of the limited number of studies, additional well-designed studies are required to determine whether USGIs are more cost-effective than LMGI.

### New Procedures and Future Trends

American Medical Society for Sports Medicine Position: USG is required to perform many new procedures (SORT Evidence Rating = C).

Finally, the scope of USG procedures in sports medicine continues to evolve with the introduction of second-generation (eg, tenotomies, transverse carpal ligament fenestrations, peripheral nerve hydrodissections) and third-generation (eg, percutaneous A1 pulley releases with a surgical hook knife) procedures. Direct visualization of the target structure, relevant surrounding structures, and guidance of the procedural device is required for the performance of these procedures. Although the need for radiologic guidance (eg, USG) is inherent to the performance of these procedures, research will be needed to determine the efficacy, safety profile, and cost-effectiveness of these new procedures.

### CONCLUSIONS

The use of diagnostic and interventional ultrasound has significantly increased over the past decade. A majority of the

increased utilization is by nonradiologists. In sports medicine, ultrasound is often used to guide interventions such as aspirations, diagnostic or therapeutic injections, tenotomies, releases, and hydrodissections, and is rapidly becoming part of the standard practice of sports medicine. The findings of this position statement indicate there is strong evidence that USGIs are more accurate than LMGI, moderate evidence that they are more efficacious, and preliminary evidence that they are more cost-effective. Furthermore, USG is required to perform many new advanced procedures and will likely enable the development of innovative USG surgical techniques in the future.

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