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CME

Does Injection Site and Imaging Make a Difference? A Systematic Review

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Background: Joint injections and aspirations are used to reduce joint pain and decrease inflammation. The efficacy of these injections is diminished when they are placed inadvertently in the wrong location or compartment. The purpose of this study was to determine whether the use of varying sites or imaging techniques affects the rate of accurate needle placement in aspiration and injection in the shoulder, elbow, and knee.

Hypotheses: (1) Accuracy rates of different joint injection sites will demonstrate variability. (2) Injection accuracy rates will be improved when performed with concomitant imaging.

Study Design: Systematic review of the literature.

Methods: Studies reporting injection accuracy based on image verification were identified through a systematic search of the English literature. Accuracy rates were compared for currently accepted injection sites in the shoulder, elbow, and knee. In addition, accuracy rates with and without imaging of these joints were compared.

Results: In the glenohumeral joint, there is a statistically higher accuracy rate with the posterior approach when compared with the anterior approach (85% vs 45%). Injection site selection did not affect accuracy for the subacromial space, acromioclavicular joint, elbow, or knee. The use of imaging improved injection accuracy in the glenohumeral joint (95% vs 79%), subacromial space (100% vs 63%), acromioclavicular joint (100% vs 45%), and knee (99% vs 79%).

Conclusion: Injection accuracy rates are significantly higher for the posterior approach compared with the anterior approach for the glenohumeral joint. Similarly, the accuracy rates are also higher when imaging is used in conjunction with injection of the glenohumeral joint, subacromial space, acromioclavicular joint, and knee.

Keywords: injection; accuracy; systematic review; joints

Intra-articular and periarticular injections are frequently used to reduce inflammation, pain, and stiffness and to diagnostically identify symptomatic structural changes. Joint aspiration is frequently performed to obtain fluid for laboratory analysis in addition to reducing pain and stiffness. The shoulder, elbow, and knee are among the most common joints that are aspirated and/or injected. Studies have demonstrated that the degree of pain relief and functional improvement is greater when the injection is documented to be in the intended location (ie, intra-articular).[10,11,20,29] In addition, misplaced injections can pose risks, such as soft tissue damage, tendon weakening, skin depigmentation with corticosteroid injections,[7] and inaccurate images with extra-articular contrast dye. Studies have shown that injection accuracy rates are poor when performed by anatomic palpation alone.[2,3,16] The success of injection and aspiration procedures depends on the placement of the needle within the joint space. Given this and the cost and time spent on these procedures, the importance of ensuring the intended location is critical.

Studies have suggested that certain anatomic portals provide greater accuracy in injection and aspiration of the shoulder, elbow, and knee joints.[5,10,13,25] In the glenohumeral joint, approaches include anterior and posterior. In the subacromial space, approaches include anterolateral, lateral, posterior, and anteromedial. In the acromioclavicular joint, only the superior approach is considered. In the elbow, typically only the lateral approach is considered. In the knee, approaches include anteromedial, anterolateral,

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and lateral midpatellar. In addition to using different anatomic injection approaches, studies have suggested that imaging modalities such as ultrasonography, magnetic resonance (MR) arthrography, and fluoroscopy can be used successfully to guide injections and aspirations.[2-4] These types of imaging can be used at the time of injection to locate the joint space, during the procedure to follow the needle in real time, or after the needle placement to adjust an incorrectly placed needle.

The purpose of this study was to determine which anatomic approaches provide the greatest accuracy rate for the glenohumeral joint, subacromial space, acromioclavicular joint, elbow, and knee. We also determined whether the use of imaging techniques such as ultrasonography, MR arthrography, and fluoroscopy affects the accuracy rate in aspiration and injection of the knee, shoulder, and elbow joint. Our hypotheses were as follows: (1) the anatomic portals would differ in their accuracy rates, and (2) imaging techniques would improve the rate of accurate needle placement at each site.

METHODS

Systematic reviews are studies that use preestablished inclusion and exclusion criteria to combine all previously published primary investigations into one review to limit bias and error. The first step of this review required the establishment of inclusion and exclusion criteria prior to initiating the literature search.

Inclusion criteria:

- Studies that performed injections or aspirations in the shoulder, elbow, or knee
- Studies presented in English
- Studies that objectively verified the location of the needle through imaging after the needle had entered the joint. Injections performed using palpation to determine the needle placement site must also use imaging to verify the needle location.

Exclusion criteria:

- Studies that performed injections or aspirations on cadavers or anesthetized patients because they were thought to inaccurately reflect the clinical situation
- Studies that did not objectively verify the location of the needle at the time of the injection but rather assumed it to be intra-articular or extra-articular solely based on patient pain levels or changes in function. These studies were excluded because perceived pain level is difficult to statistically analyze because multiple factors can contribute to decreased pain, including the placebo effect.
- Studies that were performed in tendons or fascia or nonarticulating portions of the knee, elbow, and shoulder

Using the above-mentioned criteria, Medline, PubMed, Ovid, and the Cochrane Database of Systematic Reviews and Controlled Trials were searched to find articles related to joint injection and aspiration. The MeSH terms *ultrasonography*, *fluoroscopy*, *arthrography*, *injections*, *intra-articular*, *knee*, *shoulder*, and *elbow* were searched alone and in combination to identify all relevant articles published in English. In addition, references in the articles themselves were searched to find articles not previously identified. All abstracts were then reviewed to determine the anatomic injection approach, the number of patients enrolled, how accuracy rates were determined, which imaging modality was used, and whether accuracy data were provided and verified.

Articles that met the inclusion criteria were assigned a level of evidence through collaboration between 2 investigators, according to the guidelines set forth in a publication by Wright.[30] Data were extracted for anatomic approach. In the glenohumeral joint, anterior and posterior approaches were considered. In the subacromial space, lateral, anterolateral, anteromedial, and posterior approaches were considered. In the knee, medial, lateral, and lateral midpatellar approaches were considered. No data were gathered for the acromioclavicular joint or elbow as there is typically only one approach. Studies that did not specify which approach was used were excluded from this portion of analysis (Table 1). Data were organized into tables comparing number of confirmed intra-articular injections per approach. In addition, data were extracted for imaging or nonimaging in the glenohumeral joint, subacromial space, acromioclavicular joint, elbow, and knee. Data were organized into tables comparing number of confirmed intra-articular injections with and without imaging. Studies that did not specify which part of the shoulder was injected were excluded (Table 1). In studies where multiple attempts were made to place the needle accurately, only the first attempt was considered.

Statistical Analysis

Needle accuracy rates were compared for approaches and imaging versus nonimaging using chi-square with Yates correction and relative risk with its associated 95% confidence interval when appropriate. Relative risk was calculated with its associated 95% confidence interval for the glenohumeral joint where a 2×2 contingency was possible. This calculation was not performed for the knee or subacromial joint space, as they have more than 2 possible approaches. Results were considered significant if the P value was less than .05 and if the 95% confidence interval of the relative risk did not include 1. Relative risk for imaging was calculated as the "risk" of the injection being intra-articular if exposed to the "risk factor" of imaging.

RESULTS

Literature Review

A keyword search of Medline and PubMed yielded 4732 studies relating to joint injections. An additional search of the Cochrane Database of Systematic Reviews and Controlled Trials and Ovid gave 87 and 357 articles, respectively. The abstracts of these 5176 articles were reviewed, and 160 English articles were identified that evaluated needle placement during orthopaedic injections and aspirations. Of the 160 articles, 10 were eliminated initially because these studies were performed on cadavers. The

TABLE 1
General Information and Evidence Classification[a]

Lead Author	Number of Joints Injected	Joint	Approach	Imaging Used as a Aid for Location	Imaging Used to Test Accuracy	Study Design	Level of Evidence
Bain[1]	44	Shoulder AC	Not given	Fluoro	Fluoro	Cohort	III
Balint[2]	9	Elbow	Not given	US	US	Cohort	III
	29	Knee	Not given	US	US		
	6	Shoulder	Not given	US	US		
Bisbinas[3]	66	Shoulder AC	Superior	Fluoro	Fluoro	Cohort	III
Bliddal[4]	56	Knee	Lateral	Air arthro	Air arthro	Cohort	III
Catalano[5]	147	Shoulder GH	Posterior	MR arthro	MR arthro	Cohort	III
Cicak[6]	24	Shoulder GH	Posterior	US	MR arthro	Case series	IV
DeMouy[8]	8	Shoulder GH	Anterior	None	MR arthro	Case report	IV
Depelteau[9]	65	Shoulder GH	Anterior	Fluoro	Arthro	Case series	IV
Esenyel[10]	48	Shoulder SA	Anterior	Radio	Radio	Cohort	III
Eustace[11]	14	Shoulder SA	Lateral	None	Radio	Case series	IV
	24	Shoulder GH	Anterior	None	Radio		
Farmer[12]	132	Shoulder GH	Posterior	Fluoro	MR arthro	Cohort	III
	8	Shoulder GH	Anterior	Fluoro	MR arthro		
Henkus[13]	17	Shoulder SA	Posterior	None	MRI	Cohort	II
	16	Shoulder SA	Anteromedial	None	MRI		
Hilfiker[14]	3	Shoulder GH	Not given	MR arthro	MR arthro	Case report	IV
Jackson[15]	80	Knee	Lateral	None	Fluoro	Cohort	III
	80	Knee	Medial	None	Fluoro		
	80	Knee	Lateral midpatellar	None	Fluoro		
Jones[16]	59	Knee	Not given	None	Radio	Case series	IV
	20	Shoulder	Not given	None	Radio		
	6	Elbow	Not given	None	Radio		
Kang[17]	20	Shoulder SA	Posterior	None	Radio	Cohort	II
	20	Shoulder SA	Lateral	None	Radio		
	20	Shoulder SA	Anterolateral	None	Radio		
Lopes[18]	34	Shoulder	Not given	None	Radio	Case series	IV
	31	Elbow	Not given	None	Radio		
	37	Knee	Not given	None	Radio		
Luc[19]	33	Knee	Lateral	None	Radio	Case series	IV
Naredo[21]	41	Shoulder SA	Lateral	US	US	Cohort	II
Porat[22]	100	Shoulder GH	Not given	None	MR arthro	Case series	IV
Rutten[24]	20	Shoulder SA	Not given	US	MRI	Cohort	III
Rutten[23]	25	Shoulder GH	Anterior	US	MR arthro	Cohort	III
	25	Shoulder GH	Anterior	Fluoro	MR arthro		
	25	Shoulder GH	Posterior	US	MR arthro		
	25	Shoulder GH	Posterior	Fluro	MR arthro		
Sethi[25]	41	Shoulder GH	Anterior	None	MR arthro	Case series	IV
Soh[26]	11	Shoulder GH	Anterior	MR fluoro	MR fluoro	Case series	IV
Toda[27]	50	Knee	Waddell	None	Radio	Cohort	II
		Knee	Medial	None	Radio		
		Knee	Lateral midpatellar	None	Radio		
Valls[28]	50	Shoulder SA	Anterior	US	MR arthro	Case series	IV
Yamakado[31]	56	Shoulder SA	Lateral	None	Radio	Case series	IV

[a]AC, acromioclavicular; Arthro, arthrography; Fluoro, fluoroscopy; GH, glenohumeral; MR, magnetic resonance; MRI, magnetic resonance imaging; Radio, radiographs; SA, subacromial bursa; US, ultrasound.

remaining 150 were reviewed, in entirety, to determine the method by which the needle location was verified and exact location in which the needle was placed. Of these 150 studies, 78 were eliminated on the basis of a lack of verification of needle location at the time of procedure, and 33 studies were eliminated because of injection or aspiration into a nonarticulating joint space, such as tendon or fascia. Of the remaining 39 articles, 27 were used in this review, as we eliminated studies that were not performed in the shoulder, elbow, or knee joint. The inclusion and exclusion criteria are illustrated in Figure 1. Level of evidence was determined for each of the 27 articles, and there were 0 level I, 4 level II, 11 level III, and 12 level IV studies. The general data from these studies are summarized in Table 1.

Injection Site Approach

Glenohumeral Joint. In the glenohumeral joint,[5,8,11,25] there were a total of 220 injections through 2 different

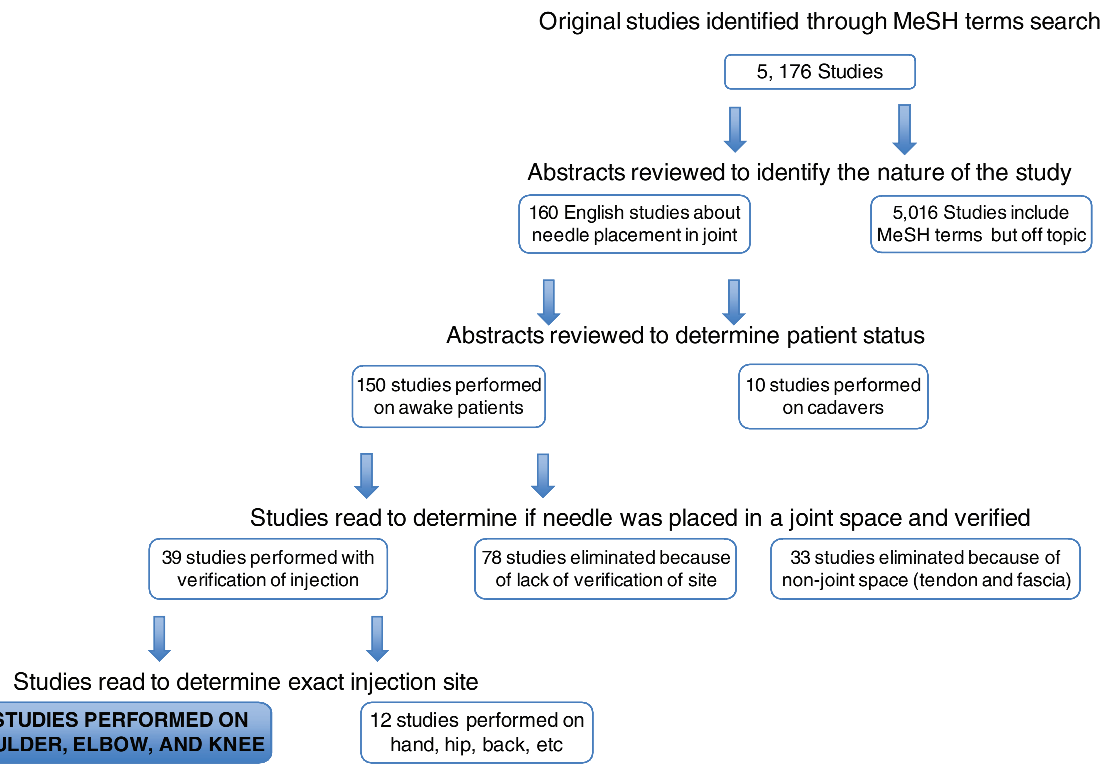

Figure 1. Inclusion and exclusion criteria analysis.

approaches. There were 73 shoulders injected through an anterior approach, and the average of the reported accuracy rates of the included studies was 40% (range, 27%-100%). There were 147 shoulders injected through a posterior approach with an average accuracy of 85% (no range because of only 1 posterior approach study). The accuracy rates of each portal were verified through imaging techniques. Catalano et al[5] and Sethi et al[25] used gadolinium injection and verified accuracy using MR arthrograms. DeMouy et al[8] used MR arthrography with saline as a contrast agent, and Eustace et al[11] verified injection accuracy through anteroposterior (AP) and axial shoulder radiographs. These data are summarized in Table 2. Chi-square with a Yates correction yielded a P value of less than .001, and the relative risk of an anterior injection being intra-articular was 0.467 with a 95% confidence interval between .378 and .577. Statistically, this supports a difference in accuracy rates between the anterior and posterior portals, with the posterior portal having a higher accuracy rate.

Subacromial Space. In the subacromial space,[10,11,13,17,21,31] 4 approaches were considered in a total of 231 injections. In the lateral approach, 110 shoulders were injected with an average accuracy of 55% (range, 29%-70%). In the anterolateral approach, 68 shoulders were injected with an average accuracy of 84% (range, 75%-88%). In the anteromedial approach, 16 shoulders were injected with an average accuracy of 63% (no range), and there were 37 posterior injections with an average accuracy of 76% (range, 75%-76%). These data are summarized in Table 3. Chi-squared statistics yielded a P value of .140, a value too large to reject the null hypothesis at a 95% confidence interval. Therefore, this analysis failed to find a statistical difference between injection site approaches in the subacromial space.

TABLE 2
Shoulder Glenohumeral Approach Accuracy

Lead Author	Anterior, No. (%)	Posterior, No. (%)
Catalano[5]		125/147 (85)
DeMouy[8]	8/8 (100)	
Eustace[11]	10/24 (42)	
Sethi[25]	11/41 (27)	
Total	29/73 (40)	125/147 (85)

Knee. In the knee,[4,15,19,27] 3 approaches were considered in a total of 429 injections. There were 130 injections through the medial approach with an average accuracy of 70% (range, 62%-75%). There were 169 injections in the lateral aspect with an average accuracy of 83% (range, 71%-97%) and 130 lateral midpatellar injections with an average accuracy of 84% (range, 70%-93%). These data are summarized in Table 4. Chi-squared analysis yielded a P value of .363, a value too large to reject the null hypothesis at a 95% confidence interval. Therefore, this analysis failed to find a difference between injection site approaches in the knee.

Imaging

Glenohumeral Joint. In the glenohumeral joint,[§] a total of 810 injections were performed. There were 490

[§]References 5, 6, 8, 9, 11, 12, 14, 22, 23, 25, 26.

TABLE 3
Shoulder Subacromial Approach Accuracy

Lead Author	Lateral, No. (%)	Anterolateral, No. (%)	Anteromedial, No. (%)	Posterior, No. (%)
Esenyel[10]		42/48 (88)		
Eustace[11]	4/14 (29)			
Henkus[13]			10/16 (63)	13/17 (76)
Kang[17]	12/20 (60)	15/20 (75)		15/20 (75)
Naredo[21]	6/20 (30)			
Yamakado[31]	39/56 (70)			
Total	61/110 (55)	57/68 (84)	10/16 (63)	28/37 (76)

injections performed with imaging with an average accuracy rate of 95% (range, 83%-100%) and 320 injections performed without imaging with an average accuracy of 79% (range, 27%-100%). These data are summarized in Table 5. Chi-squared test gave a *P* value of less than .001 and a relative risk of 1.205 with a confidence interval between 1.269 and 1.144. There is sufficient evidence to demonstrate a statistically significant difference in accuracy rates between imaging and nonimaging in the glenohumeral joint, with imaging having a higher accuracy rate.

Subacromial Space. In the subacromial space,[10,11,13,17,24,28,31] a total of 281 injections were performed. There were 60 injections performed with imaging with an average accuracy of 100% (no range) and 221 injections performed without imaging with an average accuracy of 72% (range, 29%-100%). These data are summarized in Table 6. Chi-squared analysis demonstrated a *P* value of less than .001 with a relative risk of 1.381 with a confidence interval between 1.593 and 1.197. There is sufficient evidence to demonstrate a statistically significant difference in accuracy rates between imaging and nonimaging in the subacromial space, with imaging having a higher rate of injection accuracy.

Acromioclavicular Joint. In the acromioclavicular joint,[1,3] a total of 220 total injections were evaluated. There were 110 performed with imaging with an average accuracy of 100% (no range), and 110 were performed without imaging with an average accuracy of 45% (range, 39%-55%). These data are summarized in Table 7. Chi-square with a Yates correction gave a *P* value of less than .001 with a relative risk of 2.292 and a confidence interval between 2.737 and 1.918. There is sufficient evidence to conclude there is a statistically significant difference in accuracy rates between imaging and nonimaging in the acromioclavicular joint, with imaging having a higher rate of injection accuracy.

Elbow. In the elbow,[2,16,18] a total of 42 injections were considered for comparison of accuracy between imaging and nonimaging. One elbow was injected with imaging at 100% accuracy, and 41 were injected without imaging at 90% (range, 25%-100%) accuracy. These data are summarized in Table 8. Chi-square with a Yates correction gave a *P* value of .163 with a relative risk of 1.108 with a 95% confidence interval between 0.959 and 1.279. Because only 1 elbow was injected with imaging, we were unable to perform a meaningful statistical analysis. There is currently not enough evidence to conclude that there is a difference in accuracy rates between imaging and nonimaging.

Knee. Finally, in the knee,[2,4,15,16,18,19,27] a total of 660 joints were injected. There were 75 knees injected with imaging with an average accuracy of 99% (range, 95%-100%). There were 585 knees injected without imaging with an accuracy rate of 79% (range, 40%-100%). These data are summarized in Table 9. Chi-square with Yates correction yielded a *P* value of less than .001 with a relative risk of 1.246 with a confidence interval between 1.392 and 1.117. This supports a statistically significant difference in accuracy rates when imaging is used in the knee, with imaging having a higher accuracy rate.

TABLE 4
Knee Approach Accuracy

Lead Author	Medial, No. (%)	Lateral, No. (%)	Lateral Midpatellar, No. (%)
Bliddal[4]		51/56 (91)	
Jackson[15]	60/80 (75)	57/80 (71)	74/80 (93)
Luc[19]		32/33 (97)	
Toda[27]	31/50 (62)		35/50 (70)
Total	91/130 (70)	140/169 (83)	109/130 (84)

TABLE 5
Shoulder Glenohumeral Joint Imaging Accuracy

Lead Author	Imaging, No. (%)	No Imaging, No. (%)
Catalano[5]	147/147 (100)	125/147 (85)
Cicak[6]	24/24 (100)	
DeMouy[8]		8/8 (100)
Depelteau[9]	59/65 (91)	
Eustace[11]		10/24 (42)
Farmer[12]	140/140 (100)	
Hilfiker[14]	3/3 (100)	
Porat[22]		99/100 (99)
Rutten[23]	83/100 (83)	
Sethi[25]		11/41 (27)
Soh[26]	11/11 (100)	
Total	467/490 (95)	253/320 (79)

DISCUSSION

The primary purpose of this systematic review was to provide information related to the accuracy rates of needle placement in varying anatomic portals with and without imaging assistance. Our hypothesis that the accuracy rates of joint injection will vary by anatomic portal is accepted only for the glenohumeral joint. According to statistical analysis, there is sufficient evidence to conclude that using

TABLE 6
Shoulder Subacromial Joint Imaging Accuracy

Lead Author	Imaging, No. (%)	No Imaging, No. (%)
Esenyel[10]		42/48 (95)
Eustace[11]		4/14 (29)
Henkus[13]		23/33 (70)
Kang[17]		42/60 (70)
Rutten[24]	10/10 (100)	10/10 (100)
Valls[28]	50/50 (100)	
Yamakado[31]		39/56 (70)
Total	60/60 (100)	160/221 (72)

TABLE 7
Acromioclavicular Joint Imaging Accuracy

Lead Author	Imaging, No. (%)	No Imaging, No. (%)
Bain[1]	44/44 (100)	24/44 (55)
Bisbinas[3]	66/66 (100)	26/66 (39)
Total	110/110 (100)	50/110 (45)

TABLE 8
Elbow Imaging Accuracy

Lead Author	Imaging, No. (%)	No Imaging, No. (%)
Balint[2]	1/1 (100)	1/4 (25)
Jones[16]		5/6 (83)
Lopes[18]		31/31 (100)
Total	1/1 (100)	37/41 (90)

TABLE 9
Knee Imaging Accuracy

Lead Author	Imaging, No. (%)	No Imaging, No. (%)
Balint[2]	18/19 (95)	4/10 (40)
Bliddal[4]	56/56 (100)	51/56 (91)
Jackson[15]		191/240 (80)
Jones[16]		39/59 (66)
Lopes[18]		37/37 (100)
Luc[19]		32/33 (97)
Toda[27]		109/150 (73)
Total	74/75 (99)	463/585 (79)

a posterior approach for needle placement in this joint provides a higher accuracy rate than an anterior approach. There is insufficient evidence to conclude that there is a statistical difference in needle placement accuracy rates in the subacromial space and knee. Our second hypothesis, that the use of imaging techniques will improve the accuracy of injections in the glenohumeral joint, subacromial space, acromioclavicular joint, elbow, and knee, was accepted for all joints except the elbow. There is sufficient evidence to show that using imaging improves accuracy rates in the glenohumeral joint, subacromial space, acromioclavicular joint, and knee.

The higher accuracy rate when using a posterior approach to the glenohumeral joint versus an anterior approach may be caused by anatomic differences, including greater complexity of the capsulolabral complex anteriorly.[5] There may be several reasons for higher accuracy rates when imaging modalities are used. Imaging, such as ultrasound, fluoroscopy, and arthrography, allows direct visualization of the joint space. Imaging before an injection allows for assessment of anatomic deformities or pathologic conditions such as arthritis, which can assist in needle placement. Real-time imaging permits one to dynamically follow the placement of the needle into the joint space as the injection is being performed, which increases the ability to place the needle in the correct location.

The strength of this study is that data were extracted from articles found after establishing specific inclusion and exclusion criteria. In addition, a large patient count was considered in the imaging portions of the study, which allowed us to find statistically significant and consistent data in support of the role of imaging to improve needle placement accuracy rates.

There are several limitations of this study. Considering the nature of the problem being investigated and the inability to blind researchers or patients, there are no level I studies available, and many of the current studies are level IV. There is a need for more level II research studies to be done on this topic. This review used the best currently available information, but the conclusions reached could be stronger if higher levels of evidence become available. In addition, several portions of the analysis lacked sufficient evidence to conclude whether a statistically significant difference exists. The analysis of imaging in the elbow and the approach analysis for the knee were both modestly underpowered, whereas the approach for the subacromial space was found to be only minimally underpowered. These 3 analyses could be significantly improved if more appropriately powered studies were available. Second, our review combined the use of imaging modalities before injection and during injection into one category and also combined studies using injection with those using aspiration. In addition, our review focused on only 3 joints in the body with very little data on the elbow. Future reviews could focus on other joints such as the hand, ankle, foot, and hip to support the conclusion that imaging improves joint injection accuracy rates. The final limitation in this systematic review is that we only considered studies that reported needle placement location verification determined by imaging. Many studies have been published that determined needle accuracy based on a change in the patient's pain levels or recovery of function. These data were excluded because they are difficult to statistically analyze. The accuracy of an injection is a distinctly different concept from the therapeutic benefit and patient outcome, and we thought this topic to be beyond the scope of the systematic review. Many factors beyond location of the needle can influence the patient's perceived pain levels, including the placebo effect. However, these data do provide clinical significance because reduction in pain and restoration of function are the primary purpose of injections and aspirations and could be considered a topic for a future review.

In conclusion, injection accuracy rates are significantly higher for the posterior approach in the glenohumeral joint. There is insufficient evidence to conclude that there is a statistically significant difference in injection accuracy when comparing portals in the subacromial space, acromioclavicular joint, elbow, or knee. Injection accuracy rates are significantly higher when imaging is used in the glenohumeral joint, subacromial space, acromioclavicular joint, and knee. On the basis of our systematic review, physicians wishing to improve accuracy rates of needle placement should consider using the posterior approach to the glenohumeral joint of the shoulder and imaging modalities when injecting or aspirating the glenohumeral joint, subacromial space, acromioclavicular joint, or knee.

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