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CLINICAL STUDY

Economic Analysis of Accuracy and Cost of Ultrasound-guided Intraarticular Hip Injections

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ABSTRACT

Background: Ultrasonography is an increasingly valuable tool for the diagnosis and treatment of musculoskeletal disorders. In the past, ultrasound has been used for diagnostic purposes, with increasing use of image guidance for joint injections.

Hypothesis: Ultrasound-guided intraarticular native nontraumatic hip injections are equally as accurate with less cost as other diagnostic imaging modalities including fluoroscopic-guided injections.

Design: This analysis was based on a meta-analysis of the accuracy of the different imaging modalities. Initially a search was performed for intraarticular hip injections in PubMed, EMBASE, and ClinicalTrials.gov. Injection accuracy rates between groups were analyzed via proportional meta-analysis. For the economic analysis, compensation data were determined from estimated charges from Duke University Medical Center.

Results: Compared with gold standards of accurate injections (such as fluoroscopic and computed tomography-guided injections), ultrasound is 97% as accurate (confidence interval 93%, 99%). Based on 2014 reimbursement data, reimbursement for large-joint intraarticular injection averages $61.99 (37.38£, 47.18€) ($49.20–$76.31). Fluoroscopic global reimbursement averages $105.32 (63.51£, 80.13€) ($76.75–$134.72). Ultrasound guidance global reimbursement averages $75.99 (45.86£, 57.83€) ($57.95–$93.15).

Conclusion: Ultrasound-guided hip injections are an accurate technique for alleviating hip pain at less cost. In an era of increasing concern for health care expenditures, finding an accurate, effective, and cost-friendly alternative has the potential for widespread adaptation and practice.

Keywords: Accuracy, Cost analysis, Guided injections, Musculoskeletal ultrasound.

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INTRODUCTION

Ultrasonography is an increasingly valuable tool for the diagnosis and treatment of musculoskeletal disorders. In the past, ultrasound has been used for diagnostic purposes,[1] with increasing use of imaging for guiding joint injections.

Joint injections can be beneficial for both diagnostic and therapeutic treatment of a variety of pathologies including osteoarthritis (OA), rheumatoid arthritis, and labral tears.[2] Treatment can include intraarticular injections with corticosteroids or hyaluronic acid. Intraarticular injections can also be useful diagnostically to separate intrinsic hip pathology from extrinsic pathology.[3] They have been used in the management of inflammatory and degenerative joint conditions when rest, ice, and anti-inflammatory medications fail to provide adequate symptom relief.[4] Commonly accepted indications for corticosteroid joint injections in patients with inflammatory synovitis include patients in whom systemic therapy is contraindicated or as an adjunct to systemic medical therapy in patients with rheumatoid arthritis, degenerative arthritis, or other inflammatorysynovitis.[5]

Blind techniques to access the hip joint based on bony anatomy can be difficult and traumatize the femoral neurovascular bundle.[6] Using only anatomical landmarks, the hip joint is entered only A total of 52 to 80% of the time and may pass within 4.5 mm of the femoral nerve.[2] The main advantage of image-guided joint injection over blind injection is that the needle position can be confirmed and injection of contrast medium or medication can be controlled in real time.[7] An anteroposterior approach, under fluoroscopic guidance, is generally the most frequently used method in which the patient is in a supine position with the tip of the needlepositioned along the lateral aspect of the femoral bone at the head-neck conjunction. This maneuver grants the least amount of risk for contrast extravasation and vessel or femoral nerve injury.[8]

Fluoroscopic-guided injections allow easier access to the joint, but do not visualize the vessels or nerves. Computed tomography (CT)-guided injections are expensive and time-consuming. Fluoroscopy and CT-guided injections expose the patient and staff to radiation, iodinated contrast with associated reactions,

and use of cumbersome equipment. Ultrasound allows safe, accurate, and inexpensive joint injections with real-time visualization of soft-tissue structures (Fig. 1). Furthermore, ultrasound-guided injections have the ability to visualize joint effusions, the iliopsoas bursa, and the relationship of the femoral vessels to the needle.[6] Ultrasound also has been extensively studied in one large retrospective study by Sofka[9,10] and was found to have very few complications. Ultrasound thus has several distinct advantages, such as the absence of ionizing radiation, easy availability, less invasiveness, less patient discomfort, and decreased risk of injury.[11]

Hip pain is a common presenting complaint, particularly in the elderly population, with about 15% of adults 65 years of age or older reporting hip pain or stiffness.[12] Osteoarthritis, a degenerative disease of the cartilage, is the most common human joint disease, the leading cause of disability in older persons, and is the most common reason for hip injections.[13] More than 80% of people aged ≥ 50 years have radiologic evidence of OA.[14] Approximately 27 million people in the United States aged ≥ 25 years have OA.[15] Prevalence increases with age, ranging from ~2% among persons aged < 45 years to > 80% among those ages ≥ 75 years.[13,16] Osteoarthritis of the hip has a dramatic impact on pain, function, and health-related quality of life.[15] Almost 500,000 total hip replacements are performed annually in the United States.[17]

The prevalence of OA and its significant morbidity result in large amounts of health expenditures. Berger et al analyzed the amount of heath expenditures that occurred 2 years before total hip replacement. They found that 30.3% of patients had received at least one corticosteroid injection and 2.3% received an injection with hyaluronic acid. The mean number of office visits during the 2 years preceding surgery was 30.0 (with a standard deviation of 24.1 and median of 23); patients also averaged 5.9 visits in outpatient settings (with a standard deviation of 5.9 and a median of 3).[18] The total per-patient health care costs throughout the 2-year period preceding surgery averaged $19,466 [95% confidence interval (CI) 19,011–19,922]. It is important to note that this estimation is likely an underestimation of actual expenditure, as it did not include over-the-counter pain relievers, which OA patients take frequently. Outpatient care (e.g., physician's office visits, Emergency Department visits) comprised almost one-half of the total health care costs during the 2 years period prior to surgery.[18]

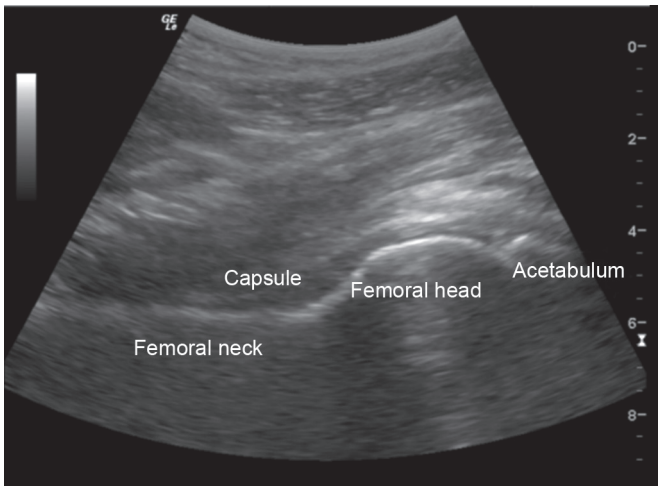


Fig. 1: Ultrasound image of hip

Given the large amount of expenditures associated with OA, it is beneficial to look for cost-effective methods for treatment. Several studies have looked at accuracy of different type of image-guided injections of the hip but have not compared their accuracy with cost. We performed this analysis to quantify the accuracy of ultrasound-guided hip injections *vs* injections assisted by other imaging regimens to further evaluate whether ultrasound is accurate for its cost.

METHODS

This study is an economic analysis of the cost and accuracy of different imaging modalities for native nontraumatic hip injections. A search of PubMed, EMBASE, and ClinicalTrials.gov was performed on November 5, 2012. Both PubMed and EMBASE were searched via MESH terms for intraarticular hip injections. The searches were limited to human studies and restricted to articles in English and Spanish. We included English and Spanish language studies that involve adult human subjects that discuss the accuracy of ultrasound-guided, fluoroscopic-guided, or CT-guided intraarticular injections of the native hip joint. Excluded studies were animal studies, patients that have received hip replacements, pediatric studies, patients with history of surgery in the joint, and patients with history of trauma. ClinicalTrials.gov was also searched and did not reveal any additional studies that would have been appropriate for inclusion. Compilation of all articles and removal of duplicates revealed a total of 653 articles.

After the collection of the literature, 581 articles were reviewed via title and abstract. Of these, 572 articles were excluded based on not having relevance with the study question. Two were excluded since they did not involve intraarticular injections. Six were excluded due to patient population involving postsurgical patients. One study was excluded due to involvement of patients with history of traumatic injury. A total of 72 articles were thus selected for more intensive review.

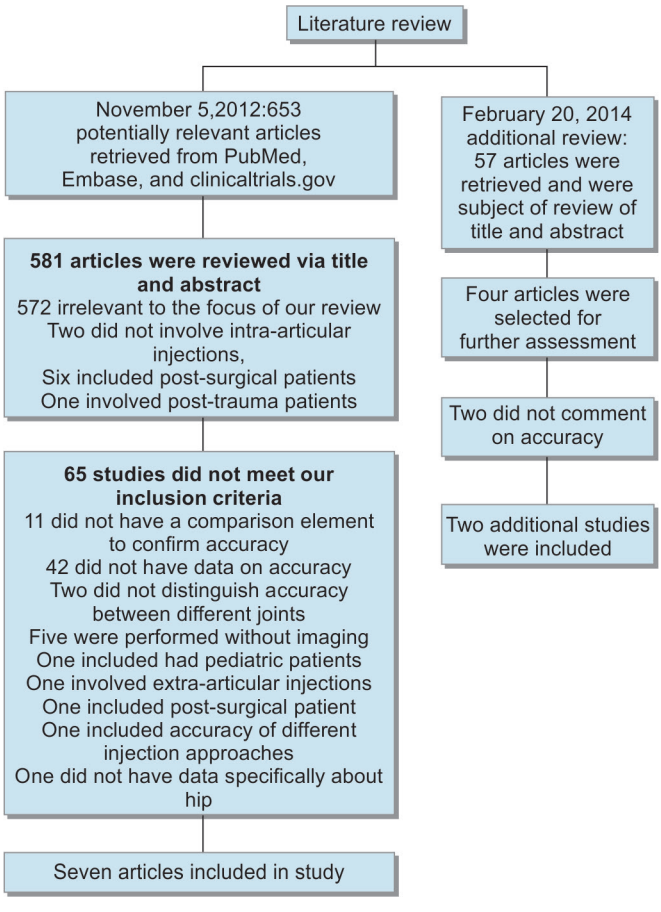
The remaining 72 articles were accessed and read to determine if inclusion/exclusion criteria were met. A total of 11 were excluded due to the fact that they did

not have a comparison element to confirm accuracy, 42 were excluded for not having data on accuracy, two were excluded because they did not distinguish accuracy between different joints, five were excluded because they were performed without imaging, one was excluded for being a pediatric study, one was excluded because it was extra-articular, one was excluded for not having data specifically about hips, one was excluded because it discussed the accuracy of different injection approaches, and one was excluded for including postsurgical patients. This allowed seven studies to be included in the analysis (Flow Chart 1). The seven articles were then subjected to a citation review to look for any further articles.

Prior to publication, a follow-up search of the literature was performed on February 20, 2014. A total of 57 new publications between November 5, 2012, and February 20, 2014, were discovered. Of those, four articles were fully reviewed to determine if they met inclusion/exclusion criteria. Two articles did not comment on accuracy of their injections and were excluded. The final two articles were included and added to the meta-analysis. The primary element of comparison of interest is that ultrasound-guided injections are equally as accurate as other diagnostic imaging modalities and come with less cost. From the articles, accuracy percentages, sample sizes, and a measure of the variation (standard deviation, standard error, or CIs) were extracted to perform a proportional meta-analysis. The study characteristics were grouped by pathology of the joint, type of procedure, image modality, and accurate injection definition. Injection accuracy rates were calculated via proportional meta-analysis.

For the economic analysis, data were obtained from the Centers for Medicare Services Physician Fee Schedule for the 2014 billing year.[19]

Flow Chart 1: Literature review



RESULTS

A total of nine studies were included in our analysis that met the inclusion criteria. Three of the studies used fluoroscopy as a confirmatory method. Two of the studies used contrast injection. One study used air injection and one study used CT confirmation. One study used visualization of the distension of the capsule on ultrasound and one study used cadaver dissection and visualization of colored latex injectate (Table 1).

Compared to gold standards of accurate injections (such as fluoroscopic and CT-guided injections), ultrasound is 97% accurate (CI 93%, 99%) (Flow Chart 1).

Costs of the procedure in US dollars were defined by costs reimbursed by 2014 Medicare (United States). For image-guided injections, the practitioner bills for the procedure and for the image guidance. Based on 2014 reimbursement data, reimbursement for large-joint intraarticular injection averages $61.99 (37.38£, 47.18€) ($49.20–$76.31). Fluoroscopic guidance technical reimbursement averages $77.73 (46.91£, 59.16€) ($63.69–$102.55) and professional reimbursement averages $28.78 (17.37£, 21.90€) ($25.09–$38.32). Thus, global reimbursement averages $105.32 (63.51£, 80.13€) ($76.75–$134.72). Ultrasound guidance technical reimbursement averages $41.21 (31.36£, 24.87€) ($27.61–$54.81) and professional reimbursement averages $34.71 (20.95£, 26.42€) ($30.34–$46.33). Thus, global reimbursement averages $75.99 (45.86£, 57.83€) ($57.95–$93.15).

DISCUSSION

As demonstrated, ultrasound-guided intraarticular hip injections offer an accurate procedure with less cost than fluoroscopic-guided hip injections. Since accuracy of ultrasound can be analyzed to be similar to other imaging modalities, this could shift the paradigm of injections from a hospital/specialist-based environment to an outpatient primary care environment. In an era of increasing concern for health care expenditures, finding an accurate, effective, and cost-friendly alternative has the potential for widespread adaptation and practice.

As with any meta-analysis, literature review can be affected by publication bias. To this effect, positive results are more likely to be submitted to and published by jour-

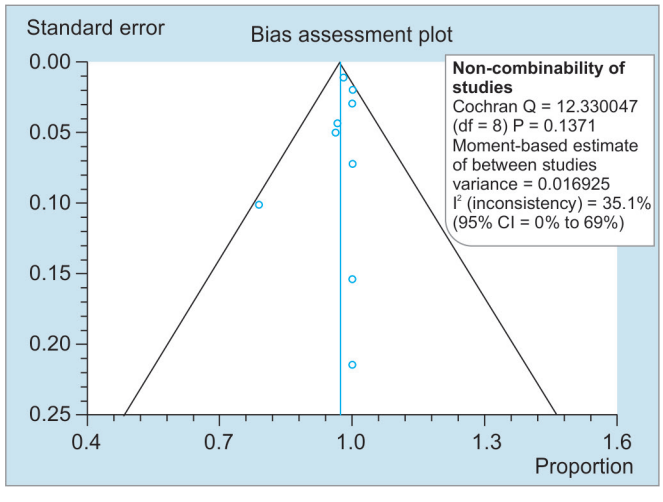
Table 1: Included studies and characteristics

Author	*Pathology of joint*	*Procedure type*	*Blinding*	*Accurate injection definition*	*Accurate #*	*Sample size*	*Ratio accuracy*
Atchia et al (2007)[20]	26 with known osteoarthritis; 14 for diagnostic anesthetic injections	Ultrasound guided	None	Radiologic localization of contrast 30 minutes after injection	25	26	0.962
Battle et al (2013)[21*]	Unknown cadaver hips; no trauma, deformities, surgeries, or intraarticular abnormalities	Ultrasound guided	Single blinded	Dissection and visualization of colored latex solution	15	19	0.79
Byrd et al (2014)[22**]	Distribution unclear but included femoral acetabular impingement, osteoarthritis, unexplained hip pain, postoperative hip pain	Ultrasound guided	None	Distention of joint capsule	202	206	0.981
Danko et al (2011)[23]	Osteoarthritis	Ultrasound guided	None	Fluoroscopic confirmation	2	2	1
Levi DS (2013)[24]	Unknown	Ultrasound guided with liner array transducer	Retrospec review	Assessment of injected contrast within the hip joint via fluoroscopic imaging	11	11	1
Micu et al (2010)[25]	Osteoarthritis	Ultrasound guided	None	Identification of needle tip-bone contact followed by millimetric retraction and distension of joint capsule	45	45	N/A
Pourbagher et al (2005)[26]	Osteoarthritis	Ultrasound guided	None	Computed tomography confirmation	30	30	2
Qvistgaard et al (2001)[27]	Osteoarthritis	Ultrasound guided	None	Air injection	4	4	1
Smith et al (2009)[2]	28 injections for osteoarthritis, 2 diagnostic hip injections	Ultrasound guided	None	Fluoroscopic confirmation	29	30	0.967

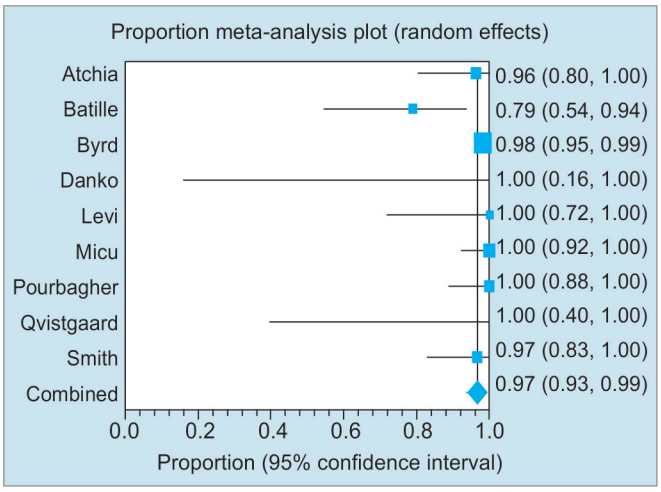
*Battle et al study commented on accuracy as "accurate" with no signs of latex observed outside the joint, "partially accurate" with some of the latex observed to have extravasated to the surrounding tissue, and "inaccurate" whereby none of the injectate entered the joint. The percentage of "accurate" injections was 79%. The percentage of "accurate" and "partially accurate" injections was 89.4%. The "inaccurate" injection percentage was 10.5%. Only the "accurate" injections were included in this study; **Byrd et al study commented on accuracy between first needle stick and second attempt. While all of the second attempt injections were successful, the data here include the accuracy of first attempt

nals than negative or equivocal results. Negative studies are more likely to be rejected because sample size may not have been adequate to establish true lack of association. In order to counter publication bias, we reviewed ClinicalTrials.gov to evaluate for any trials currently being undertaken that may have results that could skew the data. EMBASE also brings up abstracts presented at conferences that have not been published which can also limit publication bias. We also performed funnel plot of the meta-analysis to evaluate for any skew that could have publication bias as a contributing effect and the results were well distributed (Graphs 1 and 2). When there was variability in what could be determined as accurate (i.e., "accurate" *vs* "partially accurate" or number of punctures) the data included in the study were always the most conservative. For example, the Battle et al study commented on accuracy as "accurate" with no signs of latex observed outside the joint, "partially accurate" with some of the latex observed to have extravasated to the surrounding tissue, and "inaccurate" whereby none of the injectate entered the joint. Only the "accurate" injections were included in this study. The Byrd et al study commented on accuracy between first needle stick and second attempt. While all of the second attempt injections were successful, we only included data on the accuracy of first attempt.

A limitation to this analysis is that physician or institutional costs, including the expense of acquisition



Graph 1: Funnel plot for publication bias



Graph 2: Proportional meta-analysis evaluation of accuracy (random effects)

and maintenance of the ultrasound machine, image storage and sonographic supplies, and the increased operator setup and procedure time were not included in this analysis. These additional costs do not generally affect the cost to a third-party payer. Those expenses and time do affect the profit or loss for the proceduralist or institution. Important as well is that reimbursement rates vary from year to year and from country to country; thus, cost-effectiveness estimates will always be different in each country and state, and will always be changing.

SUMMARY

- Compared to gold standards of accurate injections (such as fluoroscopic and CT-guided injections), ultrasound is 97% as accurate (CI 93%, 99%).
- Fluoroscopic global reimbursement averages $105.32 (63.51£, 80.13€) ($76.75–$134.72). Ultrasound guidance global reimbursement averages $75.99 (45.86£, 57.83€) ($57.95–$93.15).
- Ultrasound-guided hip injections are an accurate technique for alleviating hip pain at less cost. In an era of increasing concern for health care expenditures, finding an accurate, effective, and cost-friendly alternative has the potential for widespread adaptation and practice.

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