Systematic Review

Is There a Role for Ultrasound in Hip Arthroscopy? A Systematic Review

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Purpose: The purpose of this study is to identify and summarize the current utility of intraoperative ultrasound (US) during hip arthroscopy. **Methods:** A systematic database query of the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Trials, EMBASE, PubMed (1980 to 2019), and Ovid MEDLINE (1980 to 2019) was performed. After article identification, descriptions of the surgical procedure, use of intraoperative US, procedural complications, and conclusions from each article were recorded and summarized. **Results:** Five studies met inclusion criteria, all of which were surgical techniques or technical notes. Four of the 5 studies described US used for placement of arthroscopic portals, and 1 described the use of an intraarticular US catheter for the assessment of an osteochondritis dissecans (OCD) lesion. Of the 4 studies using US for portal placement, 3 were performed supine and 1 was performed in the lateral decubitus position. All studies recognized the need for additional US training or the required assistance of a radiologist to incorporate US into a surgical practice. **Conclusion:** Descriptions of intraoperative US during hip arthroscopy are limited in the literature. However, existing technique reports demonstrate the feasibility of US for both portal placement with superficial probes and limited evaluation of cartilage using intraarticular US catheters. **Level of Evidence:** V, systematic review.

Hip arthroscopy is an increasingly common procedure used by surgeons for the treatment of intra-articular pathologies, with reports of a >25-fold increase since the early 2000s.[1] Common indications for surgery include symptomatic femoroacetabular impingement syndrome (FAIS), labral pathology, and other sources of hip pain including loose bodies, synovitis, and osteoarthritis.[2] Hip arthroscopy is a safe procedure with relatively low rates of major complications; however, it currently requires routine exposure to ionizing radiation in the form of intraoperative fluoroscopy.[1,3-8]

Currently, fluoroscopy is the standard method of verifying adequate distraction and resection for femoroacetabular impingement during osteoplasty.[3-5] Several studies have quantified the cumulative radiation dose for both patients and arthroscopists. Although research would suggest that exposure often falls below current recommended limits, additional efforts could be made to minimize exposure.[9,10] In addition, the physical impact of protective garments (lead aprons, etc.) merits consideration. The weight of these garments may create negative short-term (fatigue) and long-term (chronic injury) effects on the surgical workforce. Other

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nonionizing imaging modalities, such as ultrasound (US), have been commonly used for intraarticular injections of the hip, demonstrating comparable accuracy to fluoroscopic guided injections.[11] Ultrasound also provides the unique additional benefit of facilitating soft tissue visualization without the need of significant additional equipment and operating room personnel. However, the intraoperative utility of US during arthroscopy has not received equivalent attention.

The purpose of this review is to identify and summarize the current utility of intraoperative US during hip arthroscopy. It was hypothesized that identified studies would demonstrate the utility of US at multiple time points during the arthroscopic procedure, including establishment of portals and intraoperative guidance.

Methods

Study Design

This systematic review was performed based on guidelines described in the 2009 Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement (Fig 1). A systematic review of the literature was performed in July 2019 to identify all described utilities of US and sonography during hip arthroscopy. This review was registered with the PROSPERO International prospective register of systematic reviews (CRD42020142964). The systematic search included the following Boolean search terms: hip AND (arthroscopy OR arthroscopic) AND (ultrasound OR ultrasonography OR sonographic OR sonography). Search terms were used to query the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Trials, EMBASE, PubMed (1980 to 2019), and Ovid MEDLINE (1980 to 2019).

Article Inclusion Criteria

After compilation of all titles from the individual database queries, articles were systematically screened for inclusion by 2 independent reviewers (B.T.W. and A.V.). Articles were first screened for duplicates and non-English titles. Article titles were subsequently screened for relevance, including reference to hip arthroscopy and US or sonography. Vague or indeterminate titles were retained for abstract review. Abstract review included additional screening for relevance. Review articles, commentaries, and editorials were excluded. In addition, articles in which the primary outcome pertained to US-guided analgesia, injections, or nerve blocks, or those in which US was used for preoperative diagnosis or postoperative assessment, were also excluded. Articles remaining after abstract screening underwent full text review. To meet final inclusion criteria, articles had to describe hip arthroscopy with concurrent use of US or sonography. There were no exclusion criteria based on study design or level of evidence. The bibliographies of included articles were subsequently reviewed for additional articles that may have been missed in the scope of the initial search. All discrepancies in identified articles were resolved by consensus. A complete diagram of the search and screening process is illustrated in Fig 1.

Data Collection

Data extraction was completed by 2 independent reviewers (B.T.W. and A.V.) using a custom data extraction table.[12] Article information including title, first author, journal, country of origin, study design, and level of evidence were extracted and reported.[13] Additional study-specific information including number of subjects, demographic information, surgical details, and any outcome data were also noted. The primary focus of data extraction surrounded the description of the use of US during the arthroscopic procedure, including specific equipment, purpose of intraoperative US, training of the user, surgical complications, results of its use, and conclusions of the authors.

Data Analysis and Qualitative Synthesis

Given the descriptive nature of the data extracted, data analysis consisted of qualitative synthesis and reporting of results. Where possible, metrics across studies were reported as proportions and percentages. Because of the qualitative nature of the data, meta-analysis could not be performed.

Results

Study Selection

A total of 5 studies were identified for inclusion in the final analysis from the 1,345 initially screened.[14-18] All of the identified articles were technique articles or technical notes detailing descriptions of intraoperative US during hip arthroscopy. A PRISMA flow diagram, detailing study identification, screening (title, abstract, and full text), and inclusion is provided in Fig 1. Article details including author, journal, year of publication, and country of origin can be found in Table 1.

Described Surgical Techniques

Four of the 5 articles used US probes for the primary purpose of establishing hip arthroscopy portals,[14,16-18] and the remaining study used an intra-articular US catheter to evaluate the articular cartilage and navigate during retrograde drilling of an osteochondritis dissecans (OCD) lesion (Table 2).[15]

Arthroscopic Portal Placement

Four of the 5 articles used US probes for the primary purpose of establishing hip arthroscopy portals.[14,16-18]

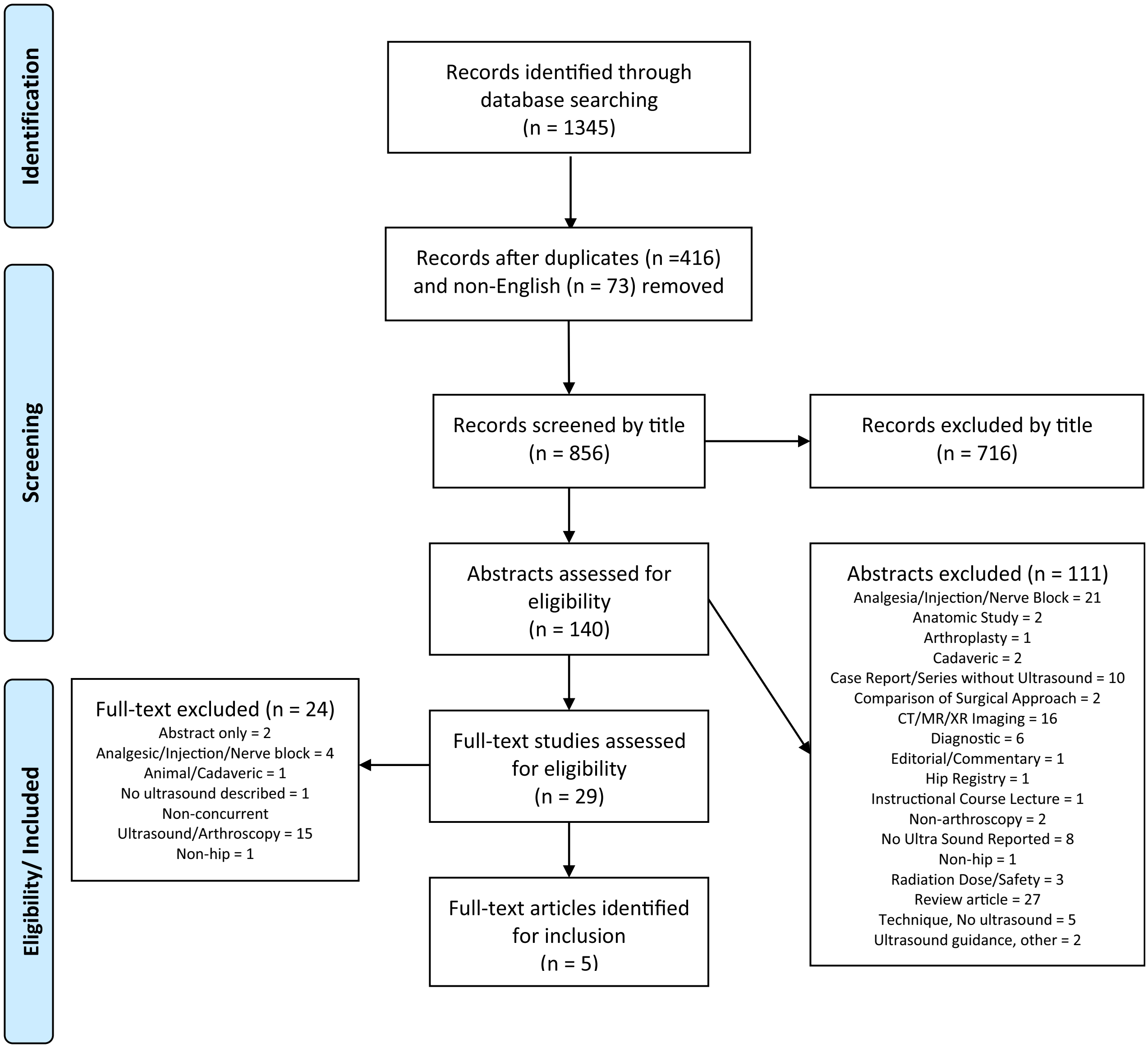

Figure. Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) flow chart of the study selection process.

Three of these articles performed arthroscopy in the supine position,[14,17,18] and 1 utilized the lateral decubitus position.[16] In 2 techniques, the first portal placed was the anterolateral portal,[14,16] and the remaining 2 techniques first placed the posterior trochanteric portal.[17,18] One study detailed specific sonographic signs used during portal placement. Weinrauch and Kermeci[18] describe the "light-saber sign," which is an artifact of the interface of the vacuum created within the hip capsule with distraction, the most superficial portion of which is targeted with a portal needle. All studies that used US for portal placement reported it to be easy, safe, precise, and reproducible.

Surgical Navigation

Two studies described utilities of US pertaining to assessments of specific procedures.[15,17] Joukainen et al.[15] described a patient with a hip OCD lesion resulting from Legg-Calvé-Perthes disease. In their report, a 2.8-mm US catheter (9 MHz) was introduced through an arthroscopic portal and slotted cannula, and guided via an arthroscopic hook probe. The US catheter was used to measure lesion depth and assess calcification, fluid beneath the lesion, and movement of the OCD fragment with probing. Qualitative parameters including decreased surface reflection, increased surface roughness, and backscattering can be used to identify the lesion. The US probe was also used to localize the 4.5-mm cannulated drill bit during drilling and assess depth of autologous iliac crest transplantation. Drilling was performed under fluoroscopic guidance.

Weinrauch and Kermeci[17] described a US-assisted arthroscopic proximal iliotibial band (ITB) release and trochanteric bursectomy. Ultrasonography was used to

Table 1. Study Characteristics and Demographics

First Author, Year	Title	Journal	Region of Origin	Study Design
Joukainen et al., 2017[15]	Ultrasound Arthroscopy of Hip in Treatment of Osteochondritis Dissecans	*Arthroscopy Techniques*	Europe	Technique
Keough et al., 2016[16]	Ultrasound-Guided Portal Placement for Hip Arthroscopy	*Arthroscopy Techniques*	North America	Technique
Weinrauch and Kermeci, 2014[18]	Ultrasound-Assisted Hip Arthroscopy	*Arthroscopy Techniques*	Australia	Technique
Weinrauch and Kermeci, 2013[17]	Ultrasonography-Assisted Arthroscopic Proximal Iliotibial Band Release and Trochanteric Bursectomy	*Arthroscopy Techniques*	Australia	Technique
Hua et al., 2009[14]	Ultrasound-Guided Establishment of Hip Arthroscopy Portals	*Arthroscopy*	Asia	Technical Note

confirm the position of the greater trochanter and the thickening of the ITB. US assistance was used to confirm the proximal ITB release and sufficient decompression.

Learning Curve and Complications

All techniques commented on the need for specialized training or assistance in performing US-guided hip arthroscopy procedures. Four of the 5 articles recommended specific US training before implementation,[15-18] and in the fifth technique, a radiologist operated the US machine and interpreted images.[14]

Two studies reported on rates of complications. In a series of 18 cases, Hua et al.[14] reported 1 labral and 3 chondral injuries confirmed by arthroscopic visualization. All injuries occurred during the first 5 cases of the series. The single labral and 2 chondral injuries occurred during placement of the first portal, and the remaining chondral injury occurred during placement of the second portal. There were no nerve or vessel complications reported. Weinrauch and Kermeci[18] did not report specific complications; however, they did report an institutional complication rate <1% to 2%.

Discussion

The most important finding of this study is that US for specific aspects of hip arthroscopy was consistently described as an easy, safe, precise, and reproducible replacement for fluoroscopy. Ultrasound was most frequently used for establishing arthroscopic portals, but also demonstrated intraarticular utility in the assessment of cartilage surfaces with an US catheter. Of note, no studies used US for assessing adequacy of resection of femoro- or acetabuloplasty intraoperatively.

If feasible, the minimization of fluoroscopy and increased utilization of US offers a range of advantages including soft tissue visualization; removal of large and cumbersome fluoroscopy equipment from the field; reduction of radiation exposure to the patient, surgeon, and operating room staff; and elimination of heavy protective garments. The most commonly reported use of intraoperative US was the placement of arthroscopic portals. Successful placement was reported for both supine and lateral positioning, as well as placement of anterolateral and posterior trochanteric portals.[14,16-18] The most specific instructional information reported was a description of the light-saber sign. Weinrauch and Kermeci[18] named this artifact based on the US appearance of the interface of the vacuum created within the hip capsule when distracted. They subsequently described that the most superficial portion of the light-saber sign is the target of the portal needle.

Although the conclusions are limited by the number of available articles, there was a reported learning curve associated with the use of US for portal placement. Weinrauch and Kermeci[18] reported concurrent use of US and fluoroscopy for the first 30 cases, after which fluoroscopy was rarely used. The learning curve was also reflected in reporting of complications. Hua et al.[14] reported 1 labral and 3 chondral injuries, all of which occurred in the first 5 of an 18-patient series, suggesting that with increased training and experience, US guidance becomes a safer, easier, and more reproducible method of portal placement.

The included articles uniformly identified the same limitations of US and its implementation for hip arthroscopy. The first limitation was the technical proficiency required, which was addressed with US-specific training for the surgeon or intraoperative collaboration with a radiologist.[14-18] The remaining hurdles are largely limitations of the technology itself. In using US for portals, all relevant studies recognize the importance of choosing the appropriate probe with sufficient penetration depth (8 to 10 cm) and acknowledge the difficulty in visualization with obese patients, in which the soft tissue envelope can be >10 cm.[14,16-18] Other reported obstacles to visualization include heterotopic ossification,[16] effusion,[18] and hematoma that may result from multiple failed introduction attempts.[14]

Lastly, the articles identified other areas in which intraoperative US is currently limited. Most notably, the current inability of US to assess adequacy and safety of resection, including femoro- and acetabuloplasty, potentially leaves a significant role for intraoperative fluoroscopy. Limited research indicates that some measures of resections can be assessed postoperatively using US.[19] To supplant intraoperative fluoroscopy,

Table 2. Surgical Techniques, Complications, and Conclusions

First Author, Year	Patients/ Cases (n)	Device Used	Ultrasound purpose	Radiologist/ Surgeon Performed	Complications	Results/Conclusion
Joukainen et al., 2017[15]	1	Flexible ultrasound catheter (center frequency, 9 MHz; diameter, 2.8 mm)	Assessment of cartilage surfaces (femoral head and acetabulum)	Not reported	None reported	UA allows for intraoperative evaluation of cartilage, including OCD lesions
Keough et al., 2016[16]	0	Terason Ultrasound machine, curved abdominal probe	Arthroscopic portal placement	Surgeon	None reported	Hip arthroscopy portal placement under ultrasound guidance is safe and reproducible
Weinrauch and Kermeci, 2014[18]	>30	LOGIQe ultrasound machine, 4C-RS 2.0- to 5.5-MHz transducer	Arthroscopic portal placement	Surgeon	Iatrogenic labral or femoral head injury rate: < 1% to 2%	Ultrasound guidance for placement of arthroscopic portals is a relatively easy technique recommended to surgeons who perform hip arthroscopy on a regular basis
Weinrauch and Kermeci, 2013[17]	1	Not reported	Arthroscopic portal placement, assessment of adequate decompression of the iliotibial band/ peritrochanteric space	Not reported	None reported	Intraoperative ultrasonography is relatively easy to conduct and allows accurate placement of portals and verification of sufficient decompression of the ITB
Hua et al., 2009[14]	18	Aloka Prosound SSD-4000 ultrasound; low-frequency (3- to 5-MHz) convex array transducer unit	Arthroscopic portal placement	Radiologist	No nerve or vessel injury; 1 labral injury, 3 chondral injuries	Ultrasound guidance is a safe and precise method to establish hip arthroscopy portals

ITB, iliotibial band; OCD, osteochondritis dissecans; UA, ultrasound arthroscopy.

however, intraoperative viability would need to be demonstrated. Keough et al.[16] contend that high-quality preoperative imaging minimizes this limitation, and fluoroscopy can always be made available if needed. Before attempts to displace fluoroscopy can occur, the comprehensive utility of intraoperative US must be further established.

Limitations

The authors acknowledge limitations to the present study. Foremost, the small number of articles meeting inclusion criteria combined with the level of evidence limit the conclusions that can be drawn based on this systematic review. The number of studies meeting inclusion criteria is evidence of the infancy of this field and highlights the opportunity for future investigation. A thorough, methodical review of available databases was performed by 2 independent and blinded reviewers to minimize the risk of omitting relevant studies. Although significant conclusions regarding surgical and patient outcomes cannot be drawn, the included articles indicate the feasibility of ultrasound use for portal placement.

Conclusion

Descriptions of intraoperative US during hip arthroscopy are limited within the literature. However, existing technique reports demonstrate the feasibility of US for both portal placement using superficial probes and limited evaluation of cartilage using intraarticular US catheters.

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