Ultrasound Arthroscopy of Hip in Treatment of Osteochondritis Dissecans

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Abstract: An ultrasound arthroscopy (UA) technique is a promising tool for the evaluation of the articular cartilage during arthroscopic examination. However, the applicability of UA for the evaluation of the hip joint is unknown. We describe a UA assessment of a patient with osteochondritis dissecans at the femoral head. An ultrasound catheter designed for intravascular imaging was inserted into the hip joint by use of conventional arthroscopic portals, and the cartilage surfaces of the femoral head and acetabulum were investigated with ultrasound. UA provided essential quantitative information on the integrity of the articular cartilage and the condition of the subchondral plate not assessable with conventional arthroscopy. Furthermore, the UA technique provided the possibility to monitor arthroscopy-assisted retrograde drilling and bone transplantation in the hip joint.

Osteochondritis dissecans (OCD), a separation of an osteochondral segment from the surrounding articular surface, is known to occur in the hip joint. The treatment of hip OCD is recommended to be addressed on a case-by-case basis, with the mechanical symptoms and stability of the OCD lesion being taken into account.[1-3] Surgical repair techniques for the treatment of hip OCD include excision of the OCD fragments, microfracturing, autologous chondrocyte transplantation, fresh osteochondral transplantation, and screw fixation.[4-8] A recent article described a technique of osteochondral autograft transplantation to repair a hip OCD lesion.[9] To select the optimal treatment method, accurate assessment of the OCD lesion and adjacent tissues is needed. Radiographic images, magnetic resonance imaging (MRI), and arthroscopic evaluation have been used to grade the OCD lesion and evaluate the integrity of adjacent cartilage.[6] However, these methods may not be optimal for accurate evaluation of cartilage integrity. Cartilage is not visible on radiographs, and the limited resolution of clinical MRI hinders the evaluation of small cartilage lesions. Furthermore, the arthroscopic evaluation of articulating surfaces is highly subjective, and in a recent study the reproducibility of arthroscopic assessment of knee articular cartilage lesions was reported to be poor.[10] Thus objective and accurate imaging techniques are needed for reliable assessment of articular cartilage and subchondral bone.

To overcome the limitations of current clinical diagnostic methods, an ultrasound arthroscopy (UA) technique was recently introduced for objective assessment of the knee and shoulder joints.[11,12] Ultrasound imaging enables evaluation of the integrity of the cartilage surface, subsurface structures, and subchondral bone, as well as accurate measurement of cartilage thickness and depth of cartilage lesions.[13,14] In addition, quantitative ultrasound parameters reflecting the integrity of the articular cartilage can be determined.[13] A UA technique has already been applied for guiding the retrograde drilling and bone transplantation of an OCD lesion in the knee joint.[15] However, the feasibility of the method in the

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hip joint is unknown. We describe a UA technique to assist the treatment of a hip OCD.

Surgical Technique

Preoperative Planning

A patient with hip OCD caused by Legg-Calvé-Perthes disease may be indicated for hip UA. The hip OCD patient may have a long history of hip complaints, which are aggravated with physical activity. Mechanical locking of the hip and anterior groin pain are common symptoms. Hip OCD may be found on radiographic imaging and MRI in a patient with Legg-Calvé-Perthes disease. During the clinical examination, the range of motion of the hip is examined and pain-aggravating tests are conducted. Typically, hip rotation and extreme positions may be painful, and snapping of the hip may be found during rotational movements.

Pelvic radiographs and a cross-lateral projection of the hip, as well as pelvic MRI, are useful for preoperative planning of the surgical procedure. The appropriately indicated patient for hip UA has an OCD lesion in the area that is reachable with hip arthroscopy instruments and an ultrasound catheter (a flexible catheter with thickness of 2.8 mm), typically near the fovea of the femoral head. If retrograde drilling or fixation of the hip OCD fragment is considered feasible, the decision to perform hip UA is made, and the surgeon needs to reserve the appropriate staff and equipment for the operation. Several arthroscopic, radiologic, and surgical techniques are used in the procedure. Advanced hip arthroscopy skills such as fluent shaver, burr, and radiofrequency device use, as well as skills to use several hip arthroscopy portals for visualization of the joint thoroughly, are necessary. Staff with experience in the use of the ultrasound imaging device and interpretation of ultrasound images is essential for a successful operation. A fluoroscope, as well as a technician experienced in using the device, is needed not only for the hip arthroscopy but also for the retrograde drilling and bone transplantation of the OCD.

Positioning, Anesthesia, and Setup

Typically, hip arthroscopy is performed with the patient under spinal anesthesia in a supine, slight Trendelenburg position. By use of a large inguinal post and a well-padded distraction device (Smith & Nephew, Andover, MA), 15° of abduction, 10° of flexion, and internal rotation of the operative hip are applied. The contralateral leg is placed in countertraction and is abducted to 45° to allow the fluoroscope arm to be placed between the legs. The standard hip arthroscopy portal areas and the ipsilateral iliac crest for the bone autograft are prepared in a sterile manner. An arthroscopy pump (Arthrex, Naples, FL) with continuous saline solution infusion and a 70° 4-mm arthroscope (Karl Storz, Tuttlingen, Germany), as well as intraoperative fluoroscopy, are used for the procedure. The arthroscope, fluoroscope, and ultrasound device imaging monitors are positioned so that they can be readily visualized by the surgeon during the procedure.

Surgical Technique of Hip UA, Retrograde Drilling, and Bone Transplantation

After sterile preparation and draping, the operative limb is distracted and visualized with the C-arm, and the hip joint is vented with a needle to release the vacuum seal and distract the joint without extensive force. The initial anterolateral hip arthroscopy portal is created with the assistance of fluoroscopy, after which the secondary anterior portal is created by use of arthroscopic guidance. Any other hip arthroscopy portals may be used, if necessary, for visualization. Interportal capsulotomy is performed with a banana knife (Arthrex) to enable free instrument movement intra-articularly. Arthroscopic evaluation of the intra-articular hip joint structures (joint cartilage, ligamentum teres, fovea, labrum) and the OCD lesion is performed with the arthroscope and UA. The UA technique has been described in more detail in previous studies.[11,14] In brief, a sterile flexible ultrasound catheter (center frequency, 9 MHz; diameter, 2.8 mm; Boston Scientific, Marlborough, MA) originally designed for intravascular imaging is used during arthroscopy to evaluate the extent of the cartilage injuries and to guide the retrograde drilling. Before the surgical procedure, an ultrasound catheter is prepared by injecting sterile saline solution into its tip. During the arthroscopic surgical procedure, the surgeon inserts the ultrasound catheter into the hip joint using an arthroscopic portal (Fig 1), sliding it into the joint through a slotted cannula.[16] The ultrasound probe is maneuvered into the areas of interest under arthroscopic control with the help of an arthroscopic hook probe by use of the same portal or another applicable portal to guide the probe.

The integrity of the articulating surfaces and the state of the OCD lesion are evaluated by use of ultrasound, hook probing, and arthroscopic images (Fig 2, Video 1). On the basis of the ultrasound image, the depth of the lesion is estimated (Fig 2). The ultrasound measurement of lesion depth is compared with the measurement based on MRI (Fig 1). Furthermore, calcification within the OCD lesion, the existence of fluid beneath the OCD lesion, and movement of the OCD fragment could be evaluated on ultrasound or arthroscopic views, when probed with a hook (Figs 1 and 2). On the basis of the ultrasound, hook probing, and arthroscopic investigation, the OCD lesion severity is graded.[17] In addition, the intact surfaces of the cartilage, as well as subchondral bone in the acetabulum, are visible on

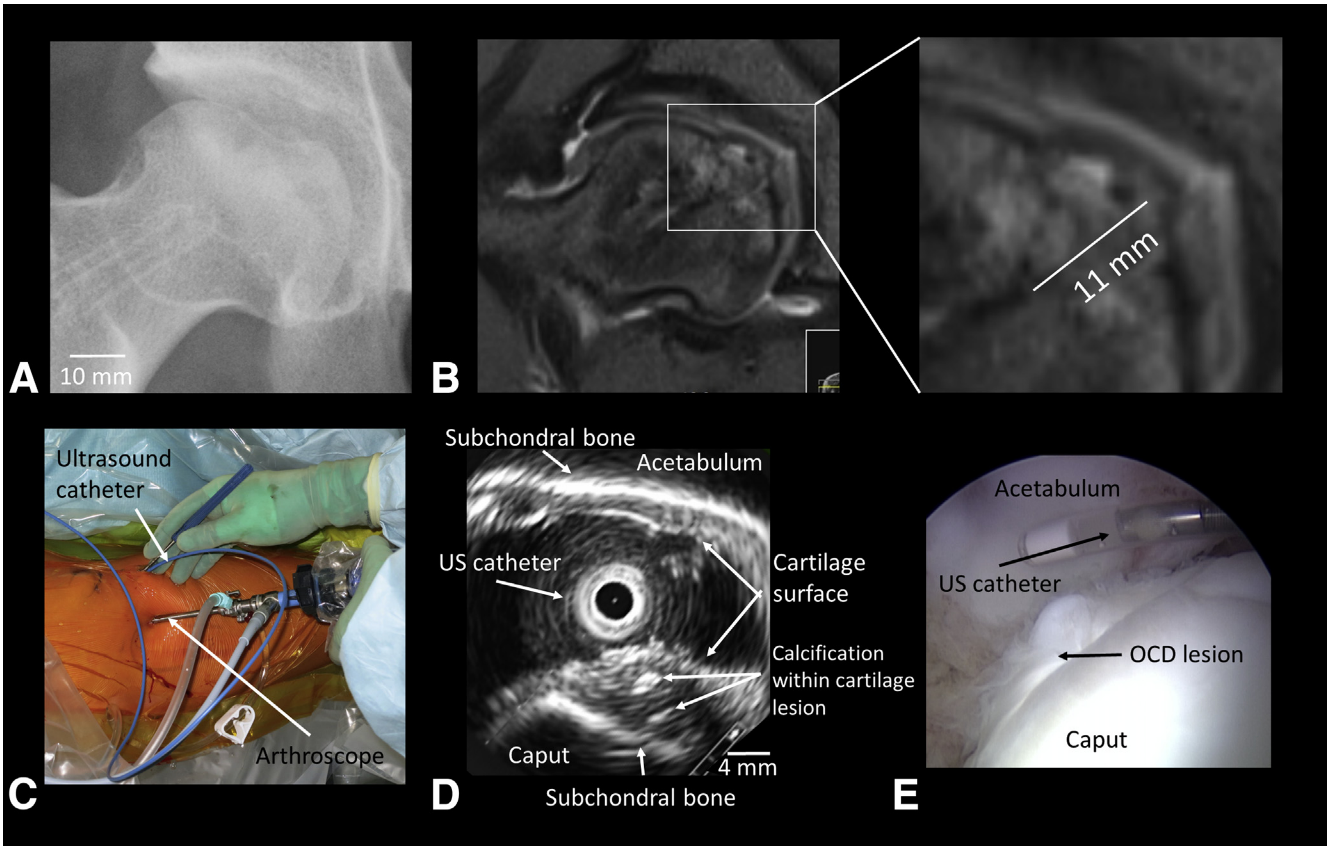

Fig 1. (A) Plain radiographic image of right proximal femur (posterior-anterior direction). (B) Magnetic resonance image of right proximal femur (proton density, coronal plane) with site of osteochondritis dissecans (OCD) lesion magnified. (C) Anterior and anterolateral arthroscopic portals used to conduct ultrasound arthroscopy. (D) Representative ultrasound image of OCD lesion in coronal plane (ultrasound [US] catheter in anterior portal). (E) Arthroscopic view of OCD lesion (arthroscope in anterolateral portal). Ultrasound (US) imaging provided highly detailed information on the OCD lesion. The real-time evaluation of the extent of the lesion, as well as the assessment of the cartilage inner structures and subchondral bone, was possible.

ultrasound images (Fig 2). Quantitative ultrasound parameters show a decrease in the surface reflection, increase in surface roughness, and increase in back-scattering from the cartilage inner structures for an OCD lesion as compared with intact cartilage in the acetabulum (Fig 2). Finally, ultrasound may be used to localize the 4.5-mm cannulated drill bit beneath the cartilage surface during retrograde drilling and bone transplantation, highlighting the potential of ultra-sound guidance of repair surgery for hip OCD lesions (Fig 3). For drilling, the hip arthroscope is usually in the anterolateral portal, and the anterior portal is used for the anterior cruciate ligament guide (Smith & Nephew, London, UK), which is aiming at the OCD fragment.[4] An additional skin incision is made in the inferior part of the greater trochanter, and a guide pin is drilled just beneath the joint cartilage. The approaching pin is monitored with the fluoroscope and US imaging before it penetrates the cartilage layer. Depending on the size of the OCD fragment, more guide pins can be used to reach the OCD fragment. Subsequently, the guide pins are drilled over with a 4.5-mm cannulated drill just beneath the cartilage, and the OCD fragment is treated with autologous transplants from the iliac crest packed into the drill channel. The bone transplantation and implantation depth may be evaluated with UA. Pearls, tips, and pitfalls of the UA technique are summarized in Table 1.

Postoperative Treatment

The patient is allowed partial weight bearing postoperatively for 4 weeks. Passive range-of-motion exercise is initiated when not painful, under the supervision of a physiotherapist. Starting in week 4, weight bearing is gradually increased, and full weight bearing is allowed at 6 weeks after surgery.

Discussion

The UA technique is mainly used to verify the diag-nosis made based on plain radiographs, MRI, and arthroscopic evaluation of the hip joint. However, UA investigation has been found to provide clinically rele-vant quantitative information on the severity and extent of the OCD lesion, as well as the integrity of the

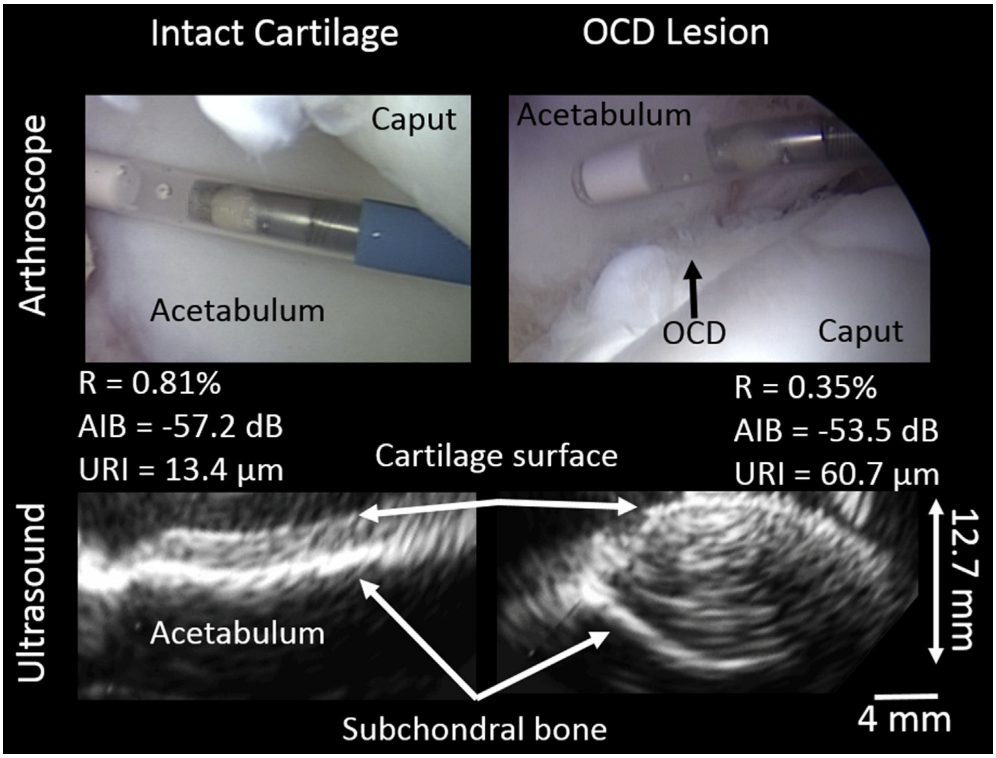

Fig 2. Arthroscopic and ultrasound images of intact cartilage in acetabulum (ultrasound catheter in anterolateral portal) and osteochondritis dissecans (OCD) lesion in femoral caput (ultrasound catheter in anterior portal). The ultrasound catheter and arthroscope were inserted into the hip by use of the anterior and anterolateral portals. Measurement of OCD lesion depth, as well as evaluation of the integrity of the cartilage inner structures and subchondral bone, was possible with the arthroscopic ultrasound technique. Furthermore, the calculation of quantitative parameters reflecting the status of the cartilage layer was possible. The quantitative ultrasound parameters are shown above the ultrasound images. (AIB, apparent integrated backscattering; R, reflection coefficient; URI, ultrasound roughness index.)

articular cartilage adjacent to the lesion. Similarly, as in previous studies in which the UA technique has been applied in human knee and shoulder joints, ultrasound evaluation of the articular cartilage was found to be clinically feasible.[12,14] Furthermore, visualization of the cartilage inner structures and subchondral bone and determination of quantitative ultrasound parameters reflecting the status of the articular cartilage, as well

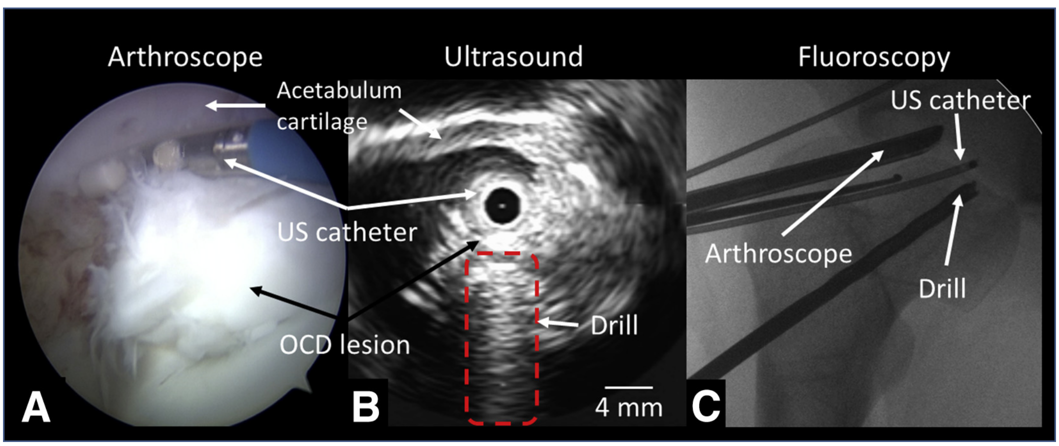

Fig 3. Retrograde drilling of a right hip osteochondritis dissecans (OCD) lesion was possible under arthroscopic ultrasound guidance. (A) Arthroscopic view of OCD lesion from anterolateral portal. (B) Ultrasound image of OCD lesion in coronal plane, showing drill underneath cartilage surface (dashed red box). The ultrasound (US) catheter was inserted into the joint from the anterior portal. (C) Fluoroscopic image of hip (posterior-anterior direction) showing ultrasound (US) catheter, arthroscope, and drill.

Table 1. Pearls, Tips, and Pitfalls

Pearls
A large capsulotomy enhances the mobility of the US catheter.
The catheter may be guided with a slotted cannula and arthroscopic hook.
Accurate imaging of OCD and monitoring of retrograde drilling are possible with UA.
Pitfalls
The tip of the US catheter requires delicate handling.
Experience in performing US imaging is needed for correct interpretation of US images.

OCD, osteochondritis dissecans; UA, ultrasound arthroscopy; US, ultrasound.

as measurement of cartilage thickness, were found to be straightforward during a routine arthroscopic examination of the hip joint. Because ultrasound imaging can be conducted in real time during the arthroscopic surgical procedure, the technique might be a valuable tool aiding in the selection of the optimal repair technique based on the status of the joint at the time of surgery. Finally, because the technique is based on the use of a thin, flexible catheter, the investigation of narrow joint spaces, not easily accessed with an arthroscope, is possible.

Fluoroscopic imaging is typically used to guide the retrograde drilling of OCD lesions. However, because the technique only enables visualization of the position of the drill relative to the bone structures on 2-dimensional projection images, accurate determination of the drill position can be challenging. Furthermore, fluoroscopic imaging exposes the patient and surgical personnel to ionizing radiation. Thus, especially when young patients are being treated, alternative nonionizing imaging techniques enabling real-time monitoring of the retrograde drilling would be highly valuable. Although the retrograde drilling was conducted under fluoroscopic guidance, the drill could be localized underneath the cartilage surface with ultrasound, enabling precise determination of the drill position and optimization of the drilling depth. Similar results have been reported in a previous study in which ultrasound enabled monitoring of retrograde drilling and bone transplantation in the knee joint.[15] However, further optimization of the ultrasound probe is needed before retrograde drilling can be routinely conducted under UA control.

Table 2. Advantages and Disadvantages

Advantages
High-resolution images from inner structures of articular cartilage and subchondral bone
Real-time imaging
No ionizing radiation
Quantitative assessment of articular cartilage and subchondral bone
Disadvantages
Technique not optimized for musculoskeletal imaging
Fragile catheters
Limited imaging depth
Steep learning curve
Additional costs

Because the applied ultrasound technique was developed for intravascular imaging, there are several limitations that need to be taken into account when the method is used during arthroscopic surgery. First, to produce high-quality ultrasound images and reliable quantitative measurements, the position of the ultrasound catheter needs to be accurately controlled. Because the catheter is designed to be flexible, additional tools such as arthroscopic hook probe are needed to guide the catheter inside the joint. However, incautious handling may easily damage the catheter. Second, the imaging depth of the high-frequency ultrasound catheter is limited. Thus degeneration of the subchondral bone can be assessed only near the cartilage-bone interface. Furthermore, monitoring of the position of the drill is possible only relatively near the cartilage-bone interface, and thus extra caution is needed when ultrasound is used for monitoring the retrograde drilling. Because of the limitations of the technique, the learning curve for reliable and successful UA investigation tends to be steep. The advantages and disadvantages of the presented UA technique are summarized in Table 2.

In conclusion, we found hip UA to be a feasible technique for intraoperative evaluation of the severity and extent of the OCD lesion, as well as evaluation of the integrity of the adjacent tissues. Furthermore, ultrasound guidance of retrograde drilling was possible. Ultrasound provided information on the location of the drill beneath the cartilage surface and, thus, enhanced aiming regarding the precise location of subchondral drilling. The UA technique will allow additional possibilities for precise treatment in some hip OCD cases. However, further patient series are needed to confirm the applicability of this promising technique.

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