Technical Note

Application of Intraoperative CT-Ultrasound Fusion Imaging in Hip Endoscopy for Treatment of Iatrogenic Impingement Due to PLLA Screw: A Novel Surgical Technique

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Abstract: Ultrasound-assisted surgery is becoming an established tool in the medical field. The addition of imagery to ultrasound-assisted surgery may enable one to perform a procedure in a safer and more accurate manner. This can be achieved through fusion imaging (fusion), a technology that synchronizes MRI or CT images with ultrasound images. We describe intraoperative CT-ultrasound fusion-guided (or -assisted) hip endoscopy for the removal of an impinging poly L-lactic acid screw, which was difficult to identify on fluoroscopy during surgery. The fusion technology enables merging two advantages of ultrasound: the real-time guidance capabilities and CT or MRI and the bird's eye view that makes minimally invasive arthroscopic and endoscopic surgery less invasive, precise, and safe.

Introduction

Arthroscopy of the hip is a commonly performed procedure, whereas extra-articular endoscopy of the hip is less common. Recently, there has been a gradual increase in the reported cases of endoscopic surgery in hip disorders, such as greater trochanteric bursitis,[1] gluteus medius and minimus tears,[2] external snapping hip,[3] sciatic nerve entrapment, and deep gluteal syndrome.[4] Unlike the arthroscopic surgery, extra-articular endoscopy can only use few anatomical landmarks for the surgical treatment. This prevents performing safe and accurate surgery, especially in less experienced physicians. Fluoroscopy can be used to identify landmarks; however, it is not possible to visualize soft tissues and their depth. Therefore, ultrasonography has attracted considerable attention in recent years.

Ultrasound-assisted surgery is becoming more popular because it is safe and less invasive.[5] However, the disadvantage of ultrasound guidance is a narrow field of view, since only the area where the transducer hits the tissue can be visualized. Fusion imaging (Fusion) can compensate for the shortcomings of such ultrasound guidance. It is possible to perform even more accurate and safe surgery. This technology synchronizes magnetic resonance imaging (MRI) or computerized tomography (CT) images by using ultrasound images.[6] Fusion imaging is becoming established in the field of internal medicine and is being used for liver cancer biopsies.[7] The MRI/CT image is inferior to the ultrasound image in terms of image quality resolution capabilities. However, it is easier to grasp the whole picture. Ultrasound images, in contrast, have a higher resolution than MRI but can only detect a small area. Therefore, a risk of missing important findings exists. Although fusion has not yet been extensively used in orthopedics, it is attracting attention as a new technology that can compensate for these shortcomings.

Surgical Technique (Video)

Preoperative Assessment

The beginning of patient evaluation should begin with a past surgical history, assessing the timeline and

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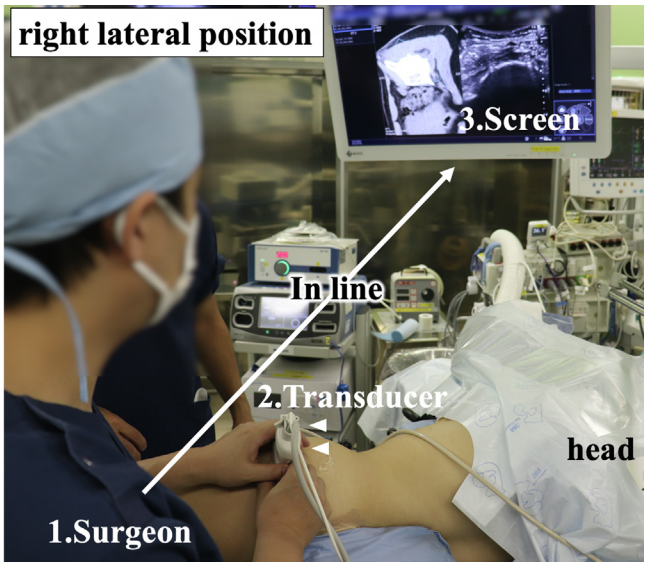

Fig 1. Prescanning. Before scanning, location of the poly L-lactic acid (PLLA) screw is confirmed the by ultrasonography. Having the ultrasound screen (3) in direct line with the surgeon (1) and transducer (2) will facilitate an easier surgery by allowing visualization of all of these components without having to avert gaze away from the transducer (in line position).

progression of the pain after surgery. Physical examination is important to evaluate surgical candidates. The patient reports experiencing residual pain in the anterior and lateral aspects of the hip joint. Intra-articular injection is administered for diagnosis, and we should confirm that the procedure fails to improve the condition of the patient. The tenderness and manual muscle testing of hip abductor muscle help in diagnosis.

On CT, there are some protrusions of the unfired and unsintered hydroxyapatite/poly L-lactic acid (PLLA) screw used in the previous surgery (R.A.O.). To relieve the symptoms, 2 mL of local anesthesia are injected near the screws under ultrasound guidance. As pain on weight bearing improve 3 hours after injection, the patient is diagnosed with iatrogenic impingement between the gluteus minimus muscle and the PLLA screw. Therefore, endoscopic surgery is planned to remove the screw.

Preparation of Fusion Images

CT images are taken with 0.5-mm slices, as the lower slice thickness of the CT images translates into fusion images of better quality. Fusion imaging is performed by using an APLIO i700 ultrasound system (Canon Medical Systems, Otawara, Japan). The CT image data are saved as DICOM data and are imported into the ultrasound system. The main hardware of the system includes a magnetic field generator and a sensing line, with the end of the sensing line attached to a 1−8 MHz convex array probe. The magnetic sensor is positioned on the opposite side of the surgeon. The effective distance between the transmitter and magnetic sensor is 20-60 cm. If the distance from the transmitter to the magnetic sensor is within this range, the puncture site can be accurately localized. We do not place any obstacles between the convex array probe and the magnetic sensor. The main software packages use included in Smart Fusion and smart three-dimensional sensors.

First, prescanning is performed, and after the femoral head is visualized in the short axis, the transducer is moved proximally, and the acetabulum is visualized (Fig 1). Having the ultrasound screen in direct line with the surgeon and transducer will facilitate an easier surgery by allowing visualization of all of these components without having to avert your gaze away from the transducer. The transducer is then moved laterally to render the gluteus minimus and identify the three PLLA screws just below the gluteus minimus. The CT image is fixed at the position where the three PLLA screws appeared. CT-US fusion is performed by synchronizing CT and ultrasonography at the middle screw (Fig 2).

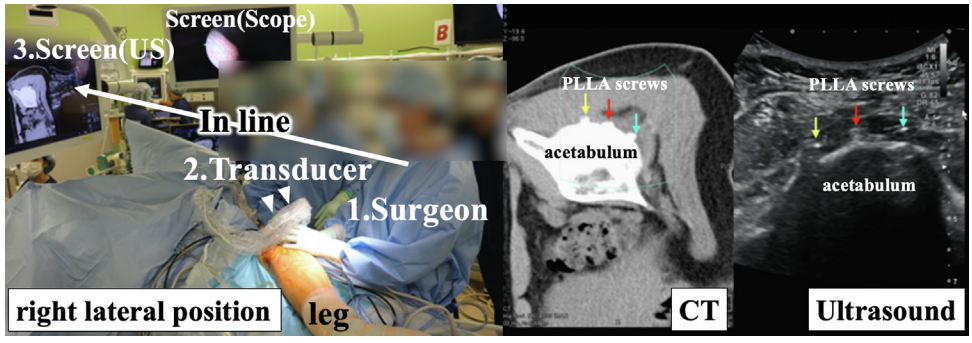

Fig 2. Computed-ultrasound fusion before surgery (in line position). The areas where the three screws are simultaneously visible were rendered, and the images are synchronized. This enables us to immediately distinguish which area we are looking at with ultrasound, even if we are to lose sight of the other screws.

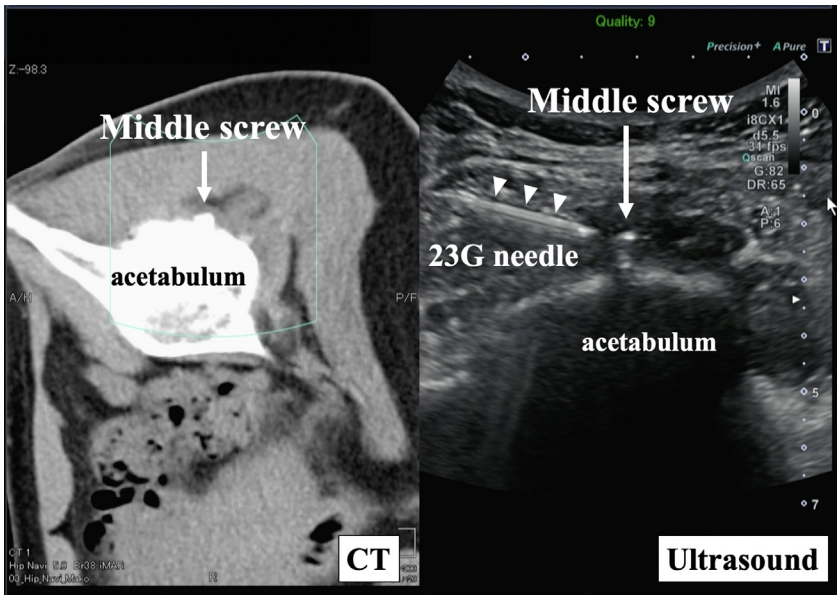

Fig 3. Bleeding control by lidocaine with epinephrine. A 23 G Cathelin needle is inserted just above the middle screw under ultrasound guidance. Lidocaine with epinephrine is injected to arrest bleeding and secure the visual field.

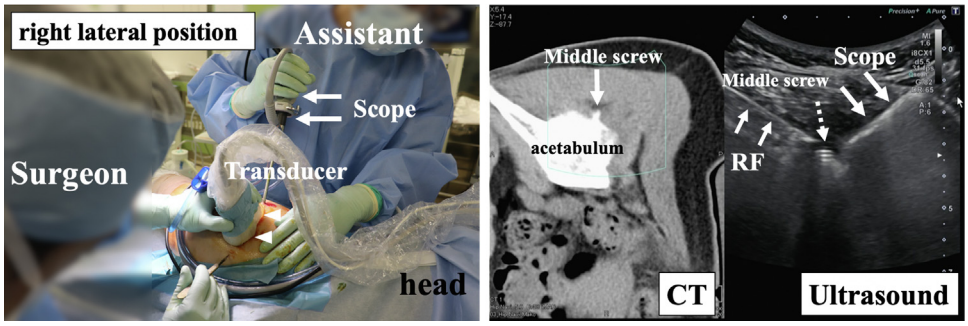

Fig 4. Surgical technique of making a portal. Fusion-assisted guidance of the arthroscope tip and radio frequency tip over the head of the poly L-lactic acid (PLLA) screw.

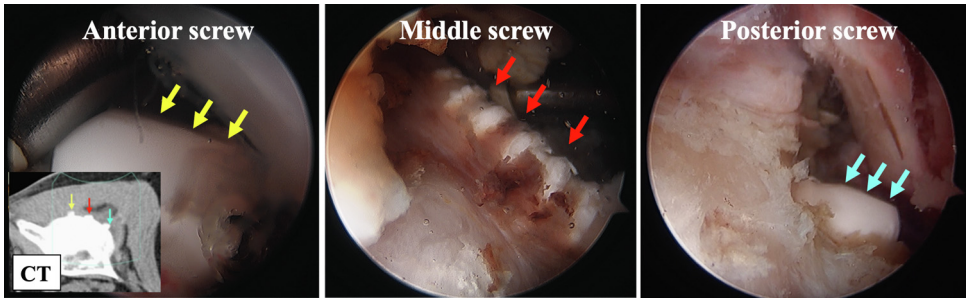

Fig 5. Identification of the poly L-lactic acid (PLLA) screws. Extra-articular endoscopy revealed three PLLA screws; the middle screw had an exposed body part and was unstable.

Operative Technique

After confirming that the CT and ultrasound images were synchronized, 10 mL of lidocaine with epinephrine is injected into the outer layers and subcutaneously in the middle screws, anteriorly. The purpose is to create space and stop the bleeding (Fig 3). A 1-cm skin incision is made anteriorly, a pean is used to create a path to the middle screw, and the arthroscope is

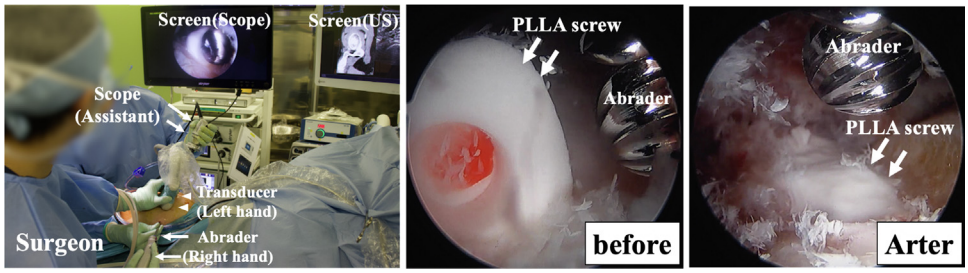

Fig 6. Shaving poly L-lactic acid (PLLA) screws. An abrader was inserted, and the screw head was eroded.

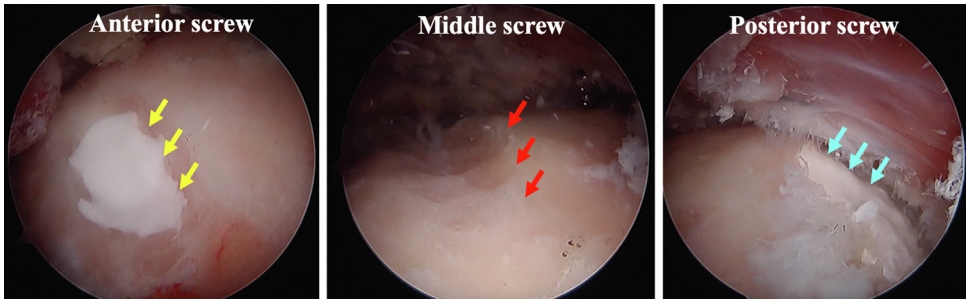

Fig 7. Resection of the PLLA screws. The middle screws were completely removed. The heads of the other screws were extracted so that they did not protrude.

introduced. First, the arthroscope is inserted using ultrasound guidance, so that its tip hit the screw, but the field of view cannot be secured. Therefore, a 23G Cathelin needle is inserted from the contralateral side under ultrasound guidance to check the path to the tip of the camera. A 1-cm skin incision is also created posteriorly, and a radio frequency (RF) device is installed (Fig 4). It is confirmed that the tip of the camera is at the ultrasound guide, and the RF tip is above the middle screw. An RF device is used to dissect the tissue surrounding the screw. Thus, the field of view is widened, and the PLLA is identified. Fusion with CT confirms that it is the middle screw, and the anterior and posterior screws are also located (Fig 5). The middle screw had a body protruding from the bone surface, and the screw was unstable. As the screw was abraded, it became increasingly unstable; therefore, hernial forceps were used to remove the entire screw. Because the anterior and posterior screws were stable, the tip of the screw was abraded until the surface was smooth by CT-ultrasound fusion-assisted endoscopy (Fig 6). After confirming that there was no extra-articular protrusion, the surgery was completed (Fig 7). Postoperative CT confirmed that the middle screw was removed and that

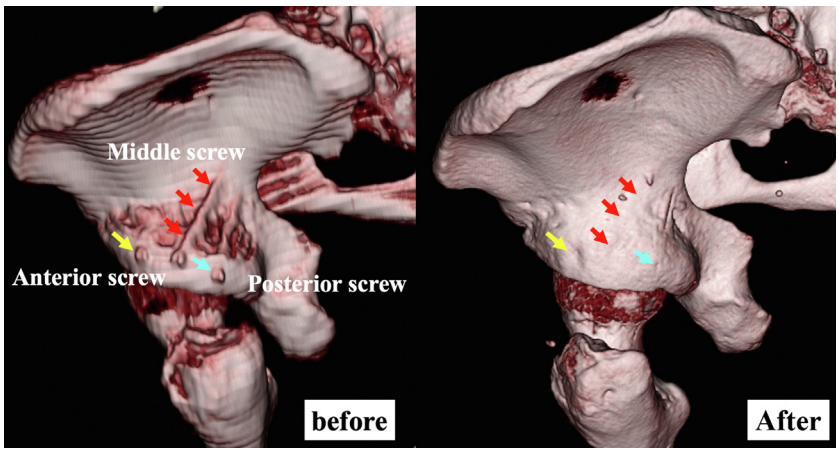

Fig 8. Three-dimensional computed tomography (CT) imaging before and after surgery. Postoperative CT confirmed that the middle screw was removed and that there was no protrusion of the poly L-lactic acid on the pelvic surface.

Table 1. Pearls and Pitfalls of Technique

Pearls
It is possible to make an accurate and safe portal.
The real-time guidance capabilities of ultrasound and the bird's-eye view of CT
Less invasive than navigation surgery
Pitfalls
CT must be taken in the same position as the surgical position.
Accuracy is dependent on the distance between the transmitter and magnetic sensor.

there was no protrusion of the PLLA on the pelvic surface (Fig 8).

Postoperative Protocol

Full weight bearing was allowed from the first postoperative day.

Discussion

CT-ultrasound fusion in hip endoscopy is new. As a similar assisted surgery, navigation surgery in orthopedics has become widespread, especially in the field of artificial joint surgery.[8] In contrast, endoscopic surgery is minimally invasive, so inserting a guide pin for navigation would be extremely invasive. Taking cues from other fields of medical practice, liver cancer biopsies are often performed under ultrasound guidance. The disadvantage of ultrasound guidance is a narrow field of view; only the area where the transducer hits the tissue can be visualized. Fusion imaging can compensate for the shortcomings of such ultrasound guidance.

It is possible to synchronize CT, MRI, PET, and other imaging data by using ultrasound images. There are two methods of synchronization: one is to determine a reliable landmark, and the other is to attach a marker in advance for easy tracking. By aligning the coordinate systems of the CT/MRI and ultrasound in regard to the markers, it is easy to align them. The markers can also be used to compensate for the magnetic field misalignment caused by body movement, and fusion images can be displayed without any misalignment. However, fusion is less accurate at the greater distance between the transmitter and magnetic sensor. Advantages and disadvantages of the technique are presented in Table 1.

Using this tool, surgeons have performed fusion-guided biopsies of liver cancer in recent years.[7] Fusion-assisted surgery is a novel navigation system that enhances the accuracy and safety of orthopedic surgery. The fusion technology enables the merging real-time guidance capabilities with CT, MRI, or PET. It makes minimally invasive arthroscopic and endoscopic surgery less invasive, safer, and more accurate. The major limitation is that not all ultrasonography instruments have a smart fusion system. It is expected that fusion-assisted surgery will spread as ultrasonography with fusion becomes more popular.

References

1. Mitchell JJ, Chahla J, Vap AR, et al. Endoscopic trochanteric bursectomy and iliotibial band release for persistent trochanteric bursitis. *Arthrosc Tech* 2016;5:e1185-e1189.
2. Domb BG, Botser I, Giordano BD. Outcomes of endoscopic gluteus medius repair with minimum 2-year follow-up. *Am J Sports Med* 2013;41:988-997.
3. Ilizaliturri VM Jr, Camacho-Galindo J, Javier Camacho-Galindo. Endoscopic treatment of snapping hips, iliotibial band, and iliopsoas tendon. *Sports Med Arthrosc Rev* 2010;18:120-127.
4. Martin HD, Shears SA, Johnson JC, Smathers AM, Palmer IJ. The endoscopic treatment of sciatic nerve entrapment/deep gluteal syndrome. *Arthroscopy* 2011;27:172-181.
5. Ozeki N, Koga H, Nakamura T, et al. Ultrasound-assisted arthroscopic all-inside repair technique for posterior lateral meniscus tear. *Arthrosc Tech* 2022;11:e929-e935.
6. Ewertsen C, Săftoiu A, Gruionu LG, Karstrup S, Nielsen MB. Real-time image fusion involving diagnostic ultrasound. *Am J Roentgenol* 2013;200:W249-W255.
7. Lee MW. Fusion imaging of real-time ultrasonography with CT or MRI for hepatic intervention. *Ultrasonography* 2014;33:227-239.
8. Abe K, Oba M, Kobayashi N, et al. Accuracy of computer-navigation-assisted arthroscopic osteochondroplasty for cam-type femoroacetabular impingement using the model-to-image registration method. *Am J Sports Med* 2022;50:1272-1280.