Examples of prior ICL chapters

ICL #9; Talk #1:

"Basic Terms of Ultrasound"

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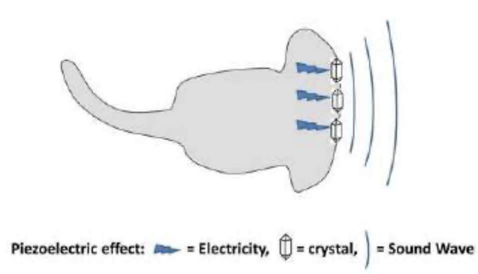
Ultrasound (US) refers to sound waves above the human range of hearing. Medical

ultrasound devices use sound waves in the range of 1–20 Mega Hertz (MHz). The first medical application of US for detecting brain tumors was published in 1942.[1] US is one of the most widely used imaging technologies in medicine. It is portable, free of radiation risk, and provides real time visual assessment for diagnostic and interventional purposes. As in other fields of medicine orthopedic surgeons integrate ultrasound into their physical exam. The use of ultrasound as a physical examination device in clinical orthopedic practice is increasing. It offers improved sensitivity for clinical localization of pathology and improves accuracy of the diagnosis. The applications of ultrasound in a hip practice include diagnosis, delivery of medicines to precise anatomic locations and localization of portals during hip arthroscopy. [2]

The basic principle of US is the **Piezoelectric effect** that is a crystal that produces sound wave, absorbs sound waves and transform it into an electric signal (**Fig 1**).

Figure 1. Piezoelectric effect: A crystal that produces sound wave, absorbs sound waves and transform it into an electric signal. Reverse Piezoelectric effect: an electric signal through a crystal converting electrical energy into kinetic or mechanical energy.

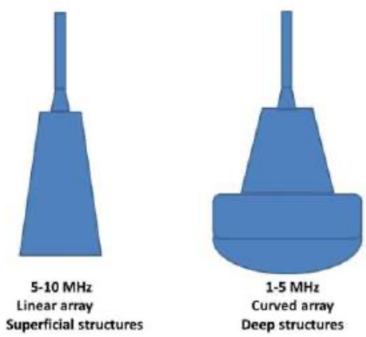
As the ultrasound waves penetrate body tissues of different acoustic impedances along the path of transmission, some are reflected back to the transducer (echo signals) and



some continue to penetrate deeper. The echo signals returned from many sequential coplanar pulses are processed and combined to generate an image. [3]

Transducer frequency determines depth of penetration and image resolution. High-frequency ultrasound waves (short wavelength) generate high resolution images. However as high-frequency waves are more attenuated than lower frequency waves for a given distance, they are suitable for imaging mainly superficial structures.[4] Low- frequency waves (long wavelength) offer images of lower resolution but can penetrate to deeper structures due to a lower degree of attenuation. Therefore, it is best to use high-frequency transducers (10–15 MHz) to image superficial structures such as the Rotator cuff or patellar tendon and low-frequency transducers (1–5 MHz) for imaging the hip or sciatic nerve (**Fig 2**).

Figure 2. Transducer frequency determines depth of penetration and image resolution.

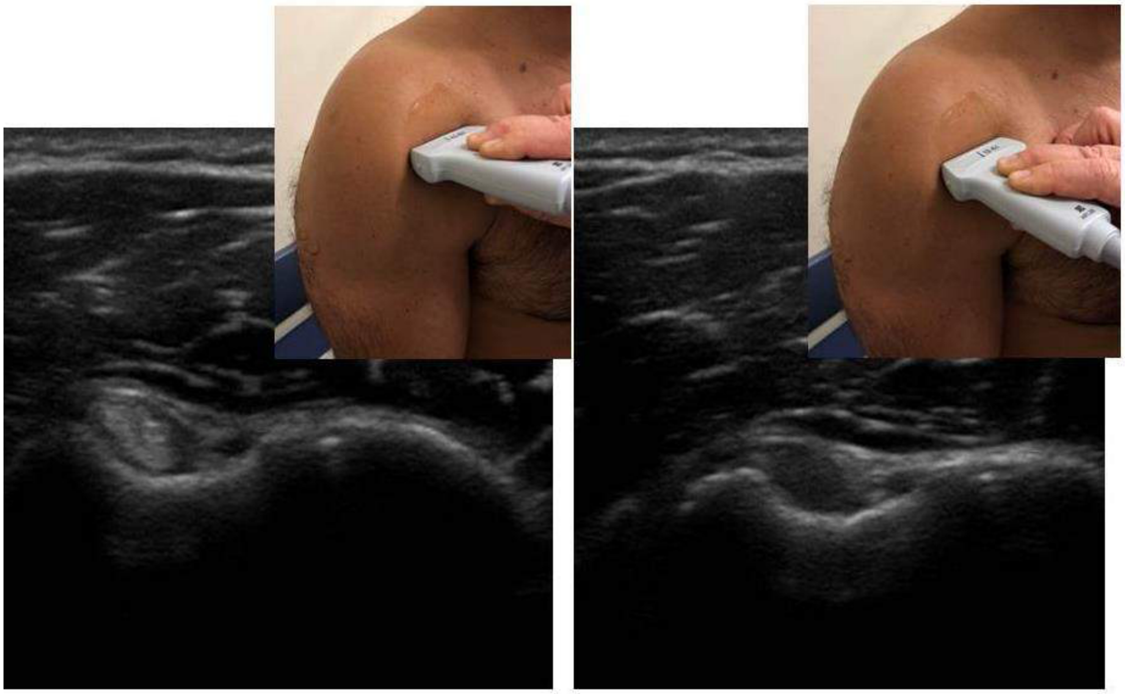


The **Acoustic Impedance** is an object's resistance to the movement of a wave or the quantity of echo returned after striking a tissue interface. When an incident ultrasound pulse encounters a large, smooth interface of two body tissues with different acoustic impedances, the sound energy is reflected back to the transducer.

If the incident US beam reaches the linear interface at 90°, almost all of the generated echo will travel back to the transducer. However, if the angle of incidence with the specular boundary is less than 90°, the echo will not return to the transducer, but rather be reflected at an angle equal to the angle of incidence. The returning echo will potentially miss the transducer and not be detected. [5]

Fluid-containing structures attenuate sound much less than solid structures so that the strength of the sound pulse is greater after passing through fluid than through an equivalent amount of solid tissue.

Figure 3. Anisotropy: a tilt of the transducer produces an artefact that may prompt an incorrect diagnosis of a tendon tear (absent LHB in the bicipital groove).



Normal Anisotropy

Anisotropy is an artefact encountered in ultrasound, notably in muscles and tendons. When the ultrasound beam is incident on a fibrillar structure as a tendon or a ligament, the organised fibrils may reflect a majority of the insonating sound beam in a direction away from the transducer. When this occurs, the transducer does not receive the returning echo and assumes that the insonated area should be hypoechoic. The artefact may prompt an incorrect diagnosis of tendinosis or tendon tear (**Fig 3**).

Refraction refers to a change in the direction of sound transmission after hitting an interface of two tissues with different speeds of sound transmission. In this instance, because the sound frequency is constant, the wavelength has to change to accommodate the difference in the speed of sound transmission in the two tissues. This results in a redirection of the sound pulse as it passes through the interface. Refraction is one of the important causes of incorrect localization of a structure on an ultrasound image.[6]

References

1. Dussik KT. Über die Möglichkeit hochfrequente mechanische Schwingungen als diagnostisches Hilfsmittel zu verwerten. Z Neurol Psychiat 1942, 174: 153
2. Byrd JW, Potts EA, Allison RK, Jones KS. Ultrasound-guided hip injections: a comparative study with fluoroscopy-guided injections. Arthroscopy. 2014;30(1):42-6

3. Vincent Chan and Anahi Perlas. Basics of Ultrasound Imaging. S.N. Narouze (ed.), Atlas of Ultrasound-Guided Procedures in Interventional Pain Management, Springer

Science+Business Media, LLC 2011. 13-19
4. Lawrence JP. Physics and instrumentation of ultrasound. Crit Care Med. 2007;35:S314–S322

5. Kossoff G. Basic physics and imaging characteristics of ultrasound. World J Surg. 2000;24: 134–142.
6. Middleton W, Kurtz A, Hertzberg B. Practical physics. In: Ultrasound, the Requisites. 2nd ed. St Louis, MO: Mosby; 2004:3–27.

ICL #3; Talk #5:

"Arthroscopic Portals via Ultrasound Guidance"

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Keywords: Arthroscopy, portals, ultrasound, X-ray, technique

Summary

The use of ultrasound to establish arthroscopic portals has several advantages over the traditional X-Ray-guided technique. Ultrasound equipment is smaller, eliminates radiation exposure, and allows for more posterior portal placement. However, the surgeon must be comfortable with ultrasound anatomy around the hip and extra time must be taken during pre-operative planning of the cam resection. This chapter outlines the technique for ultrasound-guided anterolateral and mid-anterior portals.

Ultrasound-guided hip arthroscopy is a simple technique that offers several

advantages over traditional X-ray-guidance. Ultrasound equipment is smaller, can be used in day surgery centers without access to fluoroscopy, and eliminates radiation exposure to the patient and operating room staff. The planned portal sites can also be assessed in three dimensions, allowing posterior portal placement to access the more superior joint areas. However, visualization can be difficult in obese patients with a large soft tissue envelope and if multiple needle passages have been made.

Pre-operative planning

Pre-operative planning is necessary as bony resections cannot be assessed radiographically intra-operatively. Multiple X-Ray views of the Cam lesion should be obtained to allow for accurate localization of the lesion and planning for the depth, length, and width of the resection. A CT with 3-dimensional reconstructions is especially useful for pre-operative planning and a 3-dimensional printed model allows for further

understanding of the expected intra- operative anatomy (**Fig 1**). Due to these challenges with osteoplasty, it has been recommended that surgeons use combined ultrasound and fluoroscopy for their first thirty ultrasound cases[1].

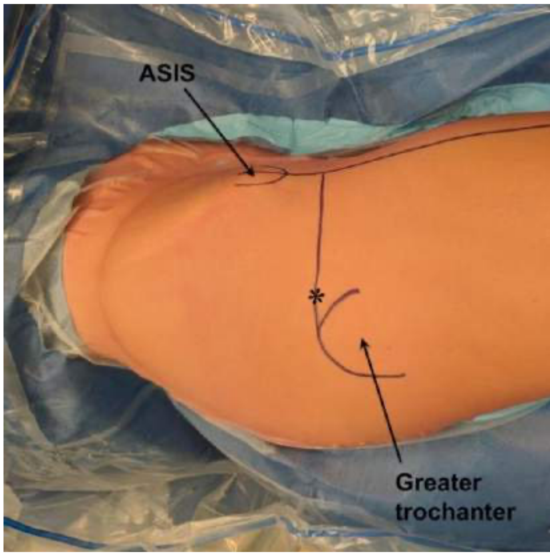
Figure 1. 3D model printed from the pre- operative CT of a patient with a large Cam lesion.

Technique for portal establishment

The establishment of portals with the patient positioned lateral decubitus was described by Keough, Wilson, and Wong in 2016[2]. Ultrasound-guided portal establishment in the supine position was described by Weinracu and Kermeci in 2014[1] as well as by Hua et al. in 2009[3]. The technique is very similar for both the lateral and supine positions. However, the lateral position may be technically easier as it uses the ultrasound probe in a vertical orientation, consistent with the majority of ultrasound imaging protocols.

A hip distractor is used to apply traction with the hip in neutral rotation, slight flexion, and neutral abduction. To ensure accurate lateral position, the alignment of the posterior superior iliac spines is kept exactly vertical. Ultrasound is used to confirm approximately 10mm of joint distraction. The leg is then prepped and draped in the usual sterile fashion and the ultrasound probe is placed in a sterile bag for use with sterile gel lubricant.

Skin landmarks for the greater trochanter and anterior superior iliac spine (ASIS) are used to approximate portal locations. The anterolateral portal is planned at the superior anterior corner of the greater trochanter (**Fig 2**). The ultrasound probe is orientated longitudinally and held over the femoral head at the landmarked portal. Translation of the probe from anterior to posterior while keeping the probe perpendicular to the floor confirms the center of the femoral head (**Fig 3**). The acetabular rim, labrum, femoral head, and capsule are all visible from this view. The skin incision for this anterolateral portal is planned as posterior as possible to allow the greatest distance between the anterolateral and mid-anterior portals.



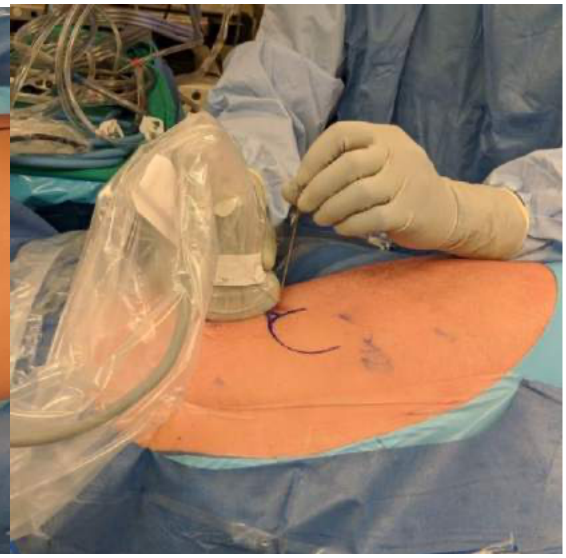


Figure 2. Skin landmarks for anterolateral and mid-anterior portals (Asterix represents planned position for anterolateral portal).

Figure 3. Position of ultrasound probe just superior to the landmarked location for the anterolateral portal.

A 17-gauge needle is inserted in line with the ultrasound probe to observe the trajectory up to the capsule (**Fig 4**). The needle is orientated with bevel toward the femoral head to prevent iatrogenic cartilage injury and is then advanced through the capsule. The inner trochar of the needle is removed and air entry into the joint is seen on the ultrasound. A syringe of air is attached to the needle, inserting air into the joint, which is again

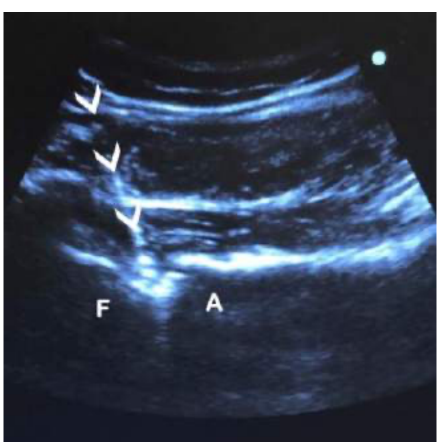


Figure 4. Ultrasound view during establishment of the anterolateral portal (A represents acetabulum; F represents femoral head; Arrow heads show path of needle in tissue).

confirmed on ultrasound. The usual cannulated instrument technique is used to insert the nitinol wire, dilators, canula, and then arthroscope, similar to the X-Ray-guided technique.

The mid-anterior portal is landmarked at a point midway between the ASIS and the anterolateral portal and 3-4cm distal. As discussed previously, the skin incisions for these portal sites should be as far away from each other as possible. The ultrasound probe is orientated longitudinally over the planned

Figure 5. Establishment of mid-anterior portal.

References

mid-anterior portal site and the location is confirmed by visualizing the femoral head, acetabulum, and labrum (**Fig 5**). Under ultrasound guidance, the 17-guage needle is inserted from the skin marking, aiming superior toward a line extended anteriorly from the anterolateral portal. The needle is advanced up to the capsule. Direct visualization from the lateral portal confirms needle entry into the joint.

1. Weinrauch P, Kermeci S. Ultrasound-assisted hip arthroscopy. Arthrosc Tech 2014;3:e255-e259.
2. Keough T, Wilson D, Wong I. Ultrasound-guided portal placement for hip arthroscopy. Arthrosc Tech 2016;5(4):e851-e856.

3. Hua Y, Yang Y, Chen S, et al. Ultrasound-guided establishment of hip arthroscopy portals. Arthroscopy 2009;25: 1491-1495.