Ultrasound Evaluation of Pediatric Orthopaedic Patients

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Abstract

Ultrasonography is a valuable tool that can be used in many capacities to evaluate and treat pediatric orthopaedic patient. It has the capability to depict bone, cartilaginous and soft-tissue structures, and provide dynamic information. This technique can be readily applied to a wide range of pediatric conditions, including developmental dysplasia of the hip, congenital limb deficiencies, fracture management, joint effusions, and many other musculoskeletal pathologies. There are many benefits of implementing ultrasonography as a regular tool. It is readily accessible at most centers, and information can be quickly obtained in a minimally invasive way, which limits the need for radiation exposure. Ultrasonography is a safe and reliable tool that pediatric orthopaedic surgeons can incorporate into the diagnosis and management of a broad spectrum of pathology.

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Ultrasonography is a valuable imaging tool that can be used by pediatric orthopaedic surgeons to obtain quick information without exposing the patient to radiation. It can be used for diagnostic and therapeutic purposes in numerous orthopaedic conditions, from hip dysplasia to forearm fractures. Ultrasonography is typically readily accessible in most medical centers and is used in the emergency departments (EDs) and in private offices. Unlike many imaging modalities, it can be performed at the bedside.

Despite this, there is a commonly held perception among orthopaedic surgeons that ultrasonography is unreliable in obtaining an accurate diagnosis and is highly operator dependent. This has led to its limited use in clinical practice as a diagnostic modality. However, when combined with a detailed history and thorough physical examination, ultrasonography can frequently provide important information on a wide variety of conditions encountered by the pediatric orthopaedic surgeon. As such, ultrasonography has been dubbed "the orthopedic stethoscope."[1] For these reasons, it is beneficial to explore the role of sonographic imaging in the evaluation and treatment of pediatric orthopaedic patients.

That being said, it is important to have adequate training on the use and interpretation of ultrasonography. In particular, orthopaedic surgery residents should have formal training on ultrasonography incorporated into their residency programs, just as they do for the interpretation of radiographs and MRI. Indications, technical skills, and interpretation can be accomplished as part of training. Implementation of ultrasonography into clinical practice will vary by institution and should be done in close coordination with our radiology colleagues.

Fractures

Fractures are common findings in pediatric patients presenting to the

ED. Traditionally, fracture diagnosis and confirmation of reduction is performed with the use of radiographic imaging. To further enhance reduction accuracy, some practitioners use fluoroscopy during the reduction maneuver and splint or cast application. Recent studies have found that sonographic imaging is an effective diagnostic test that can be used to identify fractures without exposing the patient to radiation.[2-4]

A study by Chen et al[2] evaluated 48 patients between the ages of 2 and 21 years in the pediatric ED with forearm fractures. For each patient, four views were obtained using ultrasonography and radiographs. Ultrasonography had a 97% sensitivity and 100% specificity in detecting pediatric forearm fractures. Of those 48 patients, ultrasonography was able to correctly identify the fracture location for 46 patients. In two patients, ultrasonography had identified fractures of the metaphysis of the radius but failed to diagnose ulnar styloid fractures. Nonetheless, the importance of detecting ulnar styloid fractures is minimal because these are generally not clinically significant injuries and do not change the management. Ultrasonography could therefore be used as a rapid screening tool to quickly identify patients with fractures that may warrant further radiographic imaging. Patients with negative ultrasonography examinations could be reassured that a fracture is unlikely and spared the radiation associated with radiographs.

Clavicle fractures are also successfully diagnosed with ultrasonography. A study by Cross et al[3] evaluated 100 pediatric patients in the ED, presenting with pain around the shoulder or clavicle pain, who would be obtaining a radiograph as part of his or her clinical workup. They observed a 95% sensitivity and 96% specificity for diagnosing clavicle fractures in pediatric patients with ultrasonography. Ultrasonography was unable to identify fractures in two patients, and both had nondisplaced fractures of the clavicle visible on the radiograph.[3]

In addition to the diagnosis, ultrasonography can be used as a tool to assist in fracture reduction. Fluoroscopy is often used to aid in accurately reducing and immobilizing forearm fractures. The use of fluoroscopy increases the chance that the initial reduction attempt is adequate, thereby limiting the possibility of repeated reduction attempts and subsequent number of trips to the radiology suite.[5] However, using fluoroscopy during reduction has disadvantages as well. Stand-alone EDs and smaller facilities may not have access to a C-arm. In facilities that do have a C-arm, obtaining and transporting the machine can take considerable time and effort. Maneuvering the machine while manipulating the fracture can also be cumbersome and difficult and may require an assistant. Fluoroscopy also exposes both the patient and the practitioner to additional radiation. In one study of pediatric forearm fractures reduced with a mini-C-arm, the average radiation exposure was 109 millirad (mR).[6] By comparison, a flat plate forearm radiograph exposes a patient to 20 mR of radiation, and the average radiation exposure of an individual is 620 mR per year. This illustrates that even mini-C-arm radiation exposure is not insignificant. Using ultrasonography to assist with reduction can therefore be a useful alternative to fluoroscopy.

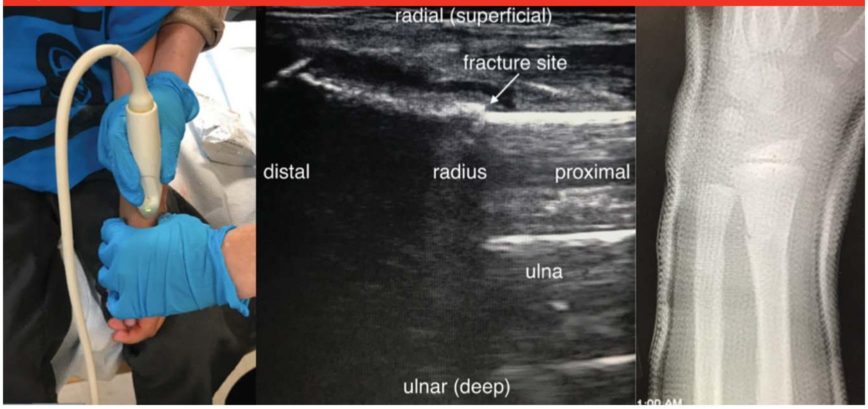
For a forearm fracture, the patient is positioned supine with the fingers suspended using finger traps. Ultrasonography is used to obtain a baseline understanding of the fracture pattern in two planes. Each ultrasonography view is analogous to one cut of a CT scan. For example, when the probe is placed longitudinally along the radial aspect of the forearm, this corresponds to a midcoronal CT image or an AP radiograph (Figure 1). When the probe is moved to the dorsum of the wrist, this is analogous to sagittal CT cut or a lateral radiograph. Ultrasonography can then be used in a dynamic fashion to visualize the reduction obtained during the reduction maneuver. A disadvantage of using ultrasonography for fracture reduction is that it cannot be used during splint or cast application. However, we have found that ultrasonography obtained after reduction but before cast application corresponds well to postcasting radiographs. Similarly, Patel et al[4] have also reported a 92.3% agreement between ultrasonography and radiographs for confirming the adequacy of reduction.

Developmental Dysplasia of the Hip

Developmental dysplasia of the hip (DDH) exists as a spectrum of anomalies of the developing hip, from a dysplastic acetabulum to dislocation.[7-9] Physical findings such as a Barlow or an Ortolani positive hip, or a Galeazzi sign suggest hip instability or frank dislocation. Even for the experienced examiner, the physical examination of the hip in infants is challenging; instability or even dislocation can be overlooked, particularly in uncooperative infants. In addition, stable hip dysplasia is clinically silent.

Any diagnostic test has to be subjected to the questions of sensitivity, specificity, safety, and accessibility; as such, we can look at physical examination, radiographs, and ultrasonography for detecting the spectrum of pathology that makes up hip dysplasia. For hip dislocation in children younger than the age of 4 months, the sensitivity of physical examination alone is only 37%, which improves to 66% with radiographs and to 89% with ultrasonography.[10] For hip instability, the sensitivity of physical

Figure 1



Radiograph demonstrating the technique for using ultrasonography to assist with reduction of a pediatric distal radius fracture. **A**, The ultrasonography probe is positioned longitudinally along the radial aspect of the forearm. **B**, The corresponding ultrasonography image produced by the probe is analogous to a coronal CT cut, demonstrating the radius superficially and the ulna deeper relative to the probe. **C**, Postreduction AP radiograph corresponding to the ultrasonography view reveals adequate reduction.

Figure 2

Photograph demonstrating the setup to perform an infant hip ultrasonography.

examination is lower. Because instability is dynamic, physical examination is a better predictor than radiographs, but sensitivity remains low. Ultrasonography captures dynamic images and therefore maintains its sensitivity for both instability and stable dysplasia.

Because hip dysplasia is a common cause of early osteoarthritis and total hip replacement,[11] improving our diagnostic tools may be the best way to reduce this. Currently, risk factors such as a first-born female, family history of DDH, and breech position select infants for ultrasonography screening.[8] Rather than considering the use of ultrasonography a screening tool, we suggest that ultrasonography be considered an integral portion of an enhanced physical examination of the hip. Our American Academy of Orthopaedic Surgeons guidelines assert that there is moderate evidence to support ultrasonography screening for infants with known risk factors, but in addition, note that there is also moderate evidence to support not implementing universal screening. Although the broad application of hip ultrasonography does have benefits, we acknowledge that it also has drawbacks, mainly in cost-effectiveness.[12] On the contrary, there are several European countries that have implemented universal screening and demonstrated reduction in both the number and severity of interventions done for DDH.[13] In our opinion, there are many more ultrasonography devices available in the clinical setting. Educating clinicians to incorporate this technique into routine clinical practice will ultimately prove cost-saving to the lifetime burden of hip dysplasia.

Another final interesting technique to consider, particularly in regions with limited resources, is the use of acoustics.[14,15] Although variations in this technique have been described, the principle is that sound transmission is measured between the patella and the pelvis and that simple instrumentations such as a stethescope and a tuning fork can be used for this purpose. Using this method, dysplastic hips have lower sound transmission compared with the normal side, providing a simple screening tool which is reliable in infants and young children.[14,15]

To perform the ultrasonography, the infant is placed in a supine position so that images in both the transverse and coronal planes of the hip can be viewed.[16-18] The setup is simple. The baby should be comfortable, in a quiet, warm, and relatively dark room. The baby is placed on their own blanket, in front of the monitor, uncovering only the necessary parts to avoid stress (Figure 2).

The first step is to determine whether the hip is reduced or dislocated, which can be determined by placing the transducer parallel to the long axis of the femur and evaluating the relationship of the femoral head in the acetabulum. This produces a transverse image, which can be thought of as cross-sectional imaging of the hip with the infant lying on its side (Figure 3). If the femoral head is seated next to acetabulum, regardless of whether it may be dysplastic, that femoral head is reduced.

The second step is to determine stability by adducting and applying stress, simulating a Barlow test under ultrasonographic examination. Displacement of the femoral head during this maneuver represents instability. There are two methods to assess displacement sonographically. One way is to measure the distance between two set points, typically the femoral head and the triradiate cartilage. Displacement greater than 4 mm between the acetabulum and femoral head signifies instability (Figure 4). The second option is to look for the "bird-in-flight" sign, which is a line drawn along the acetabulum and along the proximal femoral metaphysis. This virtual line is akin to a Shenton line on a radiograph and should be contiguous. A broken line signifies an unstable hip (Figure 5).

The third and final step is to determine hip morphology. A coronal view is constructed by rotating the transducer 90°, producing an image analogous to an AP pelvis (Figure 6). To accurately assess acetabular development, these coronal images should be captured with a perfectly flat ilium, from which measurements can be constructed. To measure acetabular depth, a line is drawn along the lateral border of the ilium. This line should intersect the femoral head, with at least 50% of the head inferior to the line, with smaller values suggesting dysplasia. A second line is then drawn along the acetabular roof to the triradiate cartilage to construct the alpha angle. The alpha angle should measure at least 60° by 4 weeks and subsequently increases with age.[19] The beta angle bisects the limbs of the alpha angle and should be no more than 55°, with increased angles representing increased severity of subluxation.

The obtained measurements can be evaluated based on the Graf classification system, which is divided into four main types as follows: I, normal; IIa-c, dysplastic; III, subluxation; and IV, dislocation. This classification has demonstrated prognostic values for the likelihood of normalization without treatment and the success of pavlik harness treatment.[16,20,21] Some disadvantages are that it has been modified several times, can be complicated to understand, and has low interobserver reliability.[22] Furthermore, sonographic measurements can vary widely between clinicians. A study by Kolb et al[23] demonstrated that relatively small variations in the positioning of the transducer can overestimate or underestimate the alpha angle. Many experienced clinicians and orthopaedic surgeons consider the construction of alpha angles and the use of classification systems unnecessary and find it is simplest to think of the spectrum of hip dysplasia as being one of these three following variables: dysplasia, instability, or dislocation. In clinical practice, treatment should be initiated in all three scenarios.

Once treatment in a Pavlik harness is begun, ultrasonography remains a useful tool. Acetabular development and the appearance of the ossific nuclei of the femoral head can be monitored. The length of treatment in a harness can be adapted to how long it takes for sonographic normalization. In addition, dislocated hips that do not reduce with a Pavlik harness can be easily identified.[24] By understanding how to perform an ultrasonography evaluation as an enhanced physical examination of the hip, we will improve our ability to detect hip dysplasia at an early and optimal age and obtain the best outcomes in the long term.

In addition to diagnosis and monitoring hip dysplasia treated in a pavlik harness, ultrasonography is also effective in evaluated closed reductions. Older infants, either diagnosed late or who have failed pavlik harness, are treated with closed reduction and spica casting. Either MRI or CT is typically used to verify the reduction of the femoral head within the spica cast. In many institutions, neither CT nor MRI can be performed intraoperatively. Ultrasonography offers an attractive alternative,[25] which can be quickly performed to either verify reduction (Figure 7) or demonstrate the need for recasting while the patient is in the operating room (Figure 8).

Figure 3

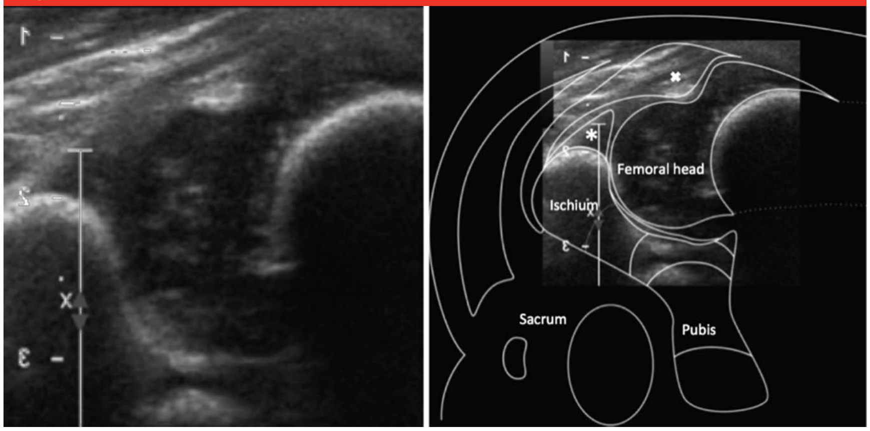


Figure demonstrating transverse ultrasonography of the hip with anatomical landmarks. The bony landmarks are labeled as follows: femoral head, ischium, pubis, and sacrum. The posterior labrum is represented by * and the gluteus medius by ×.

Soft-tissue Masses

The appearance of a soft-tissue mass is a concern that often prompts referral to pediatric orthopaedics. Often, a relatively short differential diagnosis can be made based on history and physical examination. Common causes of soft-tissue masses include ganglion cyst, popliteus cyst, abscess, giant cell of tendon sheath, foreign body, and hemangioma. Ultrasonography images can aid the orthopaedic surgeon to determine

Figure 4

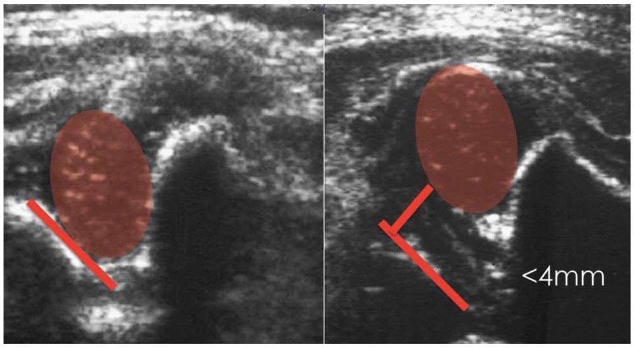


Figure demonstrating the transverse displacement of >4 mm of the hip signifies instability.

Figure 5

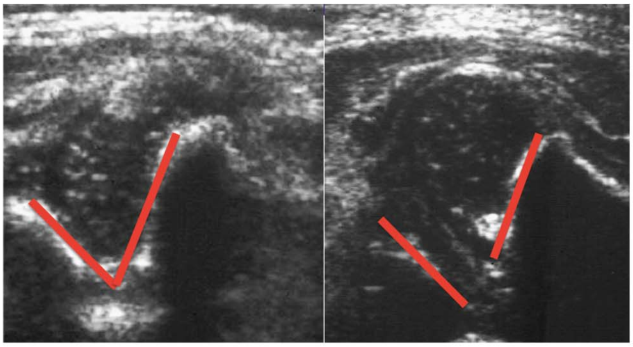


Figure demonstrating the bird-in-flight sign, an analogous line to Shenton's line on an AP radiograph.

the size and composition of a mass and its position in relation to nearby structures such as joints or vasculature.[26] Grayscale images help determine echogenicity as compared to surrounding normal tissue and the architecture of the mass, whereas color doppler can show any vascularity within the mass. In addition, compressibility of the mass can aid in the differentiation of a vascular malformation or hemangioma from a solid, otherwise noncompressible mass (Figures 9 and 10). These characteristics can help the surgeon refine the differential diagnosis and determine the appropriate course of treatment.

Although ultrasonography can be useful in the workup and management of many soft-tissue masses, it is probably most definitive as a diagnostic tool in confirming cystic masses and those associated with foreign bodies. A study by AbiEzzi and Miller[26] which evaluated soft-tissue masses in 44 pediatric patients found that ultrasonography alone was diagnostic in 11/13 cystic masses and 12/18 solid masses and helpful but not diagnostic in 12/13 mixed masses. The cystic masses identified were either ganglion or popliteus cysts. The two cystic masses that were not correctly diagnosed were found to be hemangiomas on surgical exploration. Of the 12 solid masses for which ultrasonography was diagnostic, all were foreign bodies. This study corroborates another earlier study and highlights a role for ultrasonography in aiding or confirming the diagnosis in some very common pediatric soft-tissue masses with a low rate of inaccurate information.[26,27]

Both cystic masses, either ganglion or popliteus cysts, and foreign bodies are often easily identifiable by history and clinical examination alone. However, the use of a bedside ultrasonography provides objective diagnostic information. For cystic masses, sonographic data can also be particularly reassuring for those presenting in less common areas. In children, the history may be unreliable in the cases of retained foreign bodies. Ultrasonography is an excellent tool in these instances to confirm and localize the object.

Among solid or mixed masses, the role and usefulness of ultrasonography varies. In the case of giant cell tumors of tendon sheath, ultrasonography can be definitively diagnostic.[28] Fibrous tumors or hemangiomas can be more challenging to identify. Although rare in the pediatric patient, soft-tissue sarcomas are possible. Any mass not easily identifiable by sonographic findings, or accompanied by any concerning physical examination findings and/or history, should be fully evaluated with advanced cross-sectional imaging.

Joint Effusions

Septic arthritis and transient synovitis are two commonly encountered pediatric hip conditions. It is essential to be able to distinguish between the two conditions because their treatment and prognosis differ. Septic arthritis is typically treated with surgical débridement and antibiotics, and early treatment is necessary to prevent long-term damage to the joint.[29-31] By contrast, transient synovitis is a benign condition and treatment is usually aimed toward alleviating symptoms. Diagnosis can be challenging because both conditions can cause the child to limp, be unable to bear weight, and have joint effusion.[29]

The Kocher criteria is a widely used diagnostic algorithm to predict the likelihood of septic arthritis, based on the presence of fever, inability to bear weight, elevated white blood cell count, and erythrocyte sedimentation rate.[29] Caird et al[32] additionally demonstrated that C-reactive protein is an independent predictor of joint infection. Although both studies used ultrasonography to perform joint aspiration, neither used sonographic features as diagnostic criteria to distinguish the septic joint from transient synovitis.

There is a paucity of data comparing the ultrasonography findings in these conditions, likely because ultrasonography is most valuable as a quick tool to determine the presence or absence of a hip effusion (Figure 11). This is particularly valuable in young children, who may be difficult to examine, to be confident that the hip is the source of the report. A qualitative study which evaluated 50 pediatric hips suggested that ultrasonography can serve a role in diagnosing septic arthritis and that hyperechogenicity and a thickened capsule were the most common findings[33] (Figure 12).

One study retrospectively studied 127 pediatric patients with ultrasonography data who were ultimately diagnosed with septic arthritis or transient arthritis.[30] This study used two senior radiologists to perform the ultrasonography and considered a distended anterior capsule, a hyperechogenic effusion, and capsular thickening >5 mm to be diagnostic of a septic hip. Ultrasonography had an 86% sensitivity, 90% specificity, and 88% positive and negative predictive value to identify septic arthritis of the hip. It was additionally found to be superior to radiographic, clinical, and

Figure 6

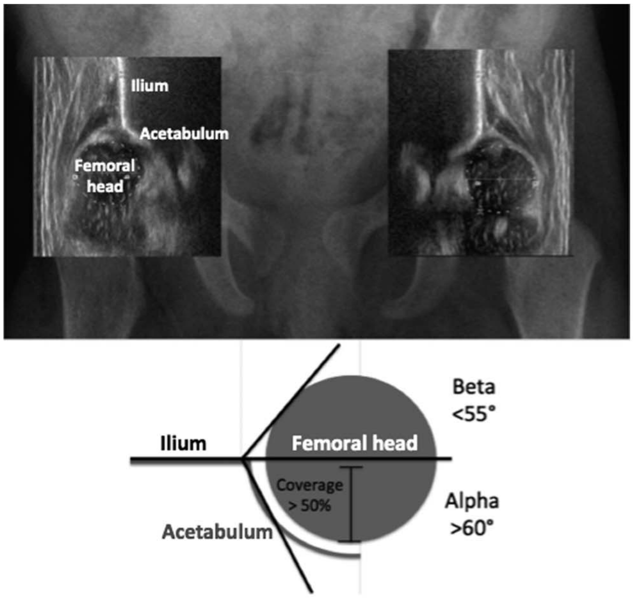


Figure demonstrating the ultrasound in relation to an AP radiograph, using measurements of coverage, alpha and beta angles on a coronal image.

Figure 7

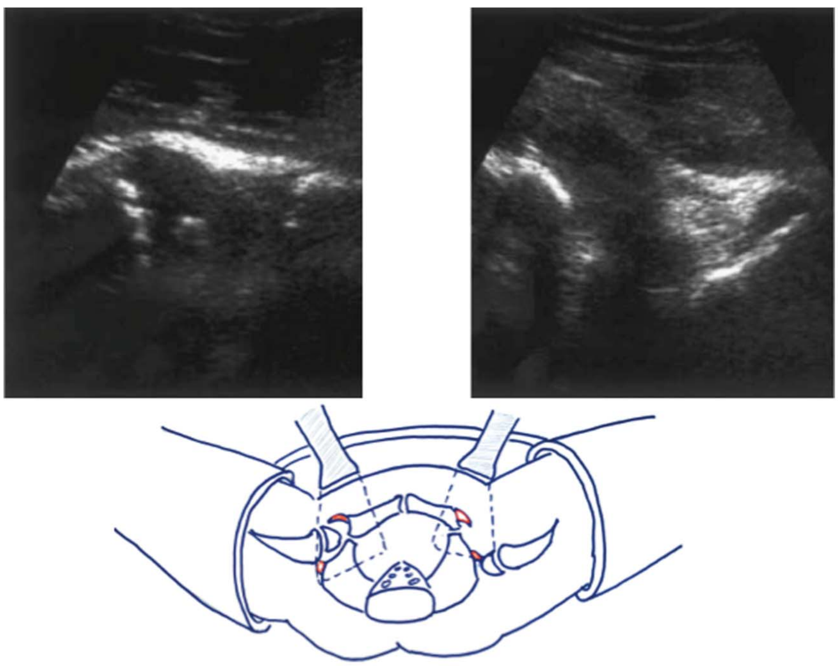


Figure demonstrating ultrasonography after closed reduction and spica casting with a persistently dislocated hip.

Figure 8

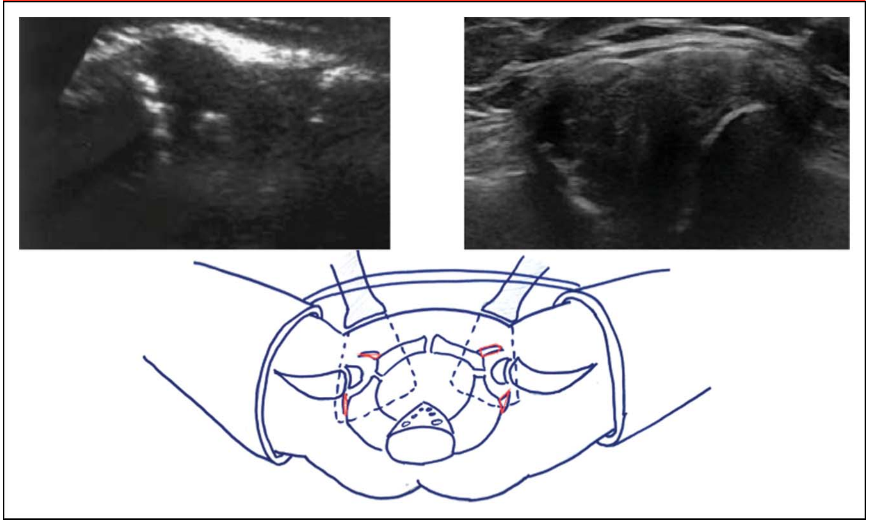


Figure demonstrating ultrasonography after closed reduction and spica casting, with a successful hip reduction.

Figure 9

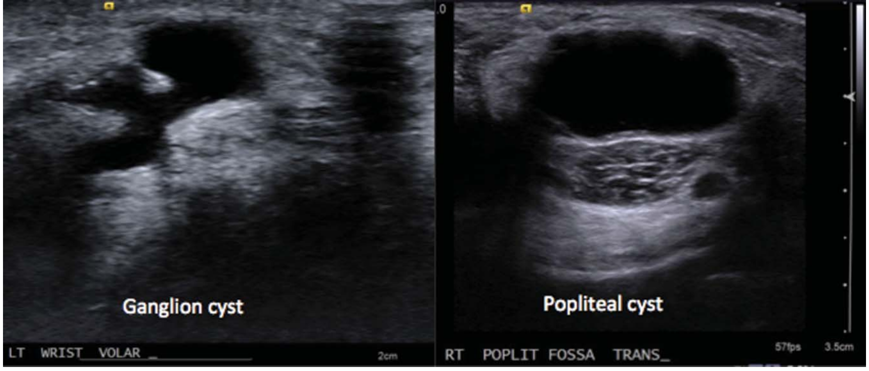


Figure demonstrating common cystic soft-tissue masses.

Figure 10

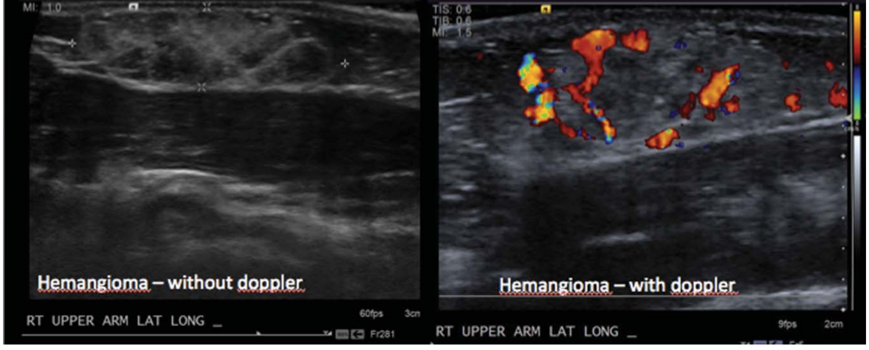


Figure demonstrating vascularity within a soft-tissue mass.

laboratory parameters collectively ($P = 0.005$).

Among those with a false-negative result, 50% had an ultrasonography performed within the first 24 hours of presentation. Similarly, Gordon et al[34] found a 5% false-negative rate in a series of 132 children and identified ultrasonography performed within 24 hours of presentation and inadequate technique as the reasons for these incorrect results. The absence of an effusion should therefore be interpreted cautiously in patients with recent onset of symptoms and monitored closely for an evolving clinical examination.

Understanding how to identify a joint effusion that seems consistent with septic arthritis can be beneficial for the orthopaedic surgeon for many reasons. It provides additional data to suggest a need for timely surgical intervention. In addition, positive results may help identify patients who should undergo further imaging studies, such as MRI. The presence of additional infections, such as osteomyelitis, pelvic abscess, and pyomyositis is becoming increasingly common in septic hips.[31] MRI is useful whenever possible to identify these additional infections so that they can be adequately addressed during irrigation and débridement of the hip joint.

However, MRI can be costly, difficult to arrange, and may require sedation. Screening patients most likely to require MRI based on ultrasonography helps stratify patients in whom further imaging will be most helpful. Similarly, this technique can also be extended to identifying fluid collections around postsurgical hardware, where metal artifact can interfere with imaging.

Congenital Bony Abnormalities

Patients with congenital conditions often have a cartilaginous component

Figure 11

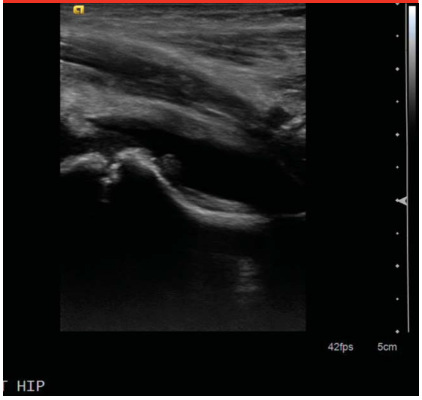


Figure demonstrating hip effusion, a 10-year-old girl.

Figure 12

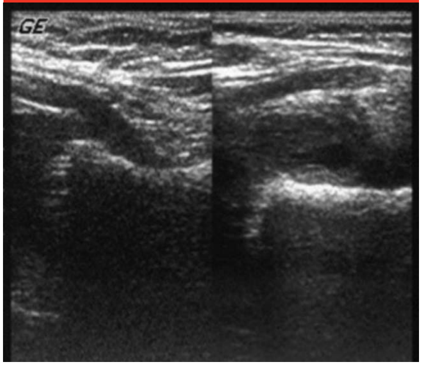


Figure demonstrating septic hip effusion, a 2-year-old girl.

Figure 13

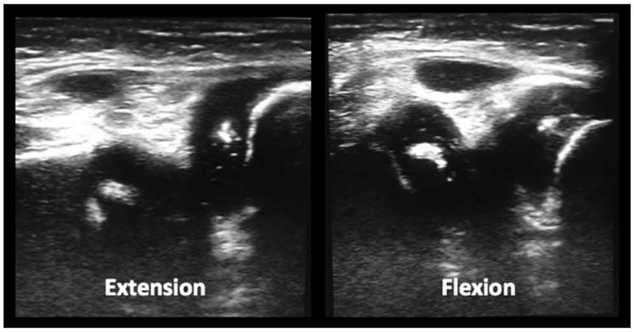


Figure demonstrating congenital knee dislocation and reduction with serial casting in flexion.

of their bony morphology that can be readily evaluated by ultrasonography. In many cases, identifying these cartilaginous components has diagnostic and prognostic implications. Some examples include congenital longitudinal deficiency, achondroplasia, and congenital dislocations of the knee.

Congenital Longitudinal Deficiencies

Two examples of congenital longitudinal deficiencies in which ultrasonography can play a role are proximal focal femoral deficiency (PFFD) and congenital tibial deficiency. PFFD ranges from mild shortening of the femur to complete absence, with associated abnormalities of the acetabulum and femoral head. It is most commonly classified according to Aitken,[35] with four types ranging in severity from A to D. Congenital tibial deficiency, most commonly classified according to Jones et al,[36] describing varying absence of the tibia with associated deformities of the knee, fibula, and foot. In both conditions, ultrasonography can be used for structural information and to provide prognostic values.

PFFD is difficult to classify in infants because the components of the proximal femur may be present, but not ossified. The femoral head and its connection to the femoral shaft may exist as fibrocartilaginous components that are not initially visible on plain radiographs. Monitoring with serial radiographs often demonstrates ossification over time, and images taken between 12 and 15 months will have better prognostic values.[37]

However, ultrasonography can be used early to identify cartilaginous structures predictive of ossification. This information is valuable for discussing treatment options with the family as early as possible. In some cases, particularly in neonates, ultrasonography can serve as a diagnostic tool. Suspected DDH, in rare cases, can be PFFD. Characteristic hip ultrasonography findings in PFFD include an inability to achieve a standard coronal image composed of the ilium, acetabular roof, labrum, and femoral head.[37,38] In addition, as in DDH, ultrasonography can identify a hip dislocation and provide dynamic information about the stability of the hip. When screening for infants with dysplasia, PFFD should be considered an unusual but possible diagnosis.[38]

Similar to PFFD, limbs with congenital tibial deficiency can contain cartilaginous precursors. The most widely used classification for congenital tibial deficiency is the Jones classification, which describes four different morphologic types.[36] Type 1 is divided into 1a and 1b and differ based on the presence of a cartilaginous anlage in the proximal tibia. Sonographic imaging is probably most useful in distinguishing Jones type 1a from type 1b because it allows for visualization of the cartilaginous anlage. This distinction is important because it has significance for determining amputation versus surgical reconstruction. Patients with a cartilaginous anlage will develop a functional knee mechanism, whereas patients without (Jones type 1a) have typically been treated with an amputation.

Besides defining a cartilaginous anlage, ultrasonography can visualize other components of the knee extensor mechanism. Static and dynamic techniques can be used to identify the quadriceps, patella, and patellar tendon.[39] A thorough understanding of the knee structure and its functionality can help the surgeon plan for surgical intervention. Although MRI is also a useful tool that depicts morphology in great detail, there is a concurrent role for ultrasonography in both PFFD and congenital tibial deficiency. Ultrasonography is a readily accessible tool, requires no patient sedation, and can provide dynamic information about the stability and function.

Achondroplasia

Achondroplasia is the most common form of skeletal dysplasia. Although inheritance is autosomal dominant, about 80% of cases are sporadic. In many instances, the diagnosis may not be expected at birth. Children with achondroplasia can be clinically identified by common features including bowed, rhizomelic extremities, an enlarged head with frontal bossing, and midface hypoplasia. Although the appearance is characteristic, the diagnosis is not clinically apparent in the newborn. Radiographic evaluation can demonstrate classic skeletal features, such as a squared "champagne glass" pelvis, and anomalies of the spine and ribs.

Ultrasonography is an additional tool that can confirm the diagnosis by characteristic hip findings. A study conducted by De Pellegrin et al[40] assessed 22 patients with achondroplasia between the ages of 7 days and 29 months with ultrasonography. They reported that hips affected by achondroplasia had a sharp, well-developed edge of the iliac wing, deep coverage, and low beta angle. The average coverage was 86.7%, with an average beta angle of 20°. The ossific nucleus appears later than the normal and was seen, on average, at around 2 years of age. In addition to achondroplasia, the same authors have also used ultrasonography to characterize other osteochondrodysplasias.[40]

Congenital Knee Dislocation

Congenital knee dislocations are rare occurrences among neonates, easily diagnosed by clinical examination. Ultrasonography is a useful adjunct to evaluate the abnormal morphology of the knee. A previous study of infants with this condition revealed thinning and fibrosis of the quadriceps tendon and abnormal development of the suprapatellar bursa and anterior cruciate ligament.[41] In addition, ultrasonography has proven to be a valuable tool to monitor the dynamic stability of congenital knee dislocations throughout treatment with serial castings.[41] Although many congenital knee dislocations easily reduce with casting, some cases may be particularly stiff and refractory to treatment. This scenario is more likely to be found in association with a syndrome, such as Larsen. Bedside ultrasonography performed in conjunction with serial casting would be most useful to evaluate the progress of treatment in these patients (Figure 13).

Summary

Ultrasonography is a technique that can be used in the diagnosis of a wide range of conditions, including fractures, hip dysplasia, joint effusions, and congenital bony abnormalities. Significant research exists which corroborate its value as a diagnostic tool. Adopting ultrasonography as part of the clinical evaluation of pediatric orthopaedic patients provides quick and useful information and can reduce patient radiation exposure. Ultrasonography is a readily available tool that the pediatric orthopaedic surgeon can master in a short period of time and broadly apply in practice.

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