[Imaging]

Sonography of Sports Injuries of the Hip

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Context: Sports-related injuries of the hip are a common complaint of both competitive and recreational athletes of all ages. The anatomic and biomechanical complexity of the hip region often cause diagnostic uncertainty for the clinicians evaluating these injuries. Therefore, obtaining additional diagnostic information is often crucial for providing injured athletes with a prompt and accurate diagnosis so they can return to activity as soon as possible. Musculoskeletal ultrasound is becoming increasingly important in evaluating and treating sports-related injuries of the hip.

Evidence Acquisition: The PubMed database was searched in May of 2013 for English-language articles pertaining to sonography of sports injuries of the hip using the following keywords in various combinations: *musculoskeletal*, *ultrasound*, *hip*, *hip sonography*, and *sports*.

Study Design: Clinical review.

Level of Evidence: Level 4.

Results: Musculoskeletal ultrasound is currently being used for both diagnosis and treatment in a wide range of acute and chronic conditions affecting the hip, including tendinosis, tendon/muscle strains, ligamentous sprains, enthesopathies, growth plate injuries, fractures, bursitis, effusions, synovitis, labral tears, and snapping hip. Therapeutically, it is used to guide injections, aspirations, and biopsies.

Conclusion: Musculoskeletal ultrasound use is expanding and will likely continue to do so as more clinicians realize its capabilities. Characteristics, including accessibility, portability, noninvasiveness, dynamic examination, power Doppler examination, and low cost highlight the potential of ultrasound.

Keywords: ultrasound; ultrasonography; sonography; musculoskeletal; hip; athletes; sports injuries

High school and collegiate team physicians are using ultrasound (US) for evaluation of acute injuries both during events and in training rooms. Interest is spurred by the relatively low cost, lack of radiation exposure, and accurate musculoskeletal diagnosis. In addition, US has better spatial resolution than magnetic resonance imaging (MRI).³⁴ Sports-related injuries of the hip are a common complaint, and the goal of this review article is to present how musculoskeletal ultrasound (MSUS) is currently being used to help evaluate and treat sports-related hip injuries.

EPIDEMIOLOGY

Approximately 5% to 6% of sports injuries in adults originate in the hip and pelvis,^{7,11} and 10% to 24% of sports- and

recreation-related injuries in children are hip related.⁶ Susceptibility to injury is largely based on a patient's age and the type of activity they are performing, but sex is also important. Age is the single most important factor in determining the etiology of hip pain.²⁷ In children aged 2 to 12 years, hip injuries compose 17% to 25% of all acute but only 2.2% to 4.8% of chronic activity-related injuries.⁵⁴ Acute injuries are often muscle/tendon strains, ligament sprains, or contusions (62%), whereas most chronic injuries affect articular, epiphyseal, and/or apophyseal cartilage (53%).⁵⁴ This study did not include transient synovitis, Perthes disease, or slipped capital femoral epiphyses as activity-related injuries. In high school athletes, 5% to 9% will report a hip- or pelvis-related injury.^{11,31} Sports are a risk factor for developing osteoarthritis (OA) of the hip. In men, the risk of developing OA was increased by 4.5%; in those with

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Figure 1. Sagittal oblique image of normal anterior hip joint. A, acetabulum; F, femoral head; IP, iliopsoas muscle; RF, rectus femoris; open arrow, iliofemoral ligament.

Figure 2. Transverse oblique image of normal anterior hip joint. I, iliopsoas tendon; P, psoas muscle; A, rim of the acetabulum; F, femoral head.

both long-term exposure to sports and a physically demanding job, the risk was increased by 8.5%.⁵³ Explosive and contact sports place the hip at risk of being injured.²⁷ Dancers, runners, and soccer players are often at the greatest risk.⁶ Ballet dancers appear to have the highest rate of hip difficulties, with the region responsible for 7% to 14.2% of all injuries suffered in this sport.^{27,44}

RESULTS AND DISCUSSION

The normal anatomy of the hip is depicted in Figures 1, 2, and 3.

Extra-Articular Conditions

Superficial muscles and tendons surrounding the hip can be evaluated with sonography. Full and partial tears of muscles, tendons, and ligaments can be identified. Dynamic US examination can be used to help differentiate confusing diagnoses by enhancing subtle injury-specific characteristics. In these injury types, diagnosis is based on the echogenicity of the tissue. A change in the normal tissue characteristics (Figure 4) is noted as anechoic, hypoechoic, or hyperechoic and a disruption of the normal well-organized fiber pattern. Hyperemia can be noted on power Doppler examination.¹⁴ Typically, tendinosis is indicated by a hypoechoic and/or hyperechoic image (Figures 5 and 6). Partial and complete tears are indicated when an extremely hypoechoic or anechoic image separates the tissue fibers. On static examination, a tissue may appear partially torn, but with dynamic examination and tissue contraction, the abnormal image may completely separate the tissue fibers, indicating a complete tear. This same concept applies to differentiating tendinosis from tears. When partial tears are examined dynamically, the hypoechoic or anechoic region of concern will increase the separation between normal tissue, which is not seen in tendinosis. Dynamic examination can also be used to examine ligament integrity when stressed.

Figure 3. Sagittal view over the greater trochanter, anterior facet. GT, greater trochanter; arrow, insertion of gluteus minimus tendon.

Ultrasound can identify the characteristics of the enthesitis, which include hypoechoic thickening, osseous erosions, bony spurs, and hyperemia.⁵ Although not sports-related, use of US in detecting enthesitis and synovial hyperemia is valuable in diagnosing and monitoring response to treatment in patients with rheumatoid arthritis.⁵ Similarly, gluteal tendon enthesitis is seen in 44% of patients with seronegative spondyloarthropathies.¹⁰ Therefore, it is important to keep these conditions in the differential when evaluating athletes with hip pain.

Ultrasound may be useful in diagnosing extra-articular soft tissue fluid collections such as hip bursal fluid collections (Figures 7, 8, and 9), hematomas (Figure 10), and seromas.⁴ Iliopsoas, trochanteric, and ischial bursitis can be identified.⁴ A distended iliopsoas bursa may clinically mimic an inguinal hernia; US is useful for distinguishing them. Dynamic US can detect true

Figure 4. (a) Normal iliopsoas tendon. Transverse sonographic image at the level of the acetabular rim best demonstrates the musculotendinous junction. The iliopsoas tendon (solid arrow) has a normal echogenic appearance. The acetabular rim (A) is seen as an hyperechoic line. The open arrow represents the iliopsoas muscle. (b) Sagittal sonographic image of the iliopsoas tendon (arrow) at its insertion on the lesser trochanter of the femur (F). Note the uniform echogenicity of the tendon.

hernias as the movement of abdominal contents into the inguinal canal or other transition sites can be seen with dynamic Valsalva.^{19,46} Ischiogluteal bursitis pain can present clinically similar to a radiculopathy but can be diagnosed with dynamic ultrasound by identifying the bursa and reproducing the patient's symptoms by compressing it with the transducer.⁹ In addition, US may be more accurate than MRI in determining whether a filled iliopsoas bursa is drainable or full with solid debris.³³ US is useful in the initial evaluation and follow-up of intramuscular hematomas.¹⁷ However, since the ultrasound findings may be nonspecific, it is critical that suspected hematomas be followed to complete resolution to exclude soft tissue tumors.¹⁷ In addition, ultrasound can detect the early stages of myositis ossificans before computed tomography, MRI, or radiography.³⁶

Figure 5. Adductor tendinosis. Longitudinal image obtained at the level of the medial pubic bone, and adductor origin demonstrates an abnormally thickened and hypoechoic proximal tendon (open arrows) with loss of normal fibrillar architecture as seen more distally (solid arrow). PR, pubic ramus; open arrows, tendinosis; solid arrow, normal tendon.

Figure 6. Gluteus medius calcific tendinosis. Transverse sonographic image shows the thickened tendon (outlined) with loss of the normal echogenic fibrillar appearance. A calcific deposit within the tendon is also seen (arrow), consistent with calcific tendinosis. GT, posterior superior facet of greater trochanter.

Sonography can be used to demonstrate physeal and epiphyseal injuries, including apophyseal avulsions (Figure 11). US can detect acute avulsions of the anterior superior and inferior iliac spines and thus could be used instead of MRI.⁴¹ Radiography should still be the initial modality because of its ability to identify other bony abnormalities.⁴¹ Sonographic findings included widening of the physis or frank displacement of the apophysis compared with the asymptomatic contralateral side.⁴¹ Hypoechoic or mixed echogenic edema or hemorrhage may be noted in the widened space, and power Doppler may demonstrate hyperemia.⁴¹

Ultrasound can contribute to the diagnosis of arthritis (Figure 12), occult fractures, and stress injuries. However, only the most

Figure 7. Gluteus minimus bursitis. A distended gluteus minimus bursa is seen deep to the tendon on this transverse view of the greater trochanter. Enthesopathy is also suspected because of the cortical irregularities noted on the trochanter.

Figure 8. Ischial bursitis. Longitudinal view of the semimembranosus tendon at the insertion on the ischial tuberosity demonstrates distension of the iliopsoas bursa (closed arrow). There is also noted tendinosis of the tendon (open arrow) and a calcific deposit within the tendon just deep to the bursa (asterisk).

Figure 9. Iliopsoas bursitis. Transverse image at the level of femoroacetabular joint demonstrates a distended iliopsoas bursa (arrows) with complex internal debris. AC, acetabulum; FH, femoral head.

Figure 10. Iliac crest hematoma. Ice hockey player hit on iliac crest with hockey stick with resultant blood collection (outlined) between the external oblique and the iliac crest.

Figure 11. Longitudinal ultrasound in an adult demonstrating an old ischial apophyseal avulsion that occurred during adolescent years. OSS, ossific density consistent with avulsed fragment; ISCH, ischial tuberosity; open arrows point to fibrous union from avulsed fragment to ischial tuberosity.

superficial portion of the cortex of bone is visualized. Therefore, if a cortical irregularity is noted, further imaging is indicated.¹⁷ US is very useful in detecting early signs of articular involvement in rheumatoid arthritis such as synovitis and bone erosions. In some cases, US can detect erosions of the femoral neck before they are apparent on radiography.⁵

Magnetic resonance imaging is the most widely used modality for identifying athletic pubalgia¹⁶; however, sonography is the procedure of choice for those who believe that a weakness of the transversalis fascia is the etiology.^{38,47} The diagnosis of osteitis pubis can be enhanced with US examination; it may show signs earlier than radiographs, such as distention of the symphysis by effusion, thickening of the joint capsule, and irregularity of the pubis.¹⁶

Chronic muscle abnormalities can also be identified using US. An example is adductor insertion avulsion syndrome. Also known as “thigh splints,” this stress-related avulsive injury of the adductor muscles occurs at the posteromedial midfemoral diaphysis.^{1,2} Sonographic findings include cortical irregularity surrounded by a hypoechoic area along the posteromedial midfemoral diaphysis. Hyperemia of the affected area is present on power Doppler. On comparison with MRI, the cortical

Figure 12. Degenerative arthrosis. Sagittal oblique sonographic image shows cortical irregularity (large arrow) and spurring of the femoral neck (N) and loss of sphericity of the femoral head (FH). The labrum is outlined in blue. A, acetabulum.

irregularity represented a cortical fracture, and the adjacent hypoechoic soft tissues showed periostitis.⁵⁵

Tensor fascia lata tendinopathy is another chronic condition that can be identified with US and should be included in the differential for anterior groin pain. The tension on the iliotibial tract helps maintain the knee in the extended position and to slow forward body movement in downhill running. US findings of tensor fascia lata tendinopathy include disruption of the normal fibrillar pattern and an increase in diameter.³

Musculoskeletal US has enhanced diagnosis of rare conditions and alternate diagnoses for several conditions. For example, isolated gracilis muscle injuries have been identified with increased frequency through use of MSUS.³⁹ Gluteal tendon tears (Figure 13), often misdiagnosed as trochanteric bursitis, are actually a frequent cause of recalcitrant lateral hip pain or greater trochanteric pain syndrome. In addition, US is superior to MRI in detecting gluteal tendon tears.⁵⁶

Ultrasound led to biomechanical explanations for common conditions such as snapping hip. Sonography enables both static and dynamic examination,^{8,20,40} which offers a distinct advantage over MRI in localizing the etiology, intra-articular or extra-articular.¹⁴ The iliopsoas tendon can cause several painful conditions such as iliopsoas bursitis, distal iliopsoas strain, and partial or complete tears and is often involved in snapping hip.^{8,58} The snapping can be caused by impingement of the iliopsoas tendon on the ilipubic eminence.^{8,58} Two recent studies illustrate the benefit of dynamic examination and provide alternative mechanisms for snapping hip.^{12,58} In 1 study, the dynamic evaluation showed that the snapping was caused by the tendon, on the deep aspect of the muscle, rolling with movement and becoming embedded within the substance of the muscle belly, producing a snap both as the rolling occurred and on the return to the normal position.⁵⁸ In the second study, the snapping was actually due to a rotational mechanism between the psoas tendon and the medial part of the iliacus muscle. The psoas tendon snaps against the superior pubic

Figure 13. Partial tear of the gluteus minimus. Transverse sonographic image of the greater trochanter (GT) shows an anechoic area consistent with a partial tear of the gluteus minimus (arrow) at the insertion onto the anterior facet.

ramus as the hip returns to a neutral position from flexion-abduction-external rotation.¹²

Intra-Articular Conditions

Sonography is the modality of choice for detecting intra-articular fluid collections in the hip joint (Figure 14),³⁵ the most common sign of pathology in both native and prosthetic hips.¹⁶ In children, capsular distension is defined as 2 mm of separation of the anterior and posterior capsule layers or total capsular distance distension greater than 5 mm, measured from the femoral neck to the outer margin of the capsule, including both anterior and posterior capsule layers.⁴⁵ In adults, current guidelines suggest using 7 mm of total capsular distension.²⁵ Many studies have shown that asymmetry of at least 1 mm between a patient's hips is the most important finding indicating an effusion.^{18,25,43,48}

Sonographic evaluation of a joint effusion can be complicated by hypoechoic synovial thickening, mimicking an effusion, or by a hyperechoic effusion caused by debris, mimicking synovial thickening.^{16,57} If hyperemia is noted with Doppler examination, it is due to synovial hyperemia, and active synovitis is confirmed. Unfortunately, because of the synovium's deep position within the joint, a lack of hyperemia does not always rule out active synovitis.^{35,57}

Labral tears of the hip occur with femoroacetabular impingement, hip dysplasia, trauma, capsular laxity, and joint degeneration (Figure 15).²³ Paralabral cysts identified with ultrasonography strongly implied a labral tear.²⁸

Ultrasonography has a high positive predictive value for labral tears, ranging from 88% to 94%.^{30,51,52} However, the very low sensitivities for detecting labral tears suggest that US cannot currently be used to rule out labral pathology. The low sensitivity is partially because of the fact that only the anterior superior labrum is satisfactorily visualized with ultrasound.^{32,37} The anterior superior labrum is the portion of the labrum that is

Figure 14. Hip joint effusions. (a) Longitudinal sonographic image of the left hip joint shows a simple effusion measuring 14.2 mm. (b) Another patient with a hip effusion. A, acetabulum; F, femur.

most commonly injured.^{4,15,17,26,29} Compared with arthroscopy, the sensitivity and specificity were 82%, and 60%, respectively, for US and 91% and 80%, respectively, for MR arthrography, which indicates that sonography is useful in anterosuperior labral tears but has less diagnostic ability than MR arthrography. There is a high rate of agreement (89%) between MR and US for determining the type of tear.²¹

Ultrasonography's real-time and interventional capabilities can confirm labral tears. During an intra-articular injection, the injected fluid and echogenic microbubbles it contains outline the labrum and provide a "sonoarthrographic effect" with a fluid interface along the labral boundaries. If a labral tear is present, the fluid fills the defect, which helps make tears more visible. However, a limitation is that the injected fluid does not always extend superiorly to fill a labral tear, and thus, this technique cannot be used to rule out a tear.⁴⁹

Theoretically, US offers potential for evaluation of calcified and noncalcified intra-articular bodies. However, a recent consensus paper from the European League Against Rheumatism (EULAR) found that US was poor at detecting loose bodies.²⁴

Intervention/Treatment

Previous studies have shown that accuracy is typically poor for blind injections of superficial joints.²² Sonographic-guided intra-articular hip injections are superior to computed tomography or fluoroscopic-guided because they show the femoral neurovascular structures well, do not involve radiation, are relatively inexpensive, and facilitate short procedure time.⁴² US-guided hip injections can

Figure 15. Labral tear demonstrated on sagittal oblique ultrasound view. The tear was later confirmed on magnetic resonance arthrography. F, femoral head; A, acetabulum; arrows, labral tear.

Figure 16. Ultrasound-guided hip injection. A sagittal oblique view of the femoral acetabular joint was used to guide a 2.5-inch spinal needle (large open arrows) through the iliofemoral ligament and into the joint capsule. A, acetabulum; F, femoral head; open arrows, needle track; X, injection target at femoral head-neck junction.

be performed on patients with radiation risk, such as adolescents and pregnant women (Figure 16).⁵⁰

Sonography can be used in the evaluation and treatment of suspected inflammation of the iliopsoas (see Figure 9), trochanteric, and subgluteal bursae. The advantage US provides is the ability to compress and change the shape of the bursa, assess the lining for synovial thickening and hyperemia, correlate location with patient symptoms, and assist with aspiration or injection. In addition, it can easily be used to aspirate soft tissue abscesses and for soft tissue biopsy, including synovial proliferative disorders.¹⁴ Recently, it has been used to guide shockwave therapy for conditions such as proximal hamstring tendinopathy.⁴

Strengths

The strengths of MSUS include accessibility, portability, point-of-care evaluation, noninvasiveness, lack of radiation, no requirement of intravenous dye, dynamic direct correlation with symptoms, comparison with an unaffected side, power Doppler,

enhanced spatial resolution, and low cost. The dynamic scanning capabilities of US are considered by some to be the single greatest advantage over other imaging modalities.¹⁷

Limitations

The greatest inherent limitation of US is the inability to completely access deeper anatomic areas, which is greatly affected by body habitus. The hip has MSUS limitations that can greatly limit its utility. Reduced resolution at greater depths is an inherent characteristic of ultrasound technology—there is greater dispersion of the ultrasound waves with increasing thickness of soft tissues. This results in less waves being reflected back to the transducer and ultimately a signal of lower resolution. In addition, US waves are unable to penetrate bone, which prevents its use in evaluating most intra-articular structures.¹³

CONCLUSION

Sports medicine clinicians continue to expand and enhance the use of US in the evaluation of acute injuries and chronic musculoskeletal pain. This growth and increased interest is largely driven by the potential of US to be the leading point-of-care tool for clinicians in the diagnosis and treatment of many acute and chronic musculoskeletal conditions.

REFERENCES

- Anderson MW, Kaplan PA, Dussault RG. Adductor insertion avulsion syndrome (thigh splints): spectrum of MR imaging features. *AJR Am J Roentgenol*. 2001;177:673-675.
- Anderson SE, Johnston JO, O'Donnel RO, Steinbach LS. MR imaging of sports-related pseudotumor in children: mid femoral diaphyseal periostitis at insertion site of adductor musculature. *AJR Am J Roentgenol*. 2001;176:1227-1231.
- Bass CJ, Connell DA. Sonographic findings of tensor fascia lata tendinopathy: another cause of anterior groin pain. *Skeletal Radiol*. 2002;31:143-148.
- Blankenbaker DG, De Smet AA. The role of ultrasound in the evaluation of sports injuries of the lower extremities. *Clin Sports Med*. 2006;25:867-897.
- Boutry N, Khalil C, Jaspert M, Marie-Helene V, Demondion X, Cotton A. Imaging of the hip in patients with rheumatic disorders. *Eur J Radiol*. 2007;63:49-58.
- Boyd KT, Pierce NS, Batt ME. Common hip injuries in sports. *Sports Med*. 1997;24:273-288.
- Brady BA, Beall DP, Martin HD. Clinical examination of the athletic hip. *Clin Sports Med*. 2006;25:199-210.
- Cardinal E, Buckwalter KA, Capellow WN, et al. US of the snapping iliopsoas tendon. *Radiology*. 1996;198:521-522.
- Cho KH, Park BH, Yeon KM. Ultrasound of the adult hip. *Semin Ultrasound MR*. 2000;21:214-230.
- D'Agostino MA, Said-Nahal R, Hacquard-Bouder C, Brasseur JL, Dougados M, Breban M. Assessment of peripheral enthesitis in the spondylarthropathies by ultrasonography combined with power Doppler: a cross-sectional study. *Arthritis Rheum*. 2003;48:523-533.
- DeAngelis NA, Busconi BD. Assessment and differential diagnosis of the painful hip. *Clin Orthop Relat Res*. 2003;(406):11-18.
- Deslandes M, Guillin R, Cardinal E, Hobden R, Bureau NJ. The snapping iliopsoas tendon: new mechanisms using dynamic sonography. *AJR Am J Roentgenol*. 2008;190:576-581.
- Ebell MH, Siwek J, Weiss BD, et al. Strength of Recommendation Taxonomy (SORT): a patient-centered approach to grading evidence in the medical literature. *Am Fam Physician*. 2004;69:548-556.
- Finlay K, Friedman L. Ultrasonography of the lower extremity. *Orthop Clin North Am*. 2006;37:245-275.
- Fitzgerald RH Jr. Acetabular labrum tears: diagnosis and treatment. *Clin Orthop Relat Res*. 1995;311:60-68.
- Friedman T, Miller TT. MR imaging and ultrasound correlation of hip pathologic conditions. *Magn Reson Imaging Clin N Am*. 2013;21:183-194.
- Girish G, Finlay K, Landry D, et al. Musculoskeletal disorders of the lower limb—ultrasound and magnetic resonance imaging correlation. *Can Assoc Radiol J*. 2007;58:152-166.
- Iagnocco A, Filippucci E, Meenagh G, et al. Ultrasound imaging for the rheumatologist III. Ultrasonography of the hip. *Clin Exp Rheumatol*. 2006;24:229-232.
- Jamadar DA, Jacobson JA, Morag Y, et al. Sonography of inguinal region hernias. *AJR Am J Roentgenol*. 2006;187:185-190.
- Janzen DL, Partridge E, Logan PM, Connell DG, Duncan CP. The snapping hip: clinical and imaging findings in transient subluxation of the iliopsoas tendon. *Can Assoc Radiol J*. 1996;47:202-208.
- Jin W, Kim KI, Rhyu KH. Sonographic evaluation of anterosuperior hip labral tears with magnetic resonance arthrographic and surgical correlation. *J Ultrasound Med*. 2012;31:439-447.
- Jones A, Regan M, Ledingham J, Patrick M, Manhire A, Doherty M. Importance of placement of intra-articular steroid injections. *BMJ*. 1993;307:1329-1330.
- Kelly BT, Weiland DE, Schenker ML, Philippon MJ. Arthroscopic labral repair in the hip: surgical technique and review of the literature. *Arthroscopy*. 2005;21:1496-1504.
- Klauser AS, Tagliafico A, Allen GM, et al. Clinical indications for musculoskeletal ultrasound: a Delphi-based consensus paper of the European Society of Musculoskeletal Radiology. *Eur Radiol*. 2012;22:1140-1148.
- Koski JM, Antilla PH, Isomaki HA. Ultrasonography of the adult hip joint. *Scand J Rheumatol*. 1989;18:113-117.
- Lage LA, Patel JV, Viller RN. The acetabular labral tear: an arthroscopic classification. *Arthroscopy*. 1996;12:269-272.
- Larkin B. *The Hip Pelvis in Sports Medicine and Primary Care*. New York, NY: Springer; 2010.
- Mervak BM, Morag Y, Marcantonio D, Jacobson J, Brandon C, Fessell D. Paralabral cysts of the hip: sonographic evaluation with magnetic resonance arthrographic correlation. *J Ultrasound Med*. 2012;31:495-500.
- McCarthy JC, Busconi B. The role of hip arthroscopy in the diagnosis and treatment of hip disease. *Orthopedics*. 1995;18:753-756.
- Mitchell B, McCrory P, Brukner P, O'Donnell J, Colson E, Howells R. Hip joint pathology: clinical presentation and correlation between magnetic resonance arthrography, ultrasound, and arthroscopic findings in 25 consecutive cases. *Clin J Sport Med*. 2003;13:152-156.
- Morelli V, Weaver V. Groin injuries and groin pain in athletes: part 1. *Prim Care*. 2005;32:163-183.
- Naredo E, Uson J, Acebes C, et al, eds. *Joint Ultrasonography. Sonoanatomy and Examination Technique*. Barcelona, Spain: Euromedicine; 2007:134-145.
- Nazarian LN. Musculoskeletal ultrasound applications in the hip. *J Dance Med Sci*. 2011;15:173-176.
- Nazarian LN. The top 10 reasons musculoskeletal sonography is an important complementary or alternative technique to MRI. *AJR Am J Roentgenol*. 2008;190:1621-1626.
- Nestorova R, Vlad V, Petranova T, et al. Ultrasonography of the hip. *Med Ultrasound*. 2012;14:217-224.
- Okayama A, Futani H, Kyo F, Maruo S, Koezuka A, Kinoshita G. Usefulness of ultrasonography for early recurrent myositis ossificans. *J Orthop Sci*. 2003;8:239-242.
- O'Neill J, Girish G. The adult hip. In: O'Neill, ed. *Musculoskeletal Ultrasound—Anatomy and Technique*. New York, NY: Springer Science Business Media; 2008:155-178.
- Orchard J, Seward H. Epidemiology of injuries in the Australian Football League, seasons 1997-2000. *Br J Sports Med*. 2002;36:39-45.
- Pedret C, Balias R, Barceló P, et al. Isolated tears of the gracilis muscle. *Am J Sports Med*. 2011;39:1077-1180.
- Pelsser V, Cardinal E, Hobden R, Aubin B, Lafortune M. Extra-articular snapping hip: sonographic findings. *AJR Am J Roentgenol*. 2001;176:67-73.
- Piscano RM, Miller TT. Comparing sonography with MR imaging of apophyseal injuries of the pelvis in four boys. *AJR Am J Roentgenol*. 2003;181:223-230.
- Pourbagher MA, Ozalay M, Pourbagher A. Accuracy and outcome of sonographically guided intra-articular sodium hyaluronate injections in patients with osteoarthritis of the hip. *J Ultrasound Med*. 2005;24:1391-1395.
- Qvistgaard E, Torp-Pedersen S, Christensen R, Bliddal H. Reproducibility and inter-reader agreement of a scoring system for ultrasound evaluation of hip osteoarthritis. *Ann Rheum Dis*. 2006;65:1613-1619.
- Reid DC. Prevention of hip and knee injuries in ballet dancers. *Sports Med*. 1988;6:295-307.
- Robben SG, Lequin MH, Diepstraten AF, den Hollander JC, Entius CA, Meradji M. Anterior joint capsule of the normal hip and in children with transient synovitis: US study with anatomic and histologic correlation. *Radiology*. 1999;210:499-507.
- Robinson P. Ultrasound of groin injury. In: Mc-Nally EG, ed. *Practical Musculoskeletal Ultrasound*. Philadelphia, PA: Elsevier Churchill Livingstone; 2005:309-327.

47. Robinson P, Barron DA, Parsons W, Grainger AJ, Schilders EM, O'Connor PJ. Adductor-related groin pain in athletes: correlation of MR imaging with clinical findings. *Skeletal Radiol*. 2004;33:451-457.
48. Schmidt WA, Schmidt H, Schicke B, Gromnica-Ihle E. Standard reference values for musculoskeletal ultrasonography. *Ann Rheum Dis*. 2004;63:988-994.
49. Sofka CM, Adler RS, Danon MA. Sonography of the acetabular labrum: visualization of labral injuries during intra-articular injections. *J Ultrasound Med*. 2006;25:1321-1326.
50. Sofka CM, Saboeiro G, Adler RS. Ultrasound-guided adult hip injections. *J Vasc Interv Radiol*. 2005;16:1121-1123.
51. Troelsen A, Jacobsen S, Bolvig L, Gelineck J, Romer L, Soballe K. Ultrasound versus magnetic resonance arthrography in acetabular labral tear diagnostics: a prospective comparison in 20 dysplastic hips. *Acta Radiol*. 2007;48:1004-1010.
52. Troelsen A, Mechlenburg I, Gelineck J, Bolvig L, Jacobsen S, Soballe K. What is the role of clinical tests and ultrasound in acetabular labral tear diagnostics? *Acta Orthop*. 2009;80:314-318.
53. Vingard E, Alfredsson L, Goldie I, Hogstedt C. Sports and osteoarthritis of the hip. An epidemiologic study. *Am J Sports Med*. 1993;21:195-200.
54. Watkins J, Peabody P. Sports injuries in children and adolescents treated at a sports injury clinic. *J Sports Med Phys Fitness*. 1996;36:43-48.
55. Weaver JS, Jacobson JA, Jamadar DA, Hayes CW. Sonographic findings of adductor insertion avulsion syndrome with magnetic resonance imaging correlation. *J Ultrasound Med*. 2003;22:403-407.
56. Westacott DJ, Minns JI, Foguet P. The diagnostic accuracy of magnetic resonance imaging and ultrasonography in gluteal tendon tears—a systematic review. *Hip Int*. 2011;21:637-645.
57. Weybright PN, Jacobson JA, Murry KH, et al. Limited effectiveness of sonography in revealing hip joint effusion: preliminary results in 21 adult patients with native and postoperative hips. *AJR Am J Roentgenol*. 2003;181:215-218.
58. Winston P, Awan R, Cassidy JD, Bleakney RK. Clinical examination and ultrasound of self-reported snapping hip syndrome in elite ballet dancers. *Am J Sports Med*. 2007;35:118-126.

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