Developmental Dysplasia of the Hip

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Developmental dysplasia of the hip (DDH) is a congenital condition of the hip joint that occurs once in every 1000 live births.[1] The term DDH has replaced congenital dislocation of the hip because it better describes the full range of abnormalities that can occur in infants' hips. The cause is not completely understood, but there are many factors that put infants at a higher risk for DDH. Treatment is available, and early detection and diagnosis allow for simpler and much more effective treatment. For this reason, it is imperative to catch DDH as early as possible. Technologists often contribute to the diagnosis of this disorder by performing sonography, computed tomography (CT), magnetic resonance (MR) imaging or routine radiographs of the hips. This article will discuss the definition, causes, signs and treatment of DDH and explain how imaging technology is used in its diagnosis.

Definition

The hip joint is a ball-and-socket joint composed of the acetabulum and femoral head. In infants this joint can be shallow, allowing the head of the femur to slip in and out of the acetabulum. DDH is defined as "the result of the disruption in the normal relationship between the acetabulum and the femoral head."[2] When this disruption occurs, the femoral head can move partially or completely out of the acetabulum, resulting in subluxation or dislocation. With a hip subluxation, a portion of the femoral head makes contact with a portion of the acetabulum. When the hip is dislocated, the femoral head has no contact with the acetabulum. (See Fig. 1.)

Causes

Many factors are linked to DDH, but there is no definitive cause for this condition. Both genetic and environmental factors are involved. DDH has been strongly linked to sex. A study in the *Journal of the American Family Physician*[3] revealed that 80% of children with DDH are girls. It is thought that the added effects of estrogen produced in the female fetus increase ligamentous laxity, thus leading to dislocation. Some babies are very sensitive to the estrogen, which they also obtain from the mother, and it is thought that the lax ligaments could render the hips unstable. Likewise, it has been shown that genetics plays a part in as many as 33% of affected patients. It is interesting to note that 60% of DDH cases involve the left hip, 20% involve the right hip and 20% involve both hips.[3]

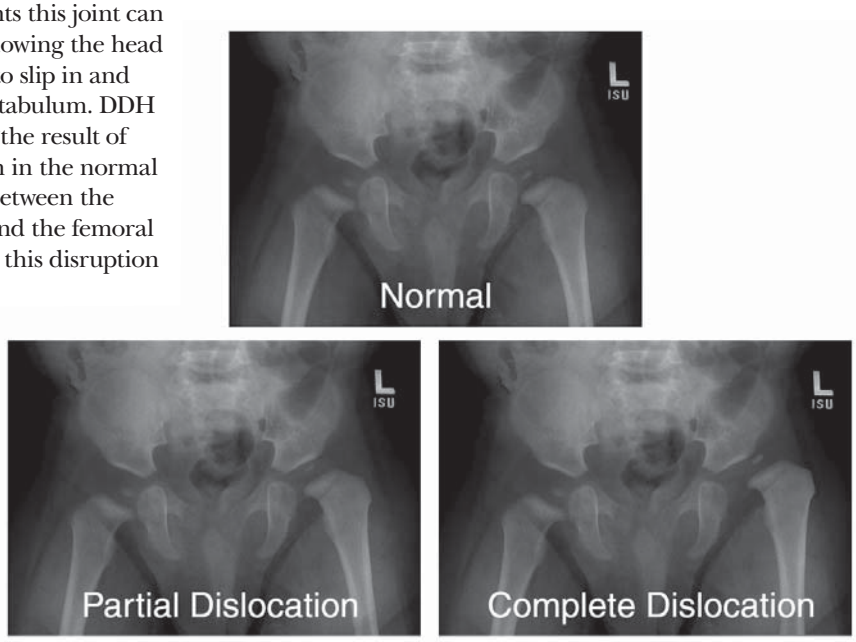

Fig. 1. *AP radiographs of the hip demonstrating a normal hip, partial dislocation and complete dislocation of the left hip.*

Environmental factors also are implicated. Some investigators postulate that a tissue-relaxing hormone that helps to loosen the mother's ligaments during childbirth might loosen the baby's joints as well. Researchers hypothesize that the size of the mother's uterus and her parity are other environmental factors that affect hip development. First-time pregnancies occur in a uterus that has not been stretched, thus providing limited room for the baby to move. Consequently, first-born babies are at a higher risk for developing DDH.

Breech delivery also can cause DDH and puts the baby at a higher risk because of the baby's position in the uterus.[1] According to Storer and Staggs,[3] breech babies are at higher risk because these infants can extend their knees with greater flexibility while in the uterus. This results in forces around the developing hamstring muscles that contribute to dislocations. Other causes are thought to be linked to syndromes such as metatarsus adductus, clubfoot deformity and congenital conditions.

Signs

Infants can have a variety of signs related to hip dysplasia. One common sign is the appearance of 1 leg being shorter than the other. This can cause an abnormal gait when the baby begins to walk. Likewise, the space between the infant's legs can appear wider than normal. Also, the leg with the dislocated hip can turn outward, and the folds in the skin of the thighs or buttocks can appear uneven. An audible sign of DDH is a "click" or "clunk" sound when the hips are manipulated by the pediatrician. Some of these signs can be noted at birth; however, if there are no outward manifestations, the pediatrician often uses screening maneuvers or medical imaging procedures to facilitate diagnosis.

Diagnosis

Physical Screening Methods

Physical examination is an important method in the diagnosis of DDH. Pediatricians use 2 kinds of maneuvers to screen newborns. The Barlow and Ortolani maneuvers are known as the gold standards for DDH screening. The Barlow maneuver is used to determine if a hip can be dislocated. The pediatrician flexes and adducts the femurs while applying gentle pressure downward. This maneuver can displace an unstable hip from the acetabulum.

The second screening is called the Ortolani maneuver. It is used to reduce a dislocated hip. During this procedure, the pediatrician listens to the "hip click" while abducting the femur. This noise is the result of stretching and snapping of the joint capsule and tendons.[2] According to Hart, "When the test is positive, the femoral head will relocate into the acetabulum with a palpable and sometimes audible clunk."[1] An experienced physician can distinguish between the "click" and the "clunk" sounds. The clunk sound is indicative of an unstable hip.

These tests generally are used in infants younger than 4 months old. As infants mature, the Barlow and Ortolani maneuvers become less reliable. After this age, pediatricians use the Galeazzi sign to look for symptoms. This sign is an asymmetry of the skin caused by an apparent shortening of the thigh. It is most noticeable when the knees are flexed and held together. The pediatrician then compares the legs side by side. If 1 knee is in a lower position than the other, the femoral head is posterior to the acetabulum, indicating a dislocation. (See Fig. 2.)

Diagnostic Imaging Methods

Pediatricians often use several imaging modalities to help confirm and monitor DDH. These include ultrasound, CT, MR imaging and radiography. Sonography is preferred for infants who are 6 months old or younger because it is a safe, noninvasive method for imaging the hips. An advantage of sonography is that it uses sound waves instead of x-rays, so there is no exposure to ionizing radiation. Furthermore, "Ultrasonography is the study of choice to evaluate for DDH in infants younger than 6 months because it is capable of visualizing the cartilaginous anatomy of the femoral head and acetabulum."[3] It is more sensitive than the clinical examination and, unlike radiography, enables direct imaging of the cartilaginous portions of the femoral head and acetabulum. The disadvantage of ultrasound is that when the baby is 4 to 6 months old the femoral heads begin to ossify. This can result in overshadowing of the femoral head, which sometimes obscures the acetabulum. Because of this limitation, radiographs are recommended after 4 to 6 months of age.[4]

CT and MR are the imaging techniques of choice for postoperative hip evaluation. CT is useful in assessing the hip position, especially when a cast obscures part of the pelvis on radiographs. CT and MR images can be reconstructed into several orthogonal planes, providing another advantage to using these modalities. Occasionally, MR is used with arthrography to better show the soft tissues of the hip. Both modalities are reliable and can be used to determine the efficacy of reduction.

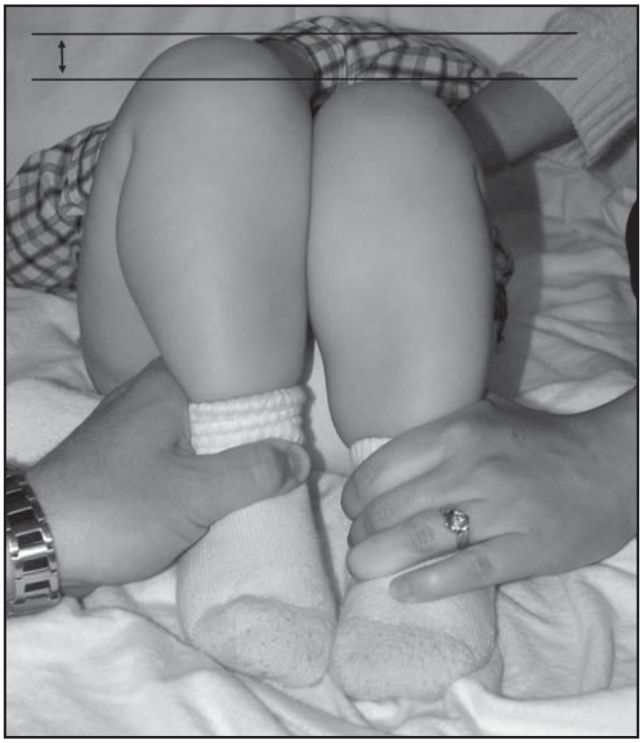

Fig. 2. *Galeazzi sign. This is a classic sign used to identify a unilateral hip dislocation. It is performed by placing the patient in a supine position with the hips and knees flexed. If the hip is dislocated, 1 leg appears shorter than the other, as in this example.*

Routine radiographs of the hips include an anteroposterior (AP) projection and an AP bilateral modified Cleaves method, commonly known to technologists as the "frog-leg" position. Radiologists use several reference lines and angles to evaluate radiographs of an infant's pelvis. One reference line is drawn horizontally through the triradiate cartilages of the pelvis and is called the Hilgenreiner line. Another line, called the Perkin line, is drawn perpendicular to the Hilgenreiner line along the lateral edges of the acetabula. The femoral head should lie in the lower medial quadrant formed by the Hilgenreiner and Perkin lines. When the femoral head lies within the superior or lateral quadrants, the hip is dysplastic. Another line, identified as the Shenton line, is defined by the superior border of the obturator foramen and the medial border of the femoral neck. Displacement of the hip joint is visible when there is a break in the Shenton line.[2] (See Fig. 3.)

Treatment

Treatment options vary depending on the infant's age, overall health, medical history, extent of the condition and tolerance for procedures or therapies. The goal of all treatments is to put the femoral head back into the socket of the hip so it can develop normally. The most common treatments are placement of a Pavlik harness, the use of traction, casting and surgery combined with casting. Each of these treatment options is discussed briefly.

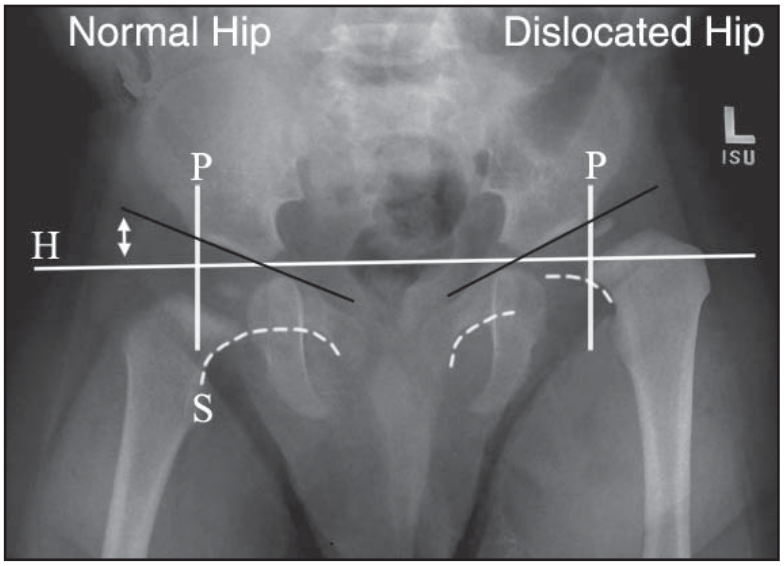

Fig. 3. *Reference lines used to evaluate DDH. Several radiographic measurements have been used to evaluate DDH. This radiograph demonstrates some of those lines and angles. The horizontal line labeled H is the Hilgenreiner line, drawn between the triradiate epiphyses. The 2 lines labeled P are the Perkin lines. They bisect the Hilgenreiner line at right angles, dividing each hip into 4 quadrants. In a normal hip, the proximal medial portion of the femur should be in the lower medial quadrant. If the head of the femur has begun to ossify, it also should be visualized in the lower medial quadrant. The double arrow signifies the acetabular index, which is the angle between the Hilgenreiner line and the triradiate epiphysis and acetabulum. This angle decreases with age and should be less than 20° by the age of 2 years. The Shenton line (S) is drawn from the medial border of the femoral neck to the inferior border of the pubic rami and should create a smooth arc. If the arc is disrupted, as is shown in the left hip, it indicates a hip subluxation or dislocation.*

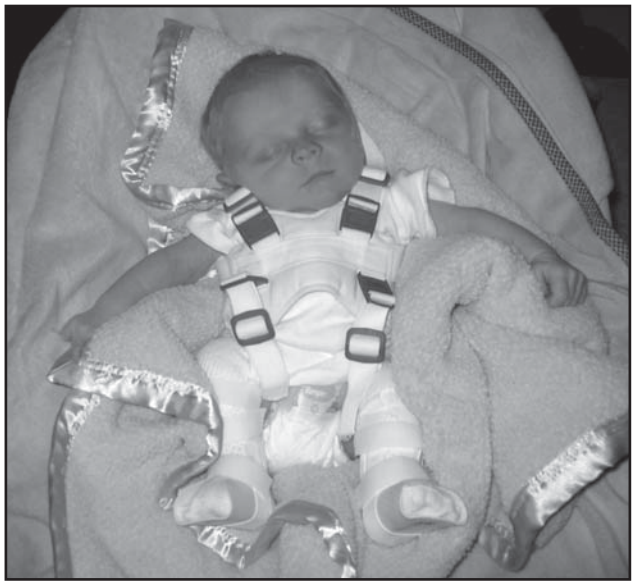

Fig. 4. *The Pavlik harness is used in the treatment of DDH in infants. It holds the hips in the proper position so that they will form properly.*

Fig. 5. *The spica cast is applied to stabilize the hips after a reduction. It is made of fiberglass and wraps around the body from the midtorso to the distal legs.*

The Pavlik Harness

The Pavlik harness is a brace that maintains the hips in flexion and abduction. (See Fig. 4.) By flexing the legs upward, with the femurs abducted, the hips are held in the proper position for healing. This allows the hips to form normally and reduces the possibility of subluxation or dislocation. The harness is worn full time for 6 weeks, then part time for an additional 6 weeks. Radiographs are used to monitor the hip during this period.

Traction

Traction, another treatment option, applies force to stretch certain parts of the body. It consists of pulleys, strings, weights and a metal frame attached to a bed. Traction can be used for up to 6 weeks or longer. A study performed in 2000 of 145 children suggested that traction should precede the application of the Pavlik harness.[5] Again, radiographs are used to monitor treatment.

Surgery and Casting

When other treatments are not successful or when DDH is diagnosed after a child is 18 months old, surgery may be required. The operation is called a hip reduction surgery and can be performed as an open or closed reduction. With closed reduction, the surgeon moves the head of the femur back into the socket. Frequently, the reduction is evaluated with an arthrogram and a postreduction CT scan. After successful manipulation, a spica cast is put on the baby. (See Fig. 5.) This cast is changed from time to time to accommodate the baby's growth and remains in place for 3 to 6 months until the hip returns to normal.

If the closed reduction procedure is unsuccessful, then an open surgical reduction is performed. During open reduction, the tissues are lengthened and the femoral head is placed into the acetabulum. The baby wears a cast for 6 to 8 weeks. As the child grows and develops, additional surgeries may be necessary because hip dislocations can recur.

Radiographic Imaging Methods

Working with pediatric patients can be a challenging experience for all technologists. Because of the young age of children undergoing radiography for DDH, most will not be cooperative. For this reason, proper immobilization techniques might be necessary. The technologist should properly prepare the room before the patient and his or her parent or caregiver enter. Lead aprons, gonadal contact shields, lead gloves, sponges, sandbags, Velcro bands and tape should be readily available and within arm's reach. The technologist should drape the table with a clean sheet and have blankets

nearby to cover the child when he or she is not being imaged. Align the x-ray tube and image receptor (IR), and then make any final adjustments before the exposure is made. These preparations will help ensure the smooth flow of the procedure.

Many children with DDH require multiple follow-up radiographs; it is paramount that technologists adhere to the ALARA (as low as reasonably achievable) principle. Technique charts should be consulted before any exposures. This will reduce the need for repeat examinations due to an improper selection of technical factors. Even though this procedure requires imaging the pelvic anatomy, gonadal contact shielding should be used. When imaging boys, the gonadal contact shield should cover the scrotum without obscuring the symphysis pubis. Gonadal protection also should be used when imaging girls, with the exception of the very first AP projection for the initial examination of the hips and pelvis.[6] Place the gonadal contact shield directly under the umbilicus with the widest part of the shield centered to the midline, level with the anterior superior iliac spines (ASISs). (See Fig. 6.) Children should never be left unattended in the room at any time. If assistance is required holding the child for the exposure, a lead apron and lead gloves must be provided for proper protection, according to ALARA principles.

Typically, a routine radiographic examination of a child with suspected DDH consists of 2 images: an AP pelvis and a bilateral frog leg. Both hips should be imaged for comparison and measurement purposes. Diapers and clothing must be removed from the pelvic area to eliminate artifacts. For the AP pelvic projection, place the child on the x-ray table and position the IR beneath the buttocks. The central ray (CR) of the tube should be perpendicular to the IR, centered midway between the level of the ASISs and the symphysis pubis at a 40-inch source-to-IR distance (SID). Carefully rotate the patient's feet internally 15º to 20º and properly immobilize them before exposure. (See Fig. 7.)

The second image is achieved by placing the plantar surfaces of the feet together and abducting both femurs 40º to 45º from the midline. (See Fig. 6.) Again, the CR is perpendicular to the IR, with the CR entering slightly above the symphysis pubis at a 40-inch SID. If the patient is able to cooperate, respiration should be suspended for both radiographic exposures. If the child is not cooperative, the technologist should watch the patient and perform the exposure when appropriate to eliminate motion artifacts.

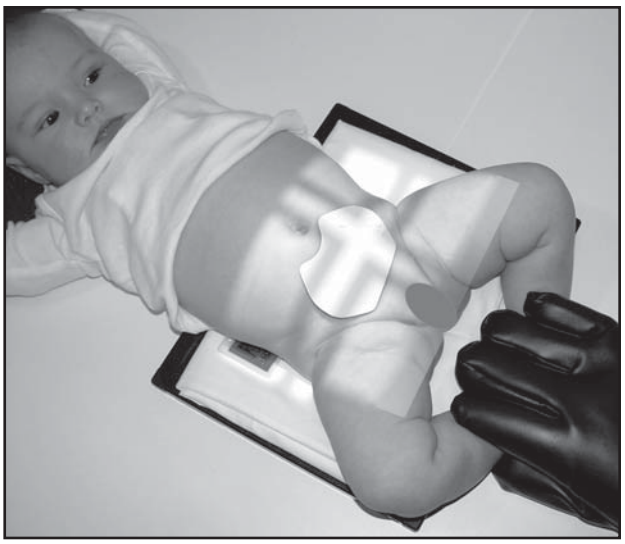

Fig. 6. *Patient positioned in the bilateral modified Cleaves method, or frog-leg position, with gonadal contact shielding applied.*

Conclusion

Hip dysplasia continues to be a frequently missed diagnosis in pediatric practice, even with increased awareness about DDH. Newborn screening for DDH allows early detection of this condition, and starting treatment immediately after birth improves the baby's prognosis. Early detection is associated with a more successful outcome and less invasive treatment. Medical imaging plays an important role in diagnosing DDH and supporting treatment. Therapy consists of using a Pavlik harness, traction, casting or a combination of these methods. If these treatments are unsuccessful, then surgery might be necessary. If DDH is left untreated, the hip joint can grow abnormally, resulting in a permanent disability.

Perhaps the methods discussed in this article will come to mind the next time you are asked to perform a hip radiograph to rule out DDH. ◆

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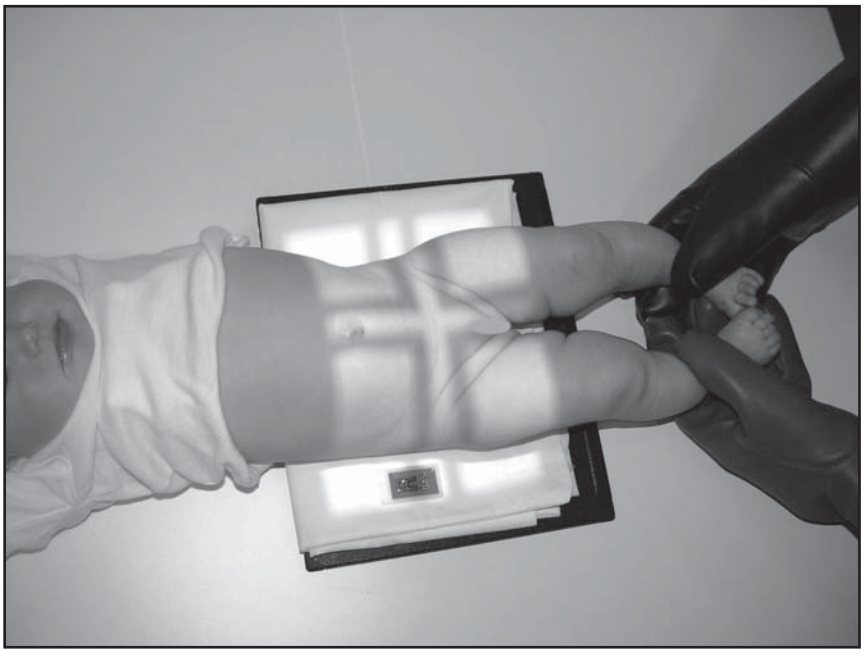

Fig. 7. *Patient positioned for an AP pelvis projection. The legs have been inverted 15° to 20°. Gonadal contact shielding should not be used for the very first examination.*

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