Continuing Medical Education

The Lower Extremity Orthopedic Evaluation of the Infant

Early examination can minimize the effects of both orthopedic and neurologic conditions.

Objectives

After reading this article, the physician should be able to:

1) Perform an orthopedic examination on a pre-walking child

2) Understand the purpose and significance of each part of the examination

3) Differentiate between normal and abnormal orthopedic findings

4) Develop an appreciation for the significance of abnormal neurologic findings

5) Recognize the presenting appearance of common lower extremity deformities

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*Following this article, an answer sheet and full set of instructions are provided (p. 180).—**Editor***

Mark A. Caselli, DPM

The earlier the detection of an orthopedic problem, the better the chances of making a significant change in the prognosis of that condition. Many lower extremity orthopedic pathologies are best treated during the earliest period of life, that of infancy, before ambulation begins. In order to detect an orthopedic problem at this stage of life, the podiatric practitioner must be familiar with both the method of performing a thorough lower extremity evaluation as well as the possible pathologies that might be present. The necessary parts of this orthopedic evaluation include a medical history, family history, musculoskeletal examination, and neurologic examination.

The earlier the detection of an orthopedic problem, the better the chances of making a significant change in the prognosis of that condition.

A prenatal, intrapartum, and postnatal history is of paramount importance in ruling out neuromotor disease. The prenatal history should include family as well as maternal history. It is important to ascertain whether or not other members of the family have lower extremity orthopedic problems. Pregnant women at both extremes of the age group, under 16 and over 30, are in the obstetric high-risk group, which may lead to neurologic deficit in the new-

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born. Previous obstetric history, including number of pregnancies, miscarriages, birth weight, and health status of other children, should be obtained.

A history of having taken any medicines or home remedies during pregnancy as well as drug abuse, both narcotic and non-narcotic, is important since they may affect the fetus and the newborn. Length of gestation information should be obtained because premature and post-mature infants are most at risk. The mother's own measure of fetal activity is sometimes helpful in assessing maturity and vigor of the fetus.

Intrapartum events, such as fetal heart rate, rupture of membranes, length of labor, and other complications of labor and delivery should be obtained. The history of the immediate postnatal course, including fetal distress and hypoxic episodes, can indicate injury to the central nervous system. Birth weight and length of hospital stay is important and easily-obtained historical information.

Figure 1: Examination of the lumbosacral region for spina bifida

Examination of the Spine

The infant is placed on his abdomen. The hand is run lightly over the spine, and palpitation for scoliosis and kyphosis is performed. Possible spina bifida is sought (Figure 1). Congenital scoliosis is associated with congenital vertebral anomalies. Some children with congenital scoliosis show curvature at birth, but many do not. The anomalies and variations in development of the vertebrae may be single or multiple, and may be associated with other anomalies, especially in the ribs, and are frequently combined with spina bifida.

Minor abnormalities of development of the lubrosacral and sacral region are common. Spina bifida occurs in one of about every 1,000 live births. Minor degrees of spina bifida affecting the fifth lumbar or first sacral vertebrae are seldom of any clinical significance. More severe abnormalities of development of the vertebral column are often associated with paralytic defects and deformities in the lower limb. Vertebral agenesis, though uncommon, has been seen to range from the absence of only the lower coccygeal segment to absence of lumbar and sacral vertebrae.

Figure 2: Ectrodactly combined with syndactyly

Spina Bifida

Spina bifida can be grouped into three clinical entities:

1) The first is simple meningocele, which may be present anywhere in the spine, though it is most common in the lubosacral and sacral regions. It presents as a swelling on the back covered by skin or sometimes by a thin membrane. It is flaccid and capable of being transilluminated. There is a failure of fusion of the vertebral arches with cystic distention of the meninges. The swelling consists of a herniation of dura and arachnoid, filled with cerebral spinal fluid. The lower extremities may show no deformity and normal spontaneous movements can often be elicited in all muscles in the lower limbs. There may be no abnormal reflexes or abnormal neurologic signs.

Figure 3: Polydactyly

2) In open myelomeningocele, the most common site is the lumbar or lumbosacral spine. In patients seen on the first day of life, there is an oval area of red, glistening tissue constituting the dysplastic portion of the spinal cord at the center of the lesion. Surrounding it and attached to its edges is a thin epithelial membrane that merges peripherally with the skin. The skin is often thin or shows pigmentation in the region adjoining its junction with the membranous area. There is a failure of fusion of verebral arches, and the spinal cord is opened out as a neural plaque that lies almost flush with the surface of the body.

The lower limbs may be undeformed in about 50 percent of the children born with myelomeningocele, or may show one or more of a variety or deformities, depending on cord level; at the hips, knees, or feet, including fixed or non-fixed flexion, adduction, and lateral rotation of the hip; fixed or limited flexion of the knee or fixed recurvatum; equinus, equinovarus, calcaneovarus, calcaneus, calcaneovalgus, equinovalgus, vertical talus de-

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Figure 4: Evaluation of legs for excessive thigh skin folds that can indicate a dislocated hip

formities, or clawing of the toes. The deformity is frequently bilateral and symmetrical.

3) Closed myelomeningocele and spinal bifida occulta present with a lipomatous or cystic swelling, abnormal pigmentation, coarse hair formation, or a dermal sinus on the lower back. The vertebral arches are unfused, but there is no gross distention of the meninges. The spinal cord and its roots may or may not be abnormal. It occurs most frequently at the fifth lumbar or first sacral level.

Figure 6: The foot is slightly externally rotated on the leg when the knee is held in a straight anterolateral position

Figure 5: Hip abduction is examined for limitation of motion

Examination of the Lower Extremities

The infant is placed on his back and any gross abnormalities in the extremities are noted. These may include congenital absence of part or all of the femur, fibula, or tibia, ectrodactly (lobster claw foot in which there is an absence of two or three digits) (Figure 2), absence of metatarsals or digits, syndactly, polydactly (Figure 3), or fractures.

The infant is then placed on his abdomen. A difference in the skin folds of the two thighs should be sought (Figure 4). The presence of excessive folds on one side is not a completely reliable sign, but it does point to the possibility of a dislocated hip on that side.

The baby is then turned over on his back to see if the legs are equal in length. Hip motion is tested and any limitation of motion is determined (Figure 5). Piston mobility of the hips is tested by pushing the thighs up and down with the hip flexed; mobility greater than a half inch means that the hip is dislocated.

Ortolani's test (as modified by Barlow) is then performed. The thigh is turned in the externally rotated position with the hip abducted; if the hip is dislocated, there is a click as the femur slides in and out of the acetabulum. In young infants, if the hip is all the way out, the Ortolani sign may not be obtained. Other clinical signs of possible hip dysplasia include the following: 1) the inguinal crease is deeper on the normal side; 2) the buttock contour is flatter and wider on the involved side (appearance of a lopsided anchor); 3) the flexed knee height is at different levels, lower on the involved side.

Radiologic and ultrasound examination in the infant should be used to confirm the diagnosis.

Congenital Dislocation of the Hip

There are three forms of congenital dislocation of the hip. The bony and cartilaginous tissues of the acetabulum can be malformed at birth resulting in congenital acetabular dysplasia. In this condition the head of the femur is severely displaced and the acetabulum represented by a dimple on the side of the pelvis. Congenital dislocation of the hip can also be secondary to a muscular or neuromuscular abnormality, as in myelomeningocele, or the dislocation can be due to capsular laxity.

The range of internal and external rotation of the hip should be tested. The infant should present with greater external than internal hip rotation. Greater internal hip rotation is associated with femoral antetorsion which can result in in-toe gait. Any indica-

Figure 7: Evaluation of ankle plantarflexion

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tion of spasticity, fracture, or other anomaly should also be noted.

Knee motion is examined next. If the knee cannot be flexed, it may be a sign of posterior dislocation of the knee. If the knee cannot be extended, it may be a sign of spasticity resulting from upper motor neuron damage such as seen in cerebral palsy. The presence of an anterior angulation of the tibia can be a sign of pending congenital pseudoarthrosis of the tibia. There can be a posterior angulation, which is not as serious a deformity. Bowing of the tibia in the infant is present in achondroplasia. When the knee of the newborn is held in a straight anterolateral position, the foot will be found slightly externally rotated by not more that 10 degrees (Figure 6). The absence of this relationship may indicate either internal or external tibia torsion.

Figure 8: Evaluation of ankle dorsiflexion

In the normal foot of the newborn the heel is in neutral position in relation to the ankle. On plantar-flexion, there are 50 degrees of motion from the neutral position (Figure 7). The skin should not appear tight on the anterior aspect of the ankle and the midtarsal region of the foot. There is 30-45 degrees of relative passive dorsiflexion from the neutral right angle position (Figure 8). The foot can be everted and inverted passively from the neutral position between 20 to 30 degrees in each direction (Figures 9 a and b).

Figure 9: (a) Determination of eversion of the foot (b) Determination of inversion of the foot

Figure 10: Congenital metatarsus adductus

On radiographic examination, the following bones are visible: The talus, the calcaneus, the cuboid, all of the metatarsals, and all of the phalanges except for the distal two phalanges of the fifth toe. There are four major congenital foot disorders that produce a significant variation from the normal foot. These conditions are metatarsus adductus, or metatarsus varus, calcaneovalgus, convex pes valgus, and talipes equinovarus.

Congenital Metatarsus Adductus

Congenital metatarsus adductus or metatarsus varus (the latter being a more severe form of the former) is a condition in which the anterior part of the foot deviates medially and there is a varus angulation at the tarsometatarsal joints (Figure 10). The heel may be in neutral or valgus position. When the heel is in valgus, the varus deformity of the forefoot is invariably severe. To diagnose this condition, the V-finger test can be used. Place the infant's foot between the first two fingers and look for a C curve (Figures 11a and b). Sometimes there is only a varus of the first metatarsal where the big toe alone is separated and curved inward (metatarsus varus primus).

Metatarsus adductus problems are usually not noticed before 4 to 8 weeks, unless they are extreme at birth. In an antereoposterior radiographic view, there is a varus deviation of all five metatarsals, and the angle between the talus and calcaneus (angle of kite) is often more than 35 degrees. The incidence of congenital metatarsus adductus has increased fourfold in the past 25 years.

Calcaneovalgus Foot

The type of flatfoot deformity most frequently found at birth is the calcaneovalgus foot. The foot lies in acute extension and slight valgus. The dorsal surface of the foot is in contact with the anterior surface of the lower leg (Figure 12). Dorsiflexion is practically absent at birth and plantar flexion is limited to the neutral position with the anterior soft tissue structures appearing tight and preventing further plantar flexion of the foot (Figure

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Figure 11: (a) "V"-finger test demonstration of a normal foot (b) "V"-finger test demonstration of metatarsus adductus

13). The heel, as well as the entire foot, is in a valgus position. The radiographic examination shows definite mal-alignment of the visible tarsal bones. In the lateral radiogram of a normal foot, the line bisecting the talus transverses through the upper half of the cuboid and there is no overlap between the talus and calcaneus.

In the calcaneovalgus foot, the talus is plantar-flexed, and the line bisecting the talus extends below the plantar surface of the cuboid. In addition, there is overlapping of the head of the talus and the anteriorsuperior edge of the calcaneous.

Congenital Convex Pes Valgus

Congenital convex pes valgus (congenital rigid flatfoot) is a condition that presents an appearance at birth similar to congenital calcaneovalgus, and thus must be differentiated. The distinctive features of congenital rigid flatfoot are as follows: 1) The foot has a C-shaped appearance and there is a valgus relationship of the rear portion of the foot with the mid and forefoot. 2) The heel is not in valgus as in a calcaneovalgus condition, but is in a neutral position. 3) The heel is tilted downward in flexion. 4) The foot is only in mild dorsiflexion, and if the foot is dorsiflexed completely, a convexity on the plantar surface is produced (rocker bottom deformity)5) (Figure 14) The foot is rigidly fixed, and cannot be easily inverted on manipulation. 6) The head of the talus is palpable as a medioplantar prominence, but it cannot be easily reduced as in the calcaneovalgus foot.

Figure 12: Congenital calcaneovalgus foot deformity

Figure 13: Limitation of plantar flexion in a calcaneovalgus deformity

The only radiographic difference between the two types of feet is that the talus is plantar-flexed in the calcaneovalgus foot while it is vertical in the rigid flatfoot.

Talipes Equinovarus (Clubfoot)

Talipes equinovarus (clubfoot) constitutes about 25 percent for all congenital anomalies seen in clinics for crippled children, and occurs once in each 700 to 1,000 live births. It is twice as common in males and bilateral in about 50 percent of cases. The heel in this condition is in an equinus position with the tuberosity of the calcaneus pointing cephalad, forming a conspicuous prominence behind the ankle joint (Figure 15). The heel and the forepart of the foot are swung medially in inversion, with supination of the forepart. The forepart of the foot is adducted, supinated, and flexed on the hind part.

The total picture is one of equinus position of the entire foot with varus position of the heel in relation to the leg and varus position of the forepart of the foot in relation to the heel (Figure 16). This position of equinovarus is fixed and rigid and cannot be manually altered. A severe metatarsus adductus may simulate a clubfoot, but shows no fixed varus or fixed equinus position of the heel and therefore the heel can be manually placed into a valgus position and the foot easily dorsi-flexed.

Neurological Evaluation

Limb symmetry, muscle bulk, tone, strength, and reflexes should be compared on each side, both proximally and distally. Muscle strength can be tested in groups. In the lower limbs L1, 2, 3 supply the hip flexors (iliopsoas), L4, 5, S1 innervate the hip extensors (glutei), L2, 3, 4 supplies the knee extensors (quadriceps), L5, S1, 2 innervate the knee flexors (hamstrings), L4, 5 supplies ankle dorsiflexion (tibialis anteri-

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or), and S1, 2 plantar flexion (gastrocnemius). Ankle inversion is supplied by L4 nerve root and eversion by L5, S1 root.

Deep Tendon Reflexes

Individual deep tendon reflexes of the lower extremity should be performed as follows:

Patellar (Quadriceps) Reflex (Knee Jerk)

The leg is flexed to about midway between contraction and relaxation, approximately 120 degrees. One strikes the quadriceps tendon just below the patella, and the leg jumps into extension. In very strong reactions one may elicit the patella-adductor reflex, in which there is also a tendency to adduct the thigh. Loss of the patellar reflex is referred to as Westphal's sign, where there is interference with the reflex arc. The anterior crural nerve and second, third, and fourth lumbar segments are involved.

Progressive extension of the leg with successive tapping of the patellar tendon is due to failure of the leg to return to the resting position. This may occur in chorea and is called a pendular knee jerk. A normal contraction with delayed relaxation of the knee may occur in hypothyroidism.

Figure 14: Rocker bottom foot deformity seen in congenital convex pes valgus

Figure 15: Equinus position of the heel seen in talipes equinovarus

Achilles (Triceps Surae) Reflex (Ankle Jerk)

In young children, the foot is held at right angles to the leg, and the Achilles tendon is tapped. As the soleus and gastrocnemius contract, the foot goes into plantarflexion. This reflex is governed by the internal popliteal nerve, and first and second sacral segments.

UMN Damage

Upper motor neuron (UMN) damage characteristically produces weakness of extensor muscle groups in the upper limb and of the flexor groups in the lower limb with spasticity, hyperreflexia, and extensor plantar response. When spasticity is unilateral, the arm is held flexed and the leg extended. There is circumduction at the hip and the toes. When there is bilateral UMN damage, there is delayed gait which is characteristically scissored with increased adductor tone resulting in the knees rubbing when walking, coupled with plantarflexion and inversion of the feet. There may also be lordosis and a rather festinant precarious gait as is seen in cerebral palsy.

Damage to the basal ganglia produces tremor, increased tone (rigidity), slowed movement (hypokinesia) and flexed posture.

Figure 16: Bilateral talipes equinovarus

Cerebellar damage will result in slurred speech, nystagamus, incoordination in the upper and lower limbs, and a wide based ataxic gait.

Lower motor neuron disorders produce wasting, fasciculations (spontaneous contraction of motor units), hypotonia, weakness, arreflexia, and flexor plantar responses without sensory changes, e.g., anterior horn cell or motor root diseases. ■

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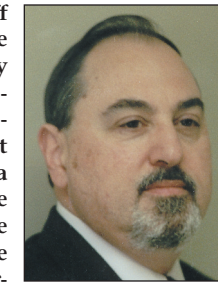

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EXAMINATION

Continuing Medical Education

See answer sheet on page 181.

1) The most important reason for examining the spine in a pre-walking infant is that:
   A) Spinal abnormalities may result in an asymmetric gait pattern and excessive pronation.
   B) Scoliosis should be treated before the child starts to walk.
   C) Spinal abnormalities may be responsible for severe hip, leg, and foot deformities.
   D) It promotes the appearance to parents that you are being thorough in your examination.

2) Which one of the following spinal abnormalities is the most pathologic?
   A) Kyphosis
   B) Meningocele
   C) Spina bifida occulta
   D) Open myelomeningocele

3) Ectrodactly is a congenital foot deformity in which the foot presents with:
   A) One or more accessory digits.
   B) The absence of two or three digits and often their associated metatarsals.
   C) A severe equinus and valgus deformity.
   D) Gigantism of the toes.

4) Asymmetry of the thigh folds may be an indication of:
   A) Cerebral palsy.
   B) A dislocated hip.
   C) A lower motor neuron disorder.
   D) A talipes equinovarus deformity.

5) Which one of the following conditions is not an etiological factor in creating a dislocated hip?
   A) Congenitally short femur.
   B) Malformed acetabulum
   C) Myelomeningocele
   D) Capsular laxity

6) Which one of the following is not an abnormal finding when evaluating the internal and external rotation of the hip?
   A) Spasticity
   B) Greater internal rotation than external rotation
   C) Greater external rotation than internal rotation
   D) Ecchymosis and swelling

7) A knee that cannot be flexed on examination may indicate:
   A) Severe ligamentous laxity
   B) Spasticity
   C) Posterior dislocation
   D) Hypotonia

8) When the knee of an infant is held in a straight anterolateral position, the position of the foot should be:
   A) Slightly externally rotated.
   B) Slightly internally rotated.
   C) Externally rotated 13 to 18 degrees.
   D) Internally rotated 13 to 18 degrees.

9) Which one of the following represents an abnormal foot range of motion in an infant?
   A) Ankle dorsi-flexion 30 degrees
   B) Ankle plantar-flexion 10 degrees
   C) Foot inversion 30 degrees
   D) Foot eversion 20 degrees

10) Congenital metatarsus adductus is a condition in which:
   A) The forefoot deviates laterally and is in varus
   B) The forefoot deviates medially and is in valgus
   C) The forefoot deviates medially and is in varus
   D) The forefoot deviates laterally and is in valgus

11) The heel position in a child with congenital metatarsus adductus is usually:
   A) Neutral or valgus
   B) Slight varus
   C) Severe varus
   D) In equinus

12) The type of flatfoot deformity most commonly found in the infant is:
   A) Convex pes valgus
   B) Peroneal spastic flatfoot
   C) Spastic equinovalgus
   D) Calcaneovalgus

13) The V-finger test is used to diagnose which one of the following conditions?
   A) Talipes equinovarus
   B) Convex pes planovalgus
   C) Metatarsus adductus
   D) Calcaneovalgus

14) Which one of the following, if any, is NOT typical of the radiographic signs of the calcaneovalgus foot?
   A) Plantar flexed talus
   B) Overlapping of the head of the talus and calcaneus
   C) Line bisecting talus transverses through upper half of cuboid
   D) All above are radiographic signs of a calcaneovalgus foot.

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EXAMINATION

(cont'd)

15) Which one of the following is NOT a term commonly used to describe a congenital convex pes valgus foot?
- A) Congenital flexible flatfoot
- B) Congenital rocker bottom foot
- C) Congenital vertical talus
- D) Congenital rigid flatfoot

16) The position of the heel in a congenital convex pes valgus foot is in what position?
- A) Varus
- B) Valgus
- C) Neutral
- D) Any of the above

17) Which one of the following is true concerning congenital talipes equinovarus?
- A) It can result from open myelomeningocele
- B) It is more common in females than males
- C) It is most often unilateral
- D) It resolves spontaneously

18) Which one of the following is not a component of talipes equinovarus?
- A) Forefoot adductus
- B) Forefoot supination
- C) Heel inversion
- D) Tuberosity of calcaneus pointing plantarly

19) Which one of the following findings is not typical of upper motor neuron damage in an infant?
- A) Spasticity
- B) Fasciculations
- C) Hyperreflexia
- D) Increased muscle tone

20) Which one of the following findings is NOT typical of basal ganglia damage in an infant?
- A) Flacidity
- B) Tremors
- C) Flexed posture
- D) Rigidity

See answer sheet on page 181.

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ENROLLMENT FORM & ANSWER SHEET (cont'd)

EXAM #3/11
The Lower Extremity Orthopedic Evaluation of the Infant (Caselli)

Circle:

1.	A	B	C	D	11.	A	B	C	D
2.	A	B	C	D	12.	A	B	C	D
3.	A	B	C	D	13.	A	B	C	D
4.	A	B	C	D	14.	A	B	C	D
5.	A	B	C	D	15.	A	B	C	D
6.	A	B	C	D	16.	A	B	C	D
7.	A	B	C	D	17.	A	B	C	D
8.	A	B	C	D	18.	A	B	C	D
9.	A	B	C	D	19.	A	B	C	D
10.	A	B	C	D	20.	A	B	C	D

LESSON EVALUATION

Please indicate the date you completed this exam

_____

How much time did it take you to complete the lesson?

_____ hours _____minutes

How well did this lesson achieve its educational objectives?

_____Very well _____Well

_____Somewhat _____Not at all

What overall grade would you assign this lesson?

A B C D

Degree_____

Additional comments and suggestions for future exams:

_____

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