Pediatric musculoskeletal radiography: Normal variants versus real lesions

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Purpose

In pediatrics is very common to find anatomical variants and there are images that can make us doubt whether it is one of them or we are instead dealing with a pathological process. That is why we must become familiar with these common variants and to correctly orient the diagnosis.

We present a serie of cases from different anatomical regions: head, trunk and extremities in which a proper lecture is mandatory, establishing a range of diagnostic possibilities and emphasizing the keys that help us to narrow the differential diagnosis.

Normal findings are labeled with the letter "N" while those who are pathological may appear are labeled with the letter "P"

Methods and Materials

The description of the findings is located in the "Results" section

Results

HEAD AND NECK
Parietal foramina (N):
It is located in the back of the parietal bone and adjacent to the upper or sagittal parietal foramen. Through it runs the sagittal emissary vein which anastomoses with the superior sagittal sinus, and sometimes a small branch of the occipital artery. It is not always present and its size varies considerably. When we make a differential diagnosis, we have to think about other causes of ossification defects such meningoeencephalocele, arachnoid cyst, ectopic glial tissue, craniolacunia, injuries and infections, as well as eosinophilic granuloma, Hans Christian Schüller disease and metastasis.

Computed tomography with bone window and 3D reconstructions, will be helpful in checking the relationship of the defect sutures and differentiate it from the cranium bifidum in which the defect is unique, central and extends from the coronal suture to the lambdoid (FIG 1, 2).

Mentonian foramen (N):
It is an opening in the side of the body of the mandible, or jaw, below the second premolar, for the vessels and the mental nerve to come through (Fig. 3).

Ponticulus Posticum (N)
In human anatomy, the term Ponticulus posticum refers to a bony bridge in the atlas vertebrae, covering the canal for the vertebral artery. It is a normal variant that occurs between 3-15% of the population. The women present more frequently than men. However, despite being a normal variant, recent studies have linked with headaches, musculoskeletal pain and even stroke (Fig. 4).

Foreign objects (N)
Sometimes there are foreign bodies that can make us doubt the diagnosis. Observe the patient will save us headaches (Fig. 5)

TRUNK
Rhomboid fossa of the clavicle (N)
It is an excavation that it is located on the underside of the sternal end of clavicle where the costoclavicular ligament attaches, which serves to stabilize the sternoclavicular joint. (Fig. 6).

Posterior arch rib fractures in abused children (P)
These fractures are often located in the posterior arch, which follow a straight line. They are produced by chest compressions, direct blows and falls on hard surfaces (Fig. 7).

Roesler sign (P)
Bone erosions in the lower edges of the ribs caused by pressure from dilated intercostal arteries in aortic coarctation (Fig. 8)

COLUMN & LIMBS

Limbus vertebrae (N-P)
The limbus vertebrae originates in childhood and is caused by an intervertebral disc displacement which causes a separation of a small segment of the vertebral ring from the rest of the vertebral body, remaining isolated. The most common location is in the lumbar region, followed by the cervical region. This defect is often seen in the supero-anterior margin. This anomaly may be confused with a fracture, infection or a tumor resulting in unnecessary invasive procedures. It is postulated that the limbus vertebrae is a sequel to a previous unnoticed injury on an immature skeleton. We must differentiate from a spectrum of disorders such as osteochondrosis deformans and Schmorl nodules. This skeletal disorder usually causes no symptoms and their treatment is conservative (Fig. 9)

Spondylolysis (P)
In children, spondylolysis usually occurs between the fifth lumbar and first sacral vertebrae, and is often due to a birth defect in that area of the spine (Fig. 10). If there is an slippage of the upper over the lower vertebrae, it would be a spondylolisthesis.

**Ischiopubic synchondrosis (N)**

The ossification of cartilage located between the ischium and the pubis is very variable. The total bone fusion occurs in only 6% of children 4 years and 83% of those 12 years. There may be an expansion and irregular ossification of this synchondrosis in the prepubertal period. The bone fusion usually preceded by an intermittent increase in size of radiolucent component of cartilage, which gives it a globular (Fig. 11). We must not confuse this entity with other tumors such as osteomyelitis or eosinophilic granuloma (Fig. 12).

**Bone island (enostosis) (N)**

Injuries are often diagnosed as incidental findings. They look like lumps in sclerotic cancellous bone of variable size and irregular surface contours of 2mm to 2cm in diameter, on the bone scan are not active, although there may be some in the larger ones. They can occur in any bone, preferably in long bones (femur), and at any age, but more often after puberty. (FIG 13).

We must not confuse this finding with metastatic osteosarcoma that may look similar, but the clinical history may guide us toward one or another diagnosis (Fig. 14).

**Femoral epiphyseal growth retardation (N)**

This entity is also called Meyer dysplasia, although a strict dysplasia is a defective development of the hip joint (hip joint), the shape or the organization of the hip joint. This delay of ossification of the femoral head, goes subsequent editing and serial radiographs, which demonstrate a secondary nucleus ossified and normal, without sequelae or deformities, although there may be minor changes that do not alter the relationship head - acetabulum.

The differential diagnosis must be made with septic arthritis, Perthes disease, multiple epiphyseal dysplasia and hypothyroidism(Fig. 15).

**Avulsion fractures (P)**

In them there is a commitment to the vertebral bone and joint. Traction mechanisms involved acute tendon or ligament elementsinserted into the apophysis. There are age of onset characteristics. Its severity and treatment depends on the area affected and the degree of displacement (Fig. 16)

**Apophysitis**
The term refers to that apophysitis Osteochondrosis and apophyseal extra-articular location and have a high prevalence in children who play sports regularly (Fig. 17).

**Metaphyseal bands (N-P)**
They may be sclerotic, usually in relation to growth stops (Fig. 18) or radiolucent-hiperclaras in to do a differential diagnosis between different entities such as: normal newborn, any severe disease, metaphyseal fracture, leukemia, lymphoma,metastases, congenital infections, scurvy (Fig. 19).

**Physiological periosteal reaction (N)**
You have to make a differential diagnosis with other causes of periosteal reaction such as child abuse, infections (syphilis), metastatic neuroblastoma, treatment with prostaglandins and Caffey disease. The periosteal new bone formation occurs symmetrically in the bodies of the long bones of infants and resolves within 3 months of age. It is believed due to the handling of the newborn. There are no associated fractures (Fig. 20).

Do not confuse this diagnosis with other more ominous prognosis as leukemia, which can show periosteal reaction (Fig. 21).

**Distal femoral cortical irregularity (N)**
This is a normal variant consisting of a periosteal fibrous proliferation, which has a predilection for the posterior cortex of the distal femoral medial metaphysis. Also known as distal femoral metaphyseal defect, cortical desmoid, irregular or defective cortical avulsion medial supracondylar femur.
The age of onset is between 12 and 20 years and preferably in males. Usually resolves spontaneously in the second decade of life.
Radiographically similar to fibrous cortical defect, except as specific location. It appears as a radiolucent lesion with sclerosis at the base, the cortex may be irregular and may have spicules that can be interpreted as a sign of aggression. MRI showed hypointensity and hyperintensity on T2-T2, with a dark rim on both sequences and near the insertion of the gastrocnemius muscle (Fig. 22).

A bone scan is usually normal. Radiological differential diagnosis: fibrous cortical defect, periosteal chondroma, #osteosarcoma. Bone abscess secondary to osteomyelitis may also show a similar appearance (Fig. 23).

**Poor radiographic technique (N)**
Sometimes the anomalous position of the pediatric patient during the acquisition of the X-ray can show us false images that can confuse in establishing a diagnosis (Fig. 24 and 25).
Irregularity of the tibial tuberosity (N)
The tibial tuberosity is an anterior extension of the epiphysis of the tibia cartilage. It is usually ossified from several sites. Ossification usually occurs between 8 and 12 years in girls and between 9 and 14 in children. The ossicles can mimic fragments produced by avulsion. Their appearance is usually not symmetrical. The soft tissue edema and thickening of the patellar tendon in a preteen, suggests the diagnosis of Osgood-Schlatter (FIG. 26).

Dorsal defect of the patella (N)
It is a normal variant that should not be confused with patellar osteochondritis dissecans and a clue to differentiate both is that the former does not produce or produces very little pain and does not dissect any osteochondral fragments (Fig. 27).

Accessory bones (P) and sesamoid (N)
Peroneum Os (N): Os peroneum is an ossicle or sesamoid bone, oval or rounded located in the thickness of the distal peroneus longus tendon near the cuboid (Fig. 28). We will establish a differential diagnosis of fractures (Fig. 29), nonfused ossification centers or pathologic calcification of soft tissues.

Accessory navicular and cuneiform
These are accessory bones due to the non-union of the ossification center with the main bone. At the base of the fifth metatarsal it must be differentiated from a Jones fracture, a clue is that the ossification center of the apophysis has a longitudinal axis to the metatarsal (Fig. 31). We should not think of ossification centers in those places where there are clearly not supposed to be (Fig. 32).

Köhler: Necrosis of the navicular tarsal (P)
Described by Köhler in 1908 as a navicular self-limiting disease characterized by flattening, sclerosis and irregular ossification of this bone. However, it is the disease that has caused more controversy regarding its possible etiology, some authors label it as a development variant. It affects children between 3 and 10 years. When radiographs are obtained we can find obvious alterations in the navicular bone ossification which appears flattened, with fragmentation and increased density. In early disease it may keep the space with neighboring bones, but may suffer a collapse in its evolution (Fig. 33).

Abused child (P):
This are quite typical fractures that should be not to be confused with other normal findings such as the proximal radius step (shown below). (Fig. 34)

Salter and Harris fracture (P)
There are several ways to systematize physeal injuries, the most widely used is the Salter-Harris classification, which is based on the extent of involvement of the physis to the metaphysis, epiphysis and / or articular surface. They are difficult to detect because the physis is a radiolucent structure
- Type I: often without alteration or only enlargement of the physis. Clinical Rx-significant correlation (Fig. 35). Sometimes the diagnosis is uncertain and will only be seen clearly in the following radiographs Rx (Fig. 36)
- Type II-III-IV are more obvious by the osseous component.
- Type V: the most dangerous. It can be expressed as a thinning of the physis or joint effusion, but is very nonspecific.

Supracondylar humeral process (N)
It is a phylogenetic vestige-atavism that can be found in some people and that corresponds to a asymptomatic normal variant but a few cases have been reported to have caused median nerve compression. Differential diagnosis should be made with osteochondroma (Fig. 37).

Scaphoid fracture (P)
In many cases, plain radiography is sufficient and decisive for the diagnosis of this entity being complementary the other type of techniques (Fig. 38)

Proximal radius step (N). Fig 39.

Humeral condyle irregularity (N). Fig. 40.

Images for this section:
**Fig. 1:** These images correspond to a child of 20 months. The plain film images showed two lytic lesions united, with well-defined edges in the path of the sagittal suture.
Fig. 2: Same patient as figure 1. CT showed no other alterations, it was a parietal foramina.
Fig. 3: This "lytic" rounded image in the jaw corresponds to a normal mentonian foramen.

Fig. 4: In this plain film of the cervical spine we can see a small osseous bridge in C2. It was a Ponticulus Posticum
Fig. 5: In this plain films these hyperdense images in the cranial vault could make us think of osteomas or other type of tumor, however it was only a "decorated" hair the responsible for so ambiguous image.

Fig. 6: Bilateral rhomboid fossa in both clavicles
Fig. 7: Multiple fractures involving the posterior arch of the ribs in an abused child
Fig. 8: Plain films an angioMRI of a 13 years old child suffering from aortic coartation. The plain films show multiple rib notches due to collateral arteries. It most often affects between 3rd and 9th. The 1st and 2nd are not affected because their arteries originate from the subclavian and do not provide collateral flow to the aorta distal to the coarctation.
**Fig. 9:** Limbus vertebrae. We can identify a triangular ossified structure in the anterosuperior portion of S1, which is accompanied by anterior disc disease and disc herniation separating the triangular fragment from the rest of the vertebral body.

**Fig. 10:** Spondylolysis affecting the L5 vertebra.
**Fig. 11:** In this child of 10 years we can observe a globular radiolucent lesion in the right aspect of the ischiopubic ramus. The scan shows a very faint radiotracer uptake. The images corresponded to a normal ischiopubic synchondrosis.
Fig. 12: In this 12-year we can see two ischiopubic synchondrosis (ellipses) and also a geographical radiolucent lesion in the right aspect of the pubic ramus which corresponded to an eosinophilic granuloma.
**Fig. 13:** In these images we see a round image with well defined sclerotic border in the right iliac bone in a totally asymptomatic patient. It was a bone island.
Fig. 14: 13 year old patient with osteosarcoma of the femur and metastases in the left iliac blade. The scan showed a clear uptake and MRI bone marrow edema was adjacent, findings that are not typically present in bone-enostosis islets.
**Fig. 15:** These images correspond to the normal evolution of a growth retardation affecting the ossification center of the left femoral epiphysis. It shows how, over time, will complete normal ossification.

**Fig. 16:** Avulsion fracture of the anterior superior iliac spine in a 13 year old football player. This lesion corresponds to where the sartorius is inserted.
Fig. 17: This patient had a selective pain in hamstring muscle insertion. The plain film showed osteochondrosis-apophysitis of the left ischial tuberosity, a rare location of this entity. These "injuries" tend to resolution, normally, with growth.
**Fig. 18:** Sclerotic bands in a child with repeated stops of growth
**Fig. 19:** Lucent bands in vertebral bodies and metaphyses of long bones in two children suffering from leukemia.

**Fig. 20:** 8-weeks baby with normal periosteal reaction
Fig. 21: Patient with hip pain. In plain film we see an increase of the left medial joint space, suggesting effusion, confirmed by ultrasound. MRI showed bone marrow and soft tissue involvement suggesting that it was a leukemia.
Fig. 22: Distal femoral cortical irregularity (N)
Fig. 23: Osteomyelitis complicated with an abscess in a 2 year old boy.

Fig. 24: Normal femur appears shortened, frayed at its distal metaphysis and an increased articular joint space, findings that are caused by bending of the left leg. The lateral radiograph shows normal morphology and length of the limb.
Fig. 25: In the plain film the right leg seems to have a bultoma and to be shortened in a 9 months old girl. The photo below shows the effect of bending (blue transparency)
**Fig. 26**: Irregularity of the tibial tuberosity, is a normal finding, Osgood-Schlatter disease is a clinical diagnosis. Radiographs or MRI are not helpful
Fig. 27: Dorsal patellar defect. Osteolytic image in the upper outer edge of the patella in an asymptomatic patient

Fig. 28: Os peroneum
**Fig. 29:** Avulsion of the fibular malleolus, intraarticular located.

**Fig. 30:** Medial cuneiform (left image) and accessory navicular bone (right image)
Fig. 31: Ossification center at the base of the fifth metatarsal (a) and line of fracture (b)
Fig. 32: We observe in plain film images a hypodense line through the intercondylar tuberosity, it was a prior avulsion fracture. Here there are no centers of ossification, so this image can never be considered normal.

Fig. 33: FIG. 31. Köhler necrosis. We can compare the navicular with the normal contralateral on the left foot.
**Fig. 34**: Fractures in an abused child. We observe an asymmetry in the normal curvature of the inner cortex in the right tibial metaphysis. Do not confuse with the radial step of Figure 39.
**Fig. 35:** There is a type I Salter and Harris fracture that affects the distal growth plate of the tibia. The physis is wider in the anterior and medial aspect. None meta-or epiphyseal osseous track is identified.
Fig. 36: A doubtful type I Salter and Harris fracture (Rx above) is clearly shown two weeks later (Rx below).
**Fig. 37:** We identify an exostosis on the distal third of the humeral shaft corresponding to a supracondylar humeral process. It differs from osteochondroma in a way that follows down (yellow), to the nearest joint and not upward, as an osteochondroma would do (red).

**Fig. 38:** In plain radiography (left) we identify a fracture line in the middle third of scaphoid which is well shown on MRI (right)
**Fig. 39:** We identified a proximal step in the radio in a 2-year-old boy who had pain in a nonossified olecranon. Supination was normal. The step was an incidental finding and it is a normal variant, not to be confused with torus fracture (Fig. 32).

**Fig. 40:** There is an irregularity and fragmentation of the nucleus of ossification of the capitellum that we should not confuse with any pathology because it is a normal finding.
Conclusion

CONCLUSIONS
• To correlate the point of pain with the suspicious image: Radiologists under command!
• To have the Keats´ Normal Variants book for consulting.
• In case of doubt, to decide the next step to be taken: ultrasound, repeat Rx in a reasonable time, scans, CT, MRI ...

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Agujeros parietales gigantes. A propósito de un caso

Dres. Beatriz Dita Moyano Recine

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