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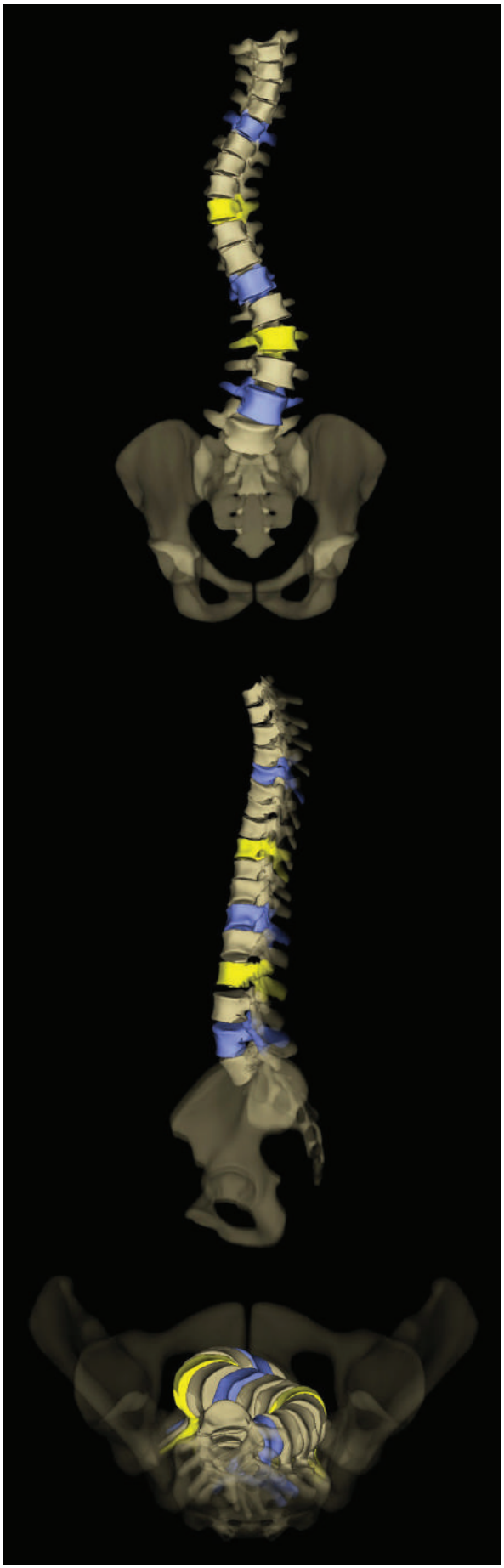

Figure 21 3D images of the spine obtained with EOS. Courtesy of EOS support

The EOS system

EOS (fig. 21) is an innovative three-dimensional imaging diagnostic system that can be used to assess the spine, pelvis, and lower limbs under load, using a low dose of ionizing radiation (less than 8-10 times compared to traditional radiography and 800-900 times compared to a CT of the same area); EOS uses a particular technology developed by Nobel laureate George Charpak that allows obtaining images without distortion or magnification, which can be manipulated on a computer as a 3D rendering. EOS is particularly indicated for the diagnosis of spinal deformities, pelvic pathologies, but also for limb length discrepancies and rotational deformities, and in all cases where visualization of the skeleton under load is necessary.

Ultrasound

Ultrasound is a harmless, inexpensive, versatile examination and is very useful in pediatric orthopedics where it is probably underutilized. Since, unlike other imaging techniques, ultrasound is an operator-dependent examination, it would be desirable for a pediatric orthopedist to be able to use the machine directly as if it were an extension of the physical examination; in any case, they must be able to judge certain parameters (for example, the correctness of the landmarks in hip dysplasia) of an examination performed by other specialists. Ultrasound can also be used in prenatal diagnosis (clubfoot, spina bifida, etc.). In children, the main focus of ultrasound evaluations is the hip, especially in the diagnosis of dysplasia in the first few months. Ultrasound also allows the detection of joint effusions and soft tissue pathologies (cysts, etc.).

CT scan

A CT scan is the examination of choice for in-depth investigation of bone pathologies. It allows for the acquisition of three-dimensional reconstructions that are particularly useful in cases of deformities that are poorly visible on X-ray (tarsal coalitions, severe epiphysiolysis, etc.) or complex (congenital scoliosis, etc.) or in bone tumors or trauma (fig. 22). However, it has the major limitation of exposure to ionizing radiation that is much higher than that of traditional radiography, so its use is reserved for very selected cases.

Magnetic resonance imaging

Magnetic resonance imaging (MRI) is a second-level investigation that is primarily used to answer specific questions raised by the physical

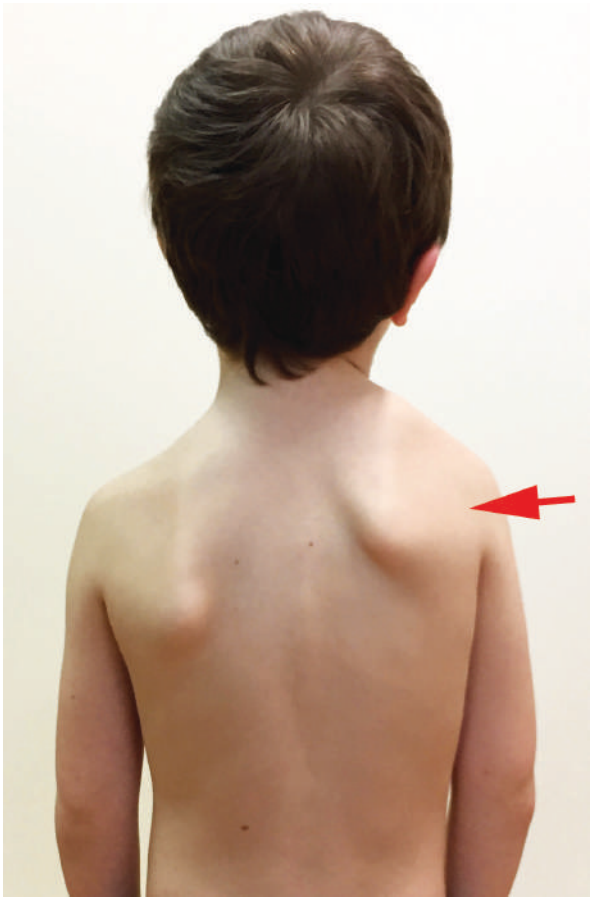

Figure 7 Clinical picture of congenital right high scapula

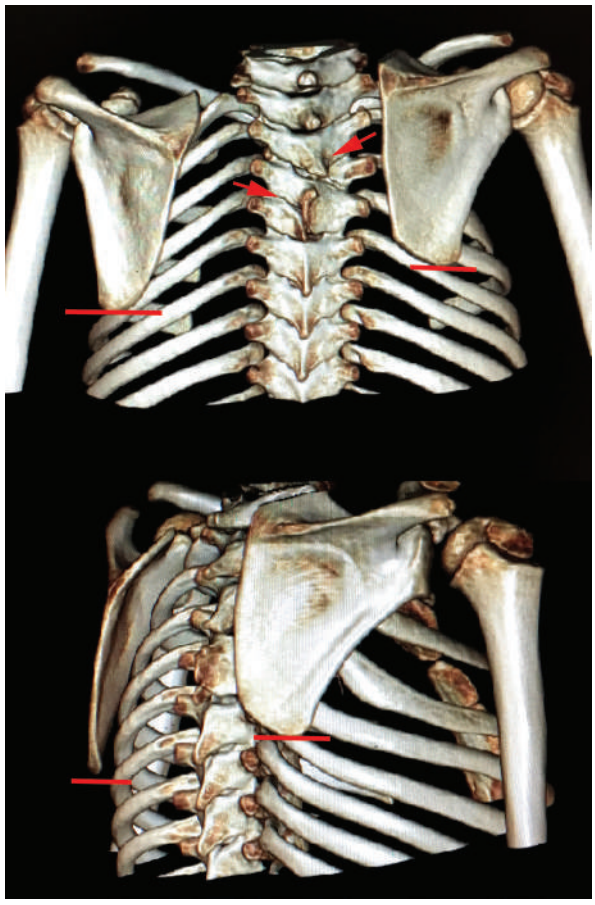

Figure 8 3D CT scan of the case from the previous figure highlighting the different heights of the scapulae and the association of vertebral malformations (arrows)

scapula does not complete its normal distal migration but remains in the embryonic site. Sometimes it can be associated with other malformations, such as Klippel-Feil syndrome. Occasionally, there may be a bony bridge (omovertebral bone) that links the scapula to one or more lower cervical vertebrae.
The diagnosis is clinical (fig. 7), with radiological confirmation (X-ray and CT) (fig. 8). In some cases, the disorder is only cosmetic; in others, there is a functional deficit, limiting shoulder abduction. In severe cases, the therapy is surgical and consists of repositioning the scapula to its normal position after sectioning the fibrous (or bony) bridge that anchors it proximally.

Congenital pseudoarthrosis of clavicle
Congenital clavicular pseudarthrosis is a very rare anomaly characterized by a failure of fusion of the two medial and lateral ossification centers of the clavicle.
The exact cause of congenital clavicular pseudarthrosis remains unclear. It likely stems from damage to the clavicle's development during fetal growth, possibly due to pressure from the subcla-

Figure 9 Clinical image of congenital right clavicular pseudarthrosis with prominence in the middle third of the clavicle

Talipes calcaneo-valgus

The term talipes calcaneo-valgus refers to a dorsal flexion of the foot (often associated with pronation and valgus) (fig. 35). It is important to remember that a mild degree of talipes calcaneo-valgus is physiological at birth: physiological talipes persists for a few days and then spontaneously regresses. Pathological forms are distinguished by the inability to flex the foot plantarly beyond 90 degrees (fig. 36). Treatment is generally limited to manipulations, but in cases of stiffness, splints can also be used, and in case of failure, corrective casts.

Figure 35 Infant born with talipes calcaneo-valgus-pronatus

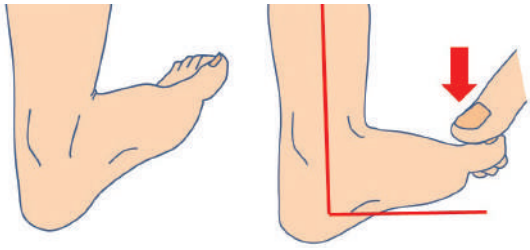

Figure 36 Talipes valgus foot. In pathological forms, it is not possible to plantarflex the foot beyond 90 degrees

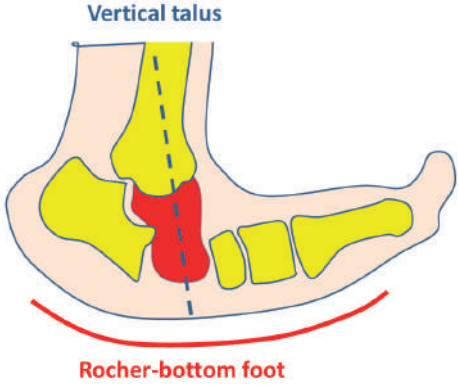

Figure 37 Schematic drawing of a vertical talus

Congenital vertical talus

Sometimes classified as a type of congenital clubfoot, talipes valgus foot is a condition present at birth where the plantar surface of the foot is deformed, appearing convex on inspection. It is often associated with other conditions (spina bifida, arthrogryposis, etc.). It is known by various names: rocker-bottom foot o boat foot. The definition refers to the radiographic examination that allows for diagnosis (fig. 37) and which shows a vertical position of the talus.

Clinical diagnosis is, however, easy, as the rigidity (which, together with equinus of the hindfoot, makes it extremely different from a flexible flatfoot) and the convex shape are very evident characteristics; sometimes a dorsal groove on the ankle can be found in the void left by the head of the vertical talus. Treatment is similar to that of equinovarus: with successive plaster casts, the verticalization of the talus is first corrected, bringing the deformity to a simple equinus foot, and then the equinus itself is corrected. Also in this case, if conservative treatment fails, surgical treatment is resorted to.

Figure 38 Complex malformation of the right foot toes, with associated polydactyly and syndactyly

Figure 42 Syndactyly of the second and third toes

Figure 43A Second toe clinodactyly

Figure 43B Curly fourth and fifth toes

tive bandaging with tape may have a short-term advantage, but usually the benefits are not stable.

Hammer toe

Hammer toe (fig. 44A) consists of a flexion of the proximal interphalangeal joint. The metatarsophalangeal and distal interphalangeal joints are extended to allow weight-bearing. It is an acquired deformity that generally appears during adolescence. It commonly affects the second toe, sometimes associated with hallux valgus. A painful callus may develop on the dorsal region of the interphalangeal joint. Surgical treatment is indicated in severe cases.

Mallet toe

Mallet toe It is a deformity characterized by an isolated flexion of the DIP joint (figs. 44B and 45). Generally, it does not cause particular problems. Surgical treatment is indicated if the deformity is such as to cause pain or produce a significant aesthetic damage.

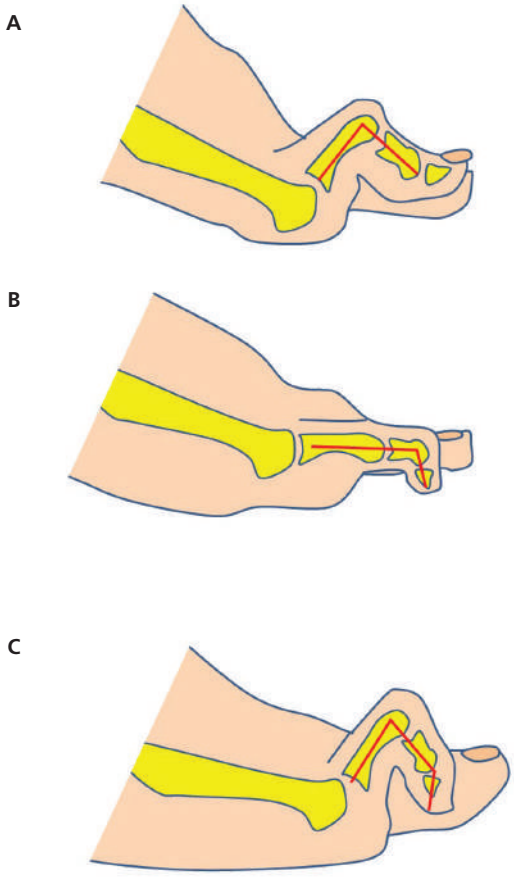

Figure 44 Three common toe deformities: A) hammer toe, characterized by a bent middle joint of the toe; B) mallet toe, featuring an excessive bend in the end joint of the toe; C) claw toe, showcasing a curled appearance of the toe with both the middle and end joints bent

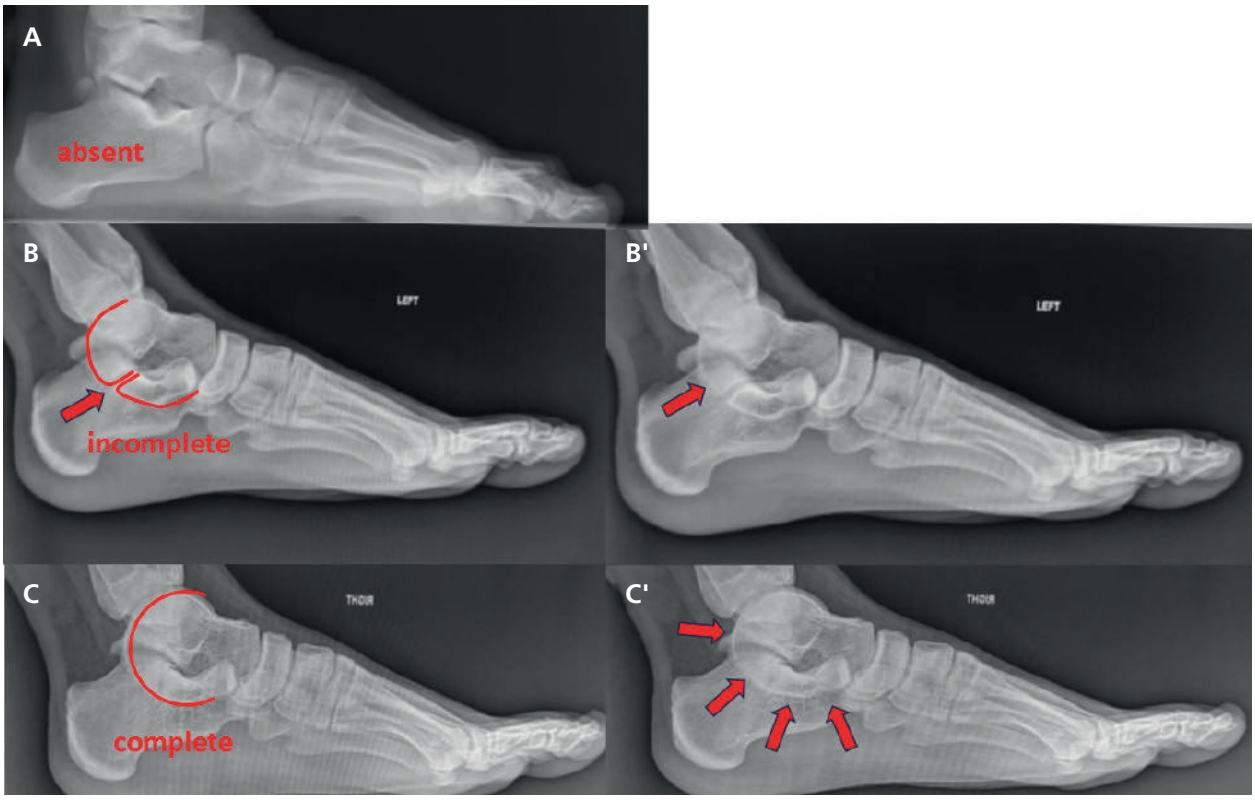

Figure 87 Radiographic demonstration of the C-sign: A) C-sign absent; B,B') C-sign interrupted; C,C') C-sign complete

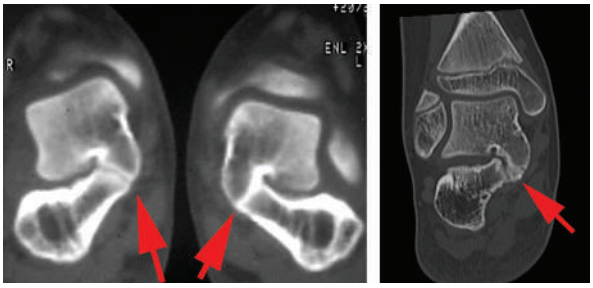

Figure 88 CT images showing astragalocalcaneal tarsal coalitions of varying severity

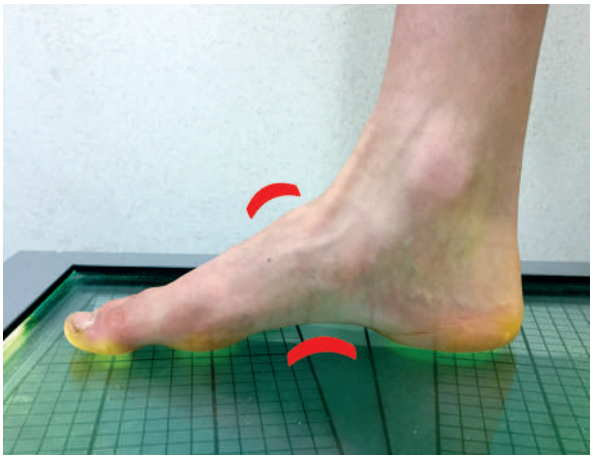

Figure 89 Clinical presentation of pes cavus

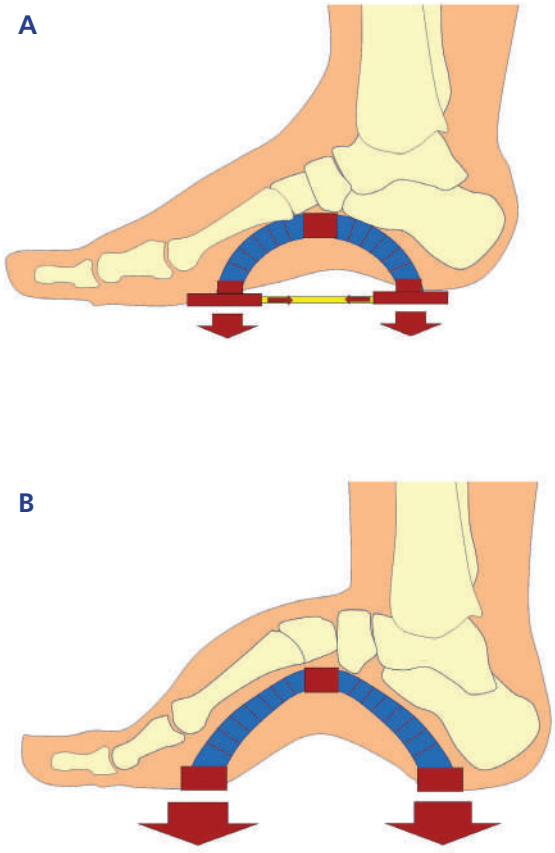

Figure 90 Schematic drawing of the architecture of a normal foot (A) resembling a full-centered arch, and of a cavus foot (B) with an arrangement of the tarsal bones resembling a pointed arch (Gothic)

posteriorly at the lumbar level (lumbar prominence). The extent of the hump depends on numerous factors and is not solely correlated with the angular value of the curve. In fact, in addition to this parameter, the extent of the prominence also depends on the location of the curve (thoracic or lumbar), its degree of rotation and torsion (which is an even more important index of "structuring" and therefore of its severity), and the thickness of the soft tissues (fig. 123).
For a clinical quantification of the deformity, the hump can be measured using two main techniques: measuring the height of the hump using a level and a rigid centimeter (fig. 124) or measuring the angle of trunk rotation with a scoliometer. The measurement of the hump height is performed by placing a level transversely on the trunk at the point of maximum evidence of the deformity and calculating the distance between the skin and the level on the less protruding side using a rigid centimeter (fig. 125). If the hump exceeds 5 mm, an X-ray examination is indicated.
The Bunnell scoliometer is an inclinometer consisting of a curved and hollow cylinder, filled with liquid, calibrated from 0 to 30 degrees to the right and left, in which a metal ball slides (fig. 126). With the scoliometer, the angle of trunk rotation (ATR) is measured, i.e. the angle formed between the horizontal plane and the tangent to the hump

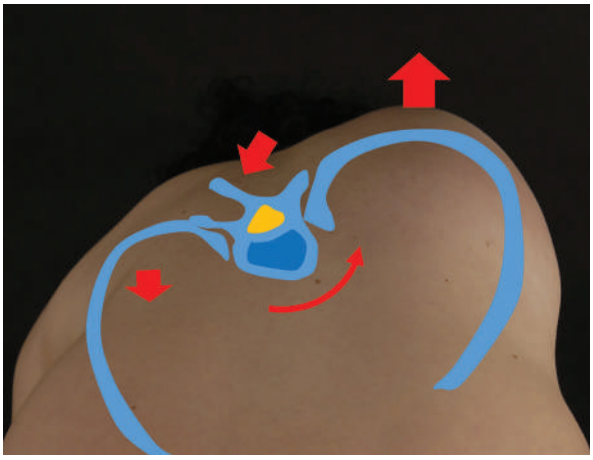

Figure 123 Rib hump in thoracic scoliosis: the deformity is not only due to the rotation of one vertebra relative to adjacent ones but also to a deformation of the vertebra itself, with torsion of the spinous processes towards the concavity relative to the body

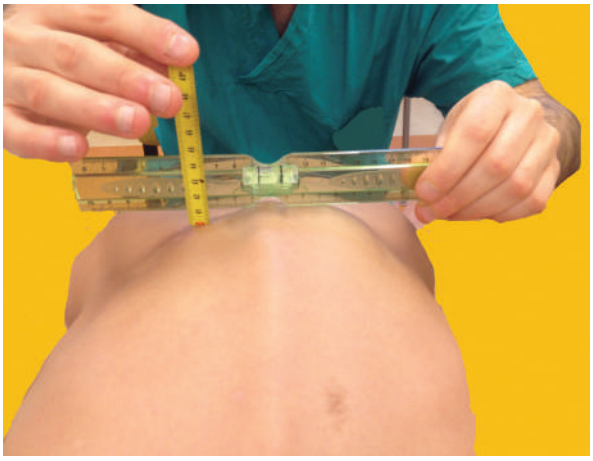

Figure 124 Measurement of hump height using a spirit level

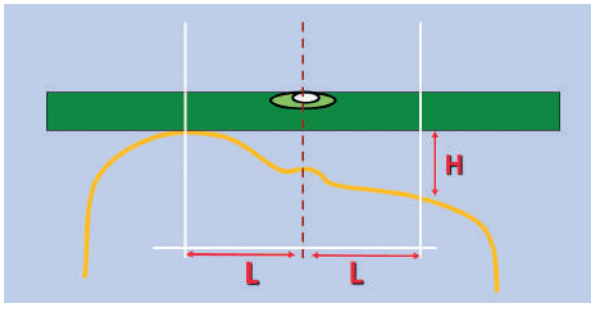

Figure 125 Measurement of hump height using a spirit level. The distance (H) between the skin and the level on the less prominent side is measured at a distance (L) from the midline equal to that at which the maximum prominence of the contralateral hump is present

Figure 126 Measurement of the hump with a Bunnell scoliometer

LUMBAR HYPERLORDOSIS

Definition. Hyperlordosis refers to an increase in the physiological lumbar curve in the sagittal plane (fig. 203).

Terminology and overview

The normal values for lumbar lordosis are not precisely defined, as they show significant variations within the healthy population. Generally, a lordosis between 20 and 55 degrees is considered normal, with a slightly greater amplitude in girls. Values vary with growth: lordosis is absent at birth and appears progressively with the onset of walking, becoming well evident at three years of age; from 2 to 4 years of age, hyperlordosis is physiological. Even after 8 years of age, a physiological increase is normal, with values above those that will be typical of adulthood: prepubertal hyperlordosis generally reduces spontaneously after 10-12 years. Given the significant changes related to growth and individual constitutional variations, the term hyperlordosis should be reserved for substantial increases in the angular value (> 70 degrees).

Lumbar lordosis is correlated with thoracic kyphosis but especially with pelvic incidence, or the relationship of the pelvis to the hips. More recent literature has established that pelvic incidence (PI, defined as the angle formed by the perpendicular to the midpoint of the sacral plate and the line joining this point to the bifemoral axis) is a fixed parameter that determines the morphological characteristics of the pelvis and that influences both the spino-pelvic orientation and the sagittal alignment of the spine (fig. 204).

Pelvic incidence (PI) increases during growth due to the assumption of an upright posture and stabilizes in adulthood. Generally speaking, the higher the PI, the more vertical the sacral plate, so the lordosis is greater and distributed over more vertebrae, while if the PI is low, the sacrum is vertical with a more horizontal S1 surface: the lordosis is consequently reduced. Based on the characteristics of thoracic kyphosis, lumbar lordosis, and pelvic incidence, various types of posture can be identified: the most followed classification is that of Roussouly (fig. 205).

Hyperlordosis can therefore be distinguished as physiological or secondary to other diseases, in particular of the hip joint (hip dysplasia), the lumbosacral junction (spondylolisthesis) or the neuromuscular system (myopathies, cerebral palsy) (table 21). All painful conditions of the lumbar spine can determine, in addition to an antalgic scoliosis, also a hyperlordosis.

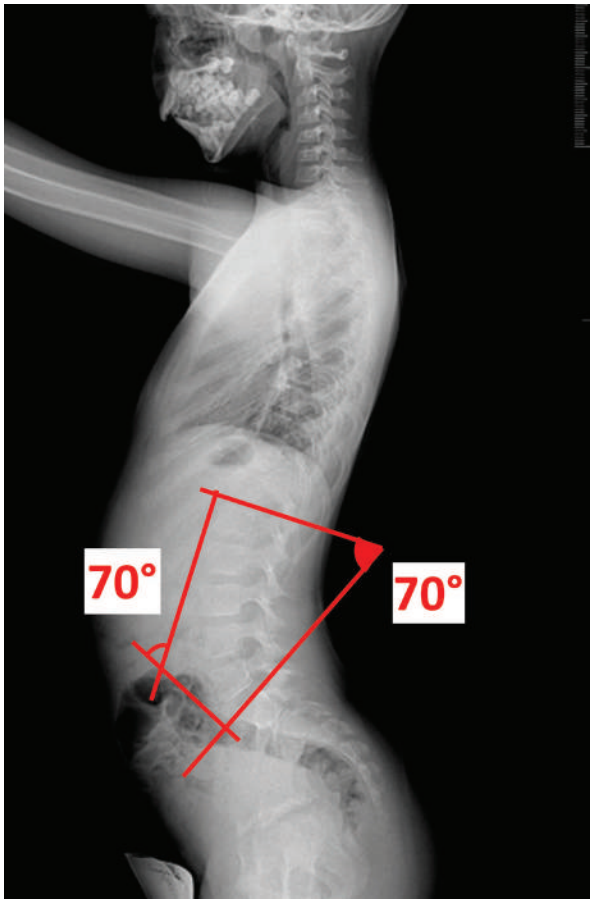

Figure 203 X-ray of lumbar hyperlordosis

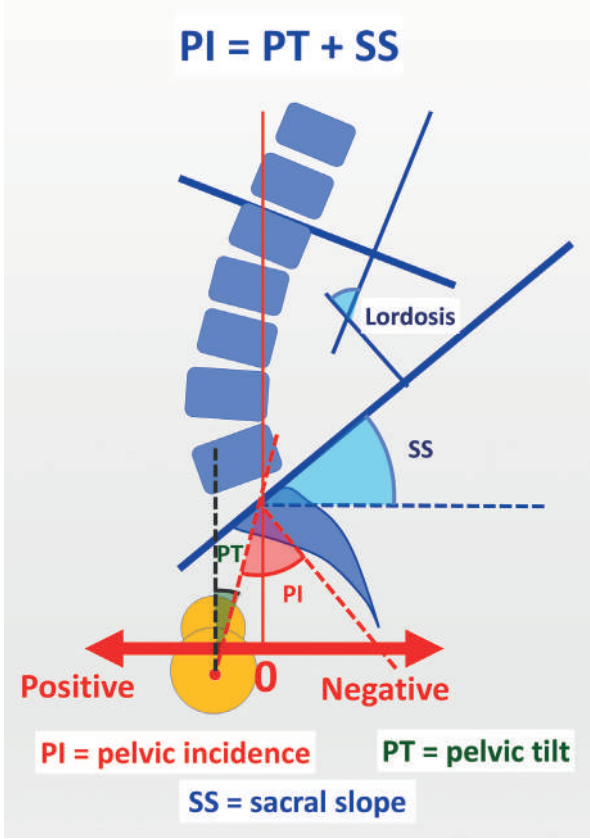

Figure 204 Schematic diagram of pelvic incidence measurement

become very common today. In childhood, coccyx pain often has a postural origin and depends largely on how and how much one sits. Overweight and certain specific shapes of the coccyx (fig. 45), generally very arched, can act as contributing factors. Sitting for too long is one of the main elements underlying coccydynia, so much so that even in the fifties they spoke of "television disease".
The position of the pelvis while sitting significantly conditions the load to which the coccyx is subjected. A relaxed back posture is associated with a backward rotation of the pelvis (retroversion) and brings the coccyx into contact with the supporting surface. In this position, the weight of the trunk, instead of being discharged onto the buttocks, is transferred to what remains of the tailbone (fig. 46).

Clinical features
Coccydynia symptoms may include: dull or sharp coccyx pain that worsens when transitioning from sitting to standing or during activities that put pressure on the affected area, such as cycling, horseback riding, and prolonged sitting, which directly stresses the coccyx. On physical examination, tenderness will be revealed upon palpation of the coccyx. A rectal examination allows the coccyx to be grasped between the index finger and thumb.

Instrumental examinations
The first diagnostic test to be performed is an X-ray of the sacrococcygeal region. Although the clinical diagnosis of coccydynia is relatively straightforward with few differential considerations beyond mechanical irritation and traumatic fracture or dislocation, imaging the coccyx and surrounding tissues presents a unique challenge to the radiologist due to the complex and variable regional anatomy. The normal curvature of the coccyx is highly variable. Numerous classifications exist, but the forms most associated with pain are those with an acutely anterior angle.
Dynamic radiography may reveal the cause of pain. Magnetic resonance imaging (MRI) can be performed to identify signal intensity alterations in or around the coccyx, which may be correlated with the specific site of irritation. In rare instances, MRI may reveal unexpected pathological conditions.

Treatment
Tailbone pain usually goes away on its own within a few weeks or months.
A fundamental part of preventing and treating postural coccydynia involves correcting sitting posture by maintaining the pelvis in a forward rotation, or anteversion. One of the most effective

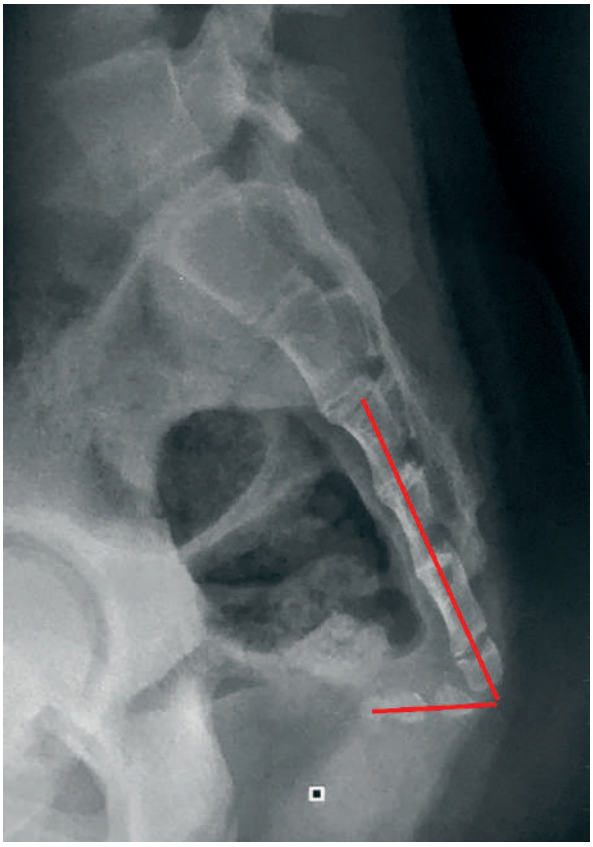

Figure 45 X-ray of the coccyx showing a markedly accentuated angle

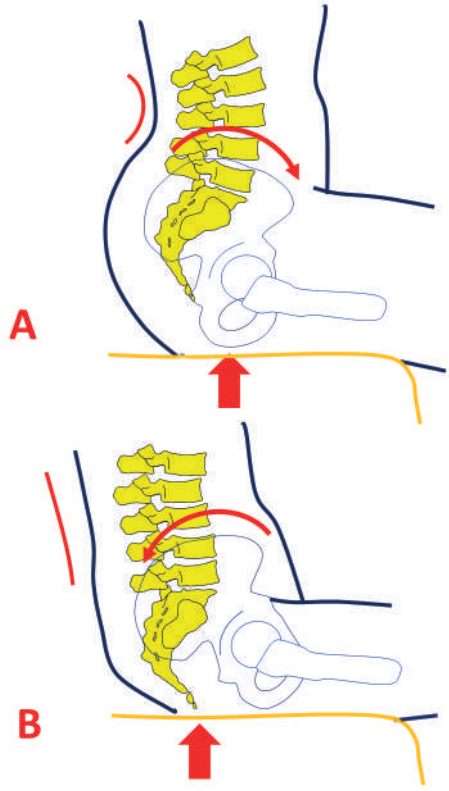

Figure 46 A) Correct sitting posture: less pressure on coccyx. B) Incorrect sitting posture: too much pressure on coccyx

sound may show a slight increase in the distance between the radial head and the humerus but is not diagnostic.
Reduction maneuvers are simple: the classic one is performed by supinating the elbow and then performing a complete passive flexion (palm up, palm shoulder) (fig. 55); alternatively, hyperpronation can be performed (fig. 56).
In typical cases, a palpable click can be felt, which also confirms the diagnosis (but this finding is not constant). The child cries during the maneuver and then continues to keep the limb in pseudoparalysis despite the reduction. Parents are then asked to leave for 15-30 minutes and distract the child; generally, after a few minutes, the child resumes normal movement of the elbow.
In some cases, the child continues to keep the arm adducted, probably due to the presence of synovitis. If the etiology is typical, the child can be checked again the following day, without further maneuvers. If it is not typical or if a recurrence occurs shortly thereafter, immobilization in a plaster splint may be indicated.
The prognosis is favorable and it is conceivable that, even without medical intervention, a spontaneous reduction will occur, as there are no reports of sequelae of unreduced pronations. Recurrences are frequent up to the age of 4-5 years.

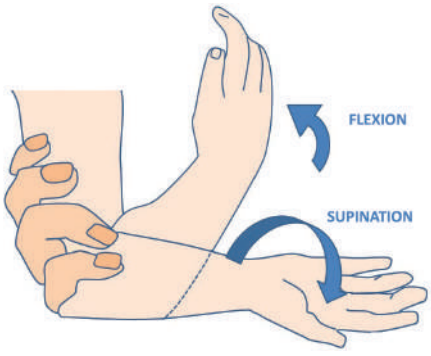

Figure 55 Classic maneuver for reducing nursemaid's elbow: supination (palm up) and full flexion (palm shoulder)

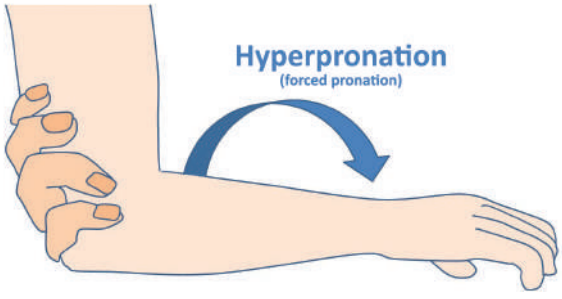

Figure 56 Maneuver for reducing nursemaid's elbowender or painful pronation through hyperpronation of the elbow

Wrist and hand pain

Painful conditions of the wrist and hand are rare during the growth period. Even in these cases, traumatic injuries predominate. Spontaneous pathologies are more common in adolescence; among these, we mention wrist cysts and Madelung's deformity (see Chapter 4). Oncological pathologies of the wrist and hand are very rare and, regarding the bone, are essentially represented by chondromas (fig. 57), while for soft tissues, angiomas are the most common.
Particular attention should be paid to some traumatic pathologies that are considered mild by parents and which do not reach the emergency room and therefore are not investigated, but their failure to be identified leads to consequences, sometimes significant. The most insidious is the scaphoid fracture which, if not diagnosed, can result in a nonunion; the subcutaneous rupture of the ulnar collateral ligament of the metacarpophalangeal joint of the thumb, which can cause instability, is also not exceptional (see Chapter 5).

Scaphoid nonunion

A scaphoid fracture is common in adolescence but can go undetected because the patient underestimates the severity of the trauma (falling on an outstretched hand) or because an initial X-ray does not show the fracture (in some cases, the fracture is initially invisible on standard X-rays).
In case of persistent wrist pain following trauma, a careful clinical examination should be performed; if there is tenderness over the scaphoid (anatomical snuffbox dorsally and/or scaphoid tubercle, volarly) (fig. 58) or with radial deviation movements of the wrist, an X-ray should be performed and, even if the images are negative, it is advisable to repeat a new control in 7-10 days, after having immobilized the wrist with the thumb included. If pain is still present over the scaphoid after removal of the splint, an X-ray should be re-

Figure 57 Typical radiographic appearance of a chondroma: on the left, located in the proximal phalanx of the second finger, on the right, in the fifth metacarpal

at the site of the apophyseal nucleus), instrumental examinations are not necessary. X-ray examination is only necessary in atypical cases or with pain of post-traumatic onset; in the lateral projection, an elevation of the ossification nucleus and, subsequently, a thickening and fragmentation are evident (fig. 98A-B). Ultrasound is not the examination of choice, but it can be useful for monitoring the stage in competitive athletes. MRI is not indicated because it only rarely provides useful information and is only used as a diagnosis of exclusion in atypical cases or as monitoring in elite athletes.

Treatment

Treatment consists mainly of reducing and, if necessary, temporarily suspending physical activity. Complete interruption of sports is not always necessary and physical activity can also be continued, keeping it below the pain threshold. Ice and anti-inflammatories are useful in more resistant cases. Recurrent pain should be expected for 6-12 months and subsequent healing without any particular aftereffects (a small local swelling may remain). Exceptionally, if the pain does not subside with healing and part of the nucleus does not fuse at the end of growth, surgical excision may be indicated.

Sinding-Larsen-Johansson syndrome

Definition. It is an overuse syndrome of the osteotendinous junction of the inferior pole of the patella, with microavulsions of immature bone, calcifications, and de novo ossifications.

Terminology and overview

Although it is generally included in the group of osteochondroses, it is not a true necrotic pathology of a growth nucleus, but rather an overload pathology of the tendinous junction, typical of young athletes. Sometimes it is called Larsen-Johansson disease, but this is incorrect, as Sinding-Larsen is the full surname of the Norwegian doctor who described the pathology, independently of the Swede Johansson.
It is a rare pathology, although probably underestimated as it is often not recognized. It is found in 10 to 13-year-olds who practice sports involving running and jumping.

Clinical features

The main symptom is a localized pain, especially at the inferior pole of the patella, without appreciable swelling (fig. 99). Local pressure exacerbates it, allowing for a diagnostic orientation. Sometimes the pain also extends to the patellar tendon, making the differential diagnosis with pure tendinitis difficult, and it may also be associated with Osgood-Schlatter

Figure 98A Clinical presentation of Osgood-Schlatter disease

Figure 98B X-ray of Osgood-Schlatter disease

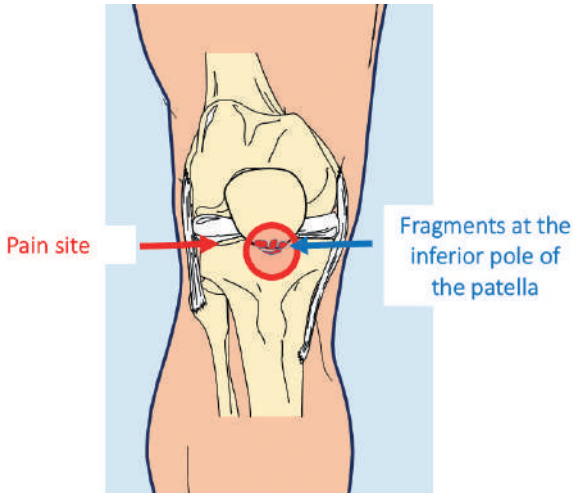

Figure 99 Schematic drawing of the painful area on palpation in Sinding-Larsen-Johansson disease