Foot and Ankle Surgery 22 (2016) 78–84

Contents lists available at ScienceDirect

Foot and Ankle Surgery

journal homepage: www.elsevier.com/locate/fas

"Coxa pedis" today

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ARTICLE INFO

Article history:
Received 11 July 2014
Received in revised form 9 February 2015
Accepted 2 May 2015

Keywords:
Coxa pedis
Subtalar joint
Tibialis posterior disfunction
Flexor digitorum longus tendon transfer

ABSTRACT

Coxa pedis is the talocalcaneonavicular joint and is the distal enarthrosis of the lower limb. It is defined coxa because of: (1) the enarthrosic meaning from an anatomical point of view, (2) the analogy to the hip.

The stabilising devices are structural, passive and active; the corresponding pathology is the "Coxa pedis destabilising syndrome".

During walking, release and stiffening of the foot are related to the opening and closure of the kinetic chain of the coxa pedis: it is mutually reversible, while opening is a passive event, closure is an active one.

Considering the importance of the flexor digitorum longus muscle in stabilising the coxa pedis, is it logical transferring it in the tibialis posterior disfunction? During walking, opening and closure of the kinetic chain of the coxa pedis intervene in the opening and closure of the kinetic chain of the entire lower limb. The kinetic chain closes starting from the bottom and moving upwards in the foot–knee–hip progression, and opens starting from the top and moving downwards. Even rotations along the orthogonal plane of the segmental axes of the limb contribute to the closure of the kinetic chain, coxa pedis dysmorphism (cavovalgus foot: false flat foot) can cause, during growth, dysmorphism of the hip (residual anteversion) and of the knee (condyles or tibial tuberosity) instead of the reverse.

Issues: subtalar joint; anomalous subtalar pronation syndrome; flexor digitorum longum transfer pro tibialis posterior tendon; coxa pedis actor or participant in the functional integration of the lower limb; anterior knee pain syndrome.

Why did I call my study *Coxa Pedis today*? Because even if I have written a lot and I have lectured a lot about the "*coxa pedis*" [1–4], only recently I have understood its real meaning; anatomical, functional and clinical meaning.

Coxa pedis (Fig. 1) is the distal enarthrosis of the lower limb. It is important from a biomechanical point of view to understand the relations between foot, knee, hip and the reverse.

In 1803 Antonio Scarpa from Pavia (Italy), in his book about the "Club foot" [5], described as *acetabolo* (Fig. 2) the anatomical formation comprising the posterior navicular and the anterior talar of the calcaneum articular surfaces and the glenoid, or fibrocartilago navicularis, which is interposed and connected between the two articular surfaces; these elements were all contained in a single articular capsule.

Analyzing from an anatomical standpoint this *acetabolo*, we notice that the articular surfaces that form it are contained, as already mentioned, with the interconnected glenoid, in a single capsular structure. This means that they belong to a single joint, that is the talocalcaneonavicular joint [6]. Consequently, the *acetabolo* cannot be divided, from a clinical standpoint, into two joints: the posterior one considered as anterior subtalar [7], or subtalar [8], joint and the distal one as talonavicular joint. For instance, to which of the two joints, anterior subtalar or talonavicular, does the glenoid belong? And, from a functional standpoint can the *acetabolo* be considered as belonging to the anterior subtalar joint functional unit with the posterior one? [9]

A question is: can a subtalar joint, anterior and posterior, be defined from an anatomical standpoint?

I would say: "No, it can't"

The contiguous articular relations between the talus and the calcaneous are mediated by two joints: the above mentioned talocalcaneonavicular joint in front and the talocalcaneal joint behind, as defined by Chiarugi [6,10] in the "proper sense of the word" to mean that all the other definitions, as posterior subtalar joint, are improper.

Observing only the foot bones (Fig. 1), in which the two articular surfaces, navicular and calcaneal, are mutually distinguished and distant because the foot skeleton lacks the interposed glenoid and the peripheral capsule, defining anatomically the *acetabolo* can be a mistake.

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http://dx.doi.org/10.1016/j.fas.2015.05.004
1268-7731/

Fig. 1. The talocalcaneonavicular joint or "coxa pedis".

Subtalar, anterior and posterior, joint is a traditional, so to say, definition, but not an anatomical entity.

The concept is recent to me. I previously overestimated the importance of the subtalar joint by defining its insufficiency syndrome [11], and proposing the reconstruction of the talocalcaneal interosseous ligament [12], talar arthroereysis with endorthesis [13] and arthrodesis with stable synthesis achieved through intraoperative compression [4].

The above statements question the so-called "Anomalous subtalar pronation syndrome [14,15], considered a set of pathological conditions to be related to the primitive anomalous pronation of the subtalar joint. The pronation of the calcaneum is always subsequent to medial and plantar destabilisation of the *coxa pedis* (talar protrusion).

What mentioned above has a functional and clinical meaning, and not only a semantic meaning.

Later, in 1981 (SICP Congress in Bari) [1] and in 1987 (SICOT Congress in Munich) [2], I proposed an epiphysis, made of the talar head and neck, into the *acetabolo* defining the overall structure as "*coxa pedis*", anatomically talocalcaneonavicular joint.

Coxa does not define only the anatomy but also the function.

The first is that, though the definition talocalcaneonavicular joint is entirely correct from an anatomical standpoint, it does not convey the idea of the joint's function, while the term "*coxa*" has also a functional enarthrosic meaning, besides an anatomical one.

The second point is that the term "*coxa*" refers to the analogies that exist between the "*coxa*" pedis and the "*coxa*" hip. These analogies are anatomical, developmental, malformative and clinical besides functional.

From an anatomical standpoint (Fig. 3), if we observe in a sagittal section a neonatal foot (3a), we will notice a well defined tibial diaphysis, medial malleolus, talar neck and head, and *acetabolo* profile. If then we imagine reversing the image by 180° (3b), the correspondence of the tibial diaphysis with the femoral diaphysis, of the medial malleolus with the lesser trochanter, of the talar neck and head with the femoral neck and head the analogy becomes evident; and the *acetabolo* profiles also correspond.

There is also an important developmental postnatal correlation between the proximal femoral epiphysis and the talar "epiphysis" [16].

Considering the detortion implemented to correct the physiological anteversion of the femoral neck on the one hand, and the physiological retroversion (adduction on the horizontal plane) of the talar neck on the other, it is interesting to notice that the two detortional moments, which start from more or less identical values around 45°, and finally settle, at the end of the developmental period, at values around 20°. But it must be observed that talar detortions close sooner, towards 6–7 years, than femoral detortions, which close later, around 14–15 years.

We shall discuss this below.

Malformative analogies concerning the hip include protrusion and dislocation. In the *coxa pedis* (Fig. 4), the analogy of dislocation is the club foot (a) in which the dorsal and lateral dislocation of the talar head, compared to the *acetabolo*, can be clinically observed. The analogy of protrusion is the congenital flat foot (vertical talar), (b) in which the talar head is, instead, embedded, and protrudes into the *acetabolo*. The clinical conditions are confirmed by the X-ray: the lateral view reveals the dorsal dislocation of the talar head in the club foot, and its protruding in the vertical talus.

There are also analogies in terms of degenerative diseases.

A study of radiographic images of arthrosis in the *coxa pedis* (Fig. 5) reveals some analogies with the primitive coxarthrosis (*malum coxae senilis*) (5a); others are, instead, typical of coxarthrosis in the dysplasic hip (5b) with the typical osteophytes.

The stabilising devices of the *coxa pedis* are structural: both passive and active; the corresponding pathology is the "*Coxa pedis destabilising syndrome*".

Structural stability is guaranteed by the anatomical epiphyso-acetabular congruence (Fig. 1).

The passive stability is ensured by the peritalar calcaneo-navicular ligaments: the superomedial, the plantar (spring ligament) and the lateral one (medial branch of Chopart's or "Y" shaped ligament).

The active stability is guaranteed by the tibialis posterior, the flexor digitorum longus and the flexor hallucis longus muscles.

The functional mechanism of the *coxa pedis* during walking is interesting.

At the start of the load bearing phase, the foot must be an elastic structure that is suitable to absorb the impact on the ground, and then it must become the rigid structure that is useful for the taking off.

Release and stiffening are related to the opening and closure of the kinetic chain of the *coxa pedis*, and are mutually reversible; we have to take into account the fact that, while opening is a passive event, closure is an active one [4,24].

Opening of the kinetic chain of the *coxa pedis* is a passive event for the medial misalignment of the tibial and talar axis, compared to the calcaneal axis (Fig. 6); hence, the talar plantar flexion and adduction are stimulated when the talus is loaded. This action is opposed by the tibialis posterior muscle and, particularly, by the flexor digitorum longus and by the flexor hallucis longus muscles,