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# SOME REMARKS ABOUT FEMOROACETABULAR IMPINGEMENT AND OSSEOUS NON-METRIC VARIATIONS OF THE PROXIMAL FEMUR

## QUELQUES REMARQUES À PROPOS DU CONFLIT FÉMORO-ACÉTABULAIRE ANTÉRIEUR ET DES VARIATIONS OSSEUSES NON-MÉTRIQUES DE LA FACE ANTÉRIEURE DU COL DU FÉMUR

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ABSTRACT

Femoroacetabular impingement is a condition of repeated contact between the acetabular rim and the femoral head-neck junction. Impingement arises as a result of abnormal morphological features involving the proximal femur (cam type) or the acetabulum (pincer type). This note illustrates the usefulness of current medical understandings of osseous modifications associated with the cam-effect in order to achieve a better understanding of osseous non-metric traits of the neck of the femur, in particular Poirier's facet and the fossa of Allen.

*Keywords*: femoroacetabular impingement, osseous non-metric traits, discrete traits, occupational stress markers, femoral neck.

RÉSUMÉ

*Le conflit fémoro-acétabulaire antérieur est un choc répétitif entre le bord de l'acetabulum et le col fémoral, à sa jonction avec la tête. Il est la conséquence d'une anomalie osseuse au niveau de la tête (effet came) ou de l'acetabulum (effet pince). Cette note illustre l'intérêt des données médicales sur les modifications associées à l'effet came pour la compréhension des variations osseuses non-métriques observées au niveau de la face antérieure du col du fémur, notamment la facette de Poirier et la fosse de Allen.*

Mots-clés : *conflit fémoro-acétabulaire antérieur, variations anatomiques non-métriques, caractères discrets, marqueurs osseux d'activité, col du fémur.*

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Recently, researchers have suggested that repetitive microtrauma from impingement of the femoral neck against the acetabular rim is the cause of many cases of idiopathic osteoarthritis of the hip (Ito *et al*. 2001; Ganz *et al*. 2003). Femoroacetabular impingement (FAI) is now well described (Ito *et al*. 2001; Notzli *et al*. 2002; Ganz *et al*. 2003; Wagner *et al*. 2003; Jäger *et al*. 2004; Kassarjian *et al*. 2005; Leunig *et al*. 2005; Sampson 2005; Philippon *et al*. 2007; Panzer *et al*. 2008). FAI arises as a result of abnormal morphological configurations of the proximal femur (cam type) and/or the acetabulum (pincer type) (Ganz *et al*. 2003). Cam impingement is caused by a non-spherical femoral head with an increased radius that enters the acetabulum during forceful movement, especially during flexion (Ito *et al*. 2001; Ganz *et al*. 2003). Pincer impingement results from direct contact between the acetabular rim and the femoral head-neck junction as a result of an underlying acetabular abnormality such as *coxa profunda* or acetabular retroversion (Ganz *et al*. 2003). The cam type is more common, with or without an associated pincer impingement, in young male athletes (Ganz *et al*. 2003; Philippon *et al*. 2007). Pincer impingement alone, however, is seen more frequently in middle-aged patients, mainly women (Ganz *et al*. 2003).

Osseous non-metric variations of the femoral head-neck junction have been the subject of anatomical and anthropological studies for more than a century. Several traits were distinguished but, for the main part, there is no consensus about their exact definition or aetiology. However, two traits have repeatedly been recognised on the anterior aspect of the femoral neck (Meyer 1924; Odgers 1931; Kostick 1963; Angel 1964; Finnegan 1978; Saunders 1978): 1) an extension of the articular surface of the head onto the neck, generally known as a "Poirier's facet", and 2) a depressed and roughened area, in which the bone is eroded to a greater or lesser extent. This latter trait, usually considered to extend below the "Poirier's facet", is known by several names: "empreinte de Poirier", "cervical fossa" or "fossa of Allen".

The Poirier's facet and the fossa of Allen were generally studied in conjunction with other traits, *e.g*. Poirier's facet and *eminentia articularis colli femoris* (an eminence stretching from the superior part of the intertrochanteric line to the head of the bone) as in Odgers (1931) or the fossa of Allen and a plaque as non-metric continuous traits of the "reaction area" of the femoral neck as in Angel (1964).

Researchers have proposed several (and sometimes contradictory) activity-related scenarios to explain the occurrence of anatomical variants in this so-called "reaction area of the femoral neck" (as defined by Angel 1964). For example, Odgers (1931) considered the extension of the cartilage of the head of the femur and its erosion as being due to the same agent: capsular pressure and friction during full extension of the thigh. According to Kostick (1963: 400), the fossa of Allen can be due to capsular pull and "then it may occur as a result of extension (as in walking or in standing) or of flexion (as in squatting) of the hip joint". Poirier's facet was considered by the same author to be associated with extension of the hip (Kostick 1963). Angel (1964) believed that the fossa, identified in a high frequency in ancient Greeks was induced by the passage of the iliofemoral ligament when the thigh was hyper-extended as in running downhill. The development of Poirier's facet was not considered to be related to the "reaction area", but more probably associated with the passage of the tendon for the *m. iliospoas* during habitual flexion and abduction of the thigh (Angel 1964). More recently, the extension of the articular surface of the femoral neck has been associated with horseback riding by Pálfi (1992) and Miller *(in* Reinhard *et al*. 1994).

In this note, we illustrate the potential usefulness of current medical insights of two osseous modifications associated with FAI in order to achieve a better understanding of these osseous non-metric traits of the neck of the femur. These are:

1) The "Bump": the cam impingement is caused by an abnormality at the anterolateral femoral head-neck junction (Ito *et al*. 2001; Ganz *et al*. 2003), sometimes called a "bump" (Jäger *et al*. 2004; Sampson 2005). Dimensions of the bump (an extension onto the femoral neck and an increased "thickness" of the femoral neck) appear highly variable among subjects as can be observed by study of gross anatomy aided by radiology (*e.g*.: Wagner *et al*. 2003; Jäger *et al*. 2004; Leunig *et al*. 2005). This bump is composed of subchondral bone and degenerative hyaline cartilage (Wagner *et al*. 2003). The cartilage surface of the bump communicates directly with the joint cartilage of the femoral head (Wagner *et al*. 2003; Jäger *et al*. 2004), and bony excrescences and an area of inflammation can surround this cartilage (Sampson 2005). The origin of the bump is unknown but a mechanical hypothesis can be considered a serious possibility. First, Kassarjian and collaborators (2005) indicated that patients with pincer impingement (*i.e*. initially without abnormality of the anterior femoral neck but only of the acetabulum) may develop an extra-articular osseous

prominence secondarily. Moreover, Jäger and colleagues (2004) noted an active osteoblastic cell differentiation in the perilesional capsule in FAI. They formulate the hypothesis that "local recruitment of osteoprogenitor cells, stimulated by biomechanical forces, is responsible for secondary tissue calcification in impingement zones and thus may promote a growing osseous bump deformity" (Jäger *et al*. 2004: 260-261).

2) "Herniation pits": an area of radiolucency surrounded by a sclerotic margin at the anterosuperior femoral neck is frequently seen in radiography. Pitt and collaborators (1982) studied gross anatomy, histology and radiological findings of these subcortical modifications. These cysts, called herniation pits (HP) by the authors, were generally found in association with the "reaction area" defined by Angel (1964). According to Pitt and collaborators (1982), this reaction area is composed of collagenous tissue, neocartilage, and reactive new bone. In a few cases of HP, they observed a defect in the surface of the neck exposing the underlying trabecular bone and medullary cavity and, according to the authors, this feature corresponds to the Allen's fossa. They also observed gradual enlargement of the HP in two active patients and "postulate that excessive hyperextension of the hip was the major contributing factor" (Pitt *et al*. 1982: 1121). Leuning and collaborators (2005) report a high frequency of HP in FAI: 33% of 117 hips (101 patients), compared with a prevalence of 5% in healthy populations (Pitt *et al*. 1982; Nokes *et al*. 1989). The authors note that the cause of herniation pits is unlikely to be extension but rather repeated movements requiring extreme hip flexion with internal rotation (Leuning *et al*. 2005). Panzer and collaborators (2008) also identified HP for the greater part of their sample (85 of 200 patients, 107 of 400 hips), not only at the superior portion of the proximal anterior femoral neck, but also in the inferior portion and at the transition between the superior and inferior regions. They found a correlation between the presence of HP and a non-spherical femoral head (illustrated by a large $\alpha$ angle, defined by Nötzli and colleagues in 2002).

Based on these medical studies, we can make four observations:

1) After the disappearance of soft tissues, it is highly probable that at least the medial part of some bumps corresponds to an extension of the articular surface of the head onto the neck *(i.e*. a Poirier's facet) associated with an *eminentia articularis colli femoris*.

2) The placement of tissue calcification, osteoarthritic changes and inflammation of tissues seen at or around the bump corresponds, at least in great part, to the "reaction area". We hypothesize that osteological modifications such as plaques or a roughened imprint (*i.e*. "empreinte") could be related in some cases to the presence of a bump during life.

3) As pointed out by Pitt and collaborators (1982), perforation(s) of the plaque or a cribriform fossa (*i.e*. a fossa of Allen) within the reaction area on dry bones could be related to a subcortical herniation pit.

4) According to remarks 1, 2 and 3 and the possible aetiology of bumps and herniation pits, it is expected that osseous non-metric variations of the femoral head-neck junction for some skeletons could be considered possible occupational stress markers. It should be noted that the hypothesis of a femoroacetabular impingement as a possible cause of bony modifications (the "empreinte") was initially formulated by Poirier and Charpy (1899: 231-232) *contra* a capsular pressure hypothesis defended later by Odgers (1931), Kostick (1963) and Angel (1964).

Anthropologists have formulated several, sometimes inconsistent, hypotheses to explain the occurrence of osseous non-metric traits of the femoral neck. Although all osseous modifications seen at the anterior aspect of the femoral neck of human remains are unlikely to be related to FAI, it seems evident that the relevant literature about this condition could be useful in a new investigation of osseous non-metric variations of the femoral head-neck junction.

We suggest:

1) a new typological approach combining measurements (*e.g*. $\alpha$ angle), osteological macroscopic observations, and a radiographic study of the associated area of radiolucency and 2) a synthetic study of these defects with data obtained from studies on cadavers such as those previously performed by Odgers (1931) and Angel (1964), as well as based on observations from more recent research works on FAI. We are convinced that reliable occupational stress markers could be described and defined in this way.

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