PRENATAL DEVELOPMENT OF THE HUMAN PELVIS AND ACETABULUM

O. DELAERE, A. DHEM

The prenatal development of the human pelvic bone and acetabulum has been studied by means of classical histology and microradiography. The embryonic phase leads to a fully developed hip within 8 weeks of gestation. The fetal period is a growth phase, including the following main features : endochondral ossification of the ilium from the ninth week, asymmetrical development of the iliac shaft from the fifteenth week, "chondroid-like" tissue formation above the acetabulum from the twenty-sixth week and haversian bone remodelling from the twenty-eighth week. The fetal development of the pelvis and acetabulum seems to be highly related to mechanical stimuli, the most important being the gluteal muscular activity and the simultaneous pressure of the femoral head.

Keywords : pelvis ; acetabulum ; embryology.
Mots-clés : bassin ; acetabulum ; embryologie.

The embryonic period, representing the first two months of gestation, is a differentiation phase. All the elements of the pelvis and hip joint differentiate from a single mass of mesoderm, and within a few weeks, they become blastemic tissue, precartilage and cartilage. The acetabulum develops by fusion of the iliac, ischial and pubic cartilages, which keep the same proportions over time (17, 19). The earliest features of a hip joint may be visible from about the sixth gestational week (18). Then cavitation starts and leads to a fully developed hip joint at eight weeks. Therefore, at the end of the embryonic period, all the elements of the hip joint are present, such as the acetabular labrum and the femoral head ligament (figs. 1, 2).

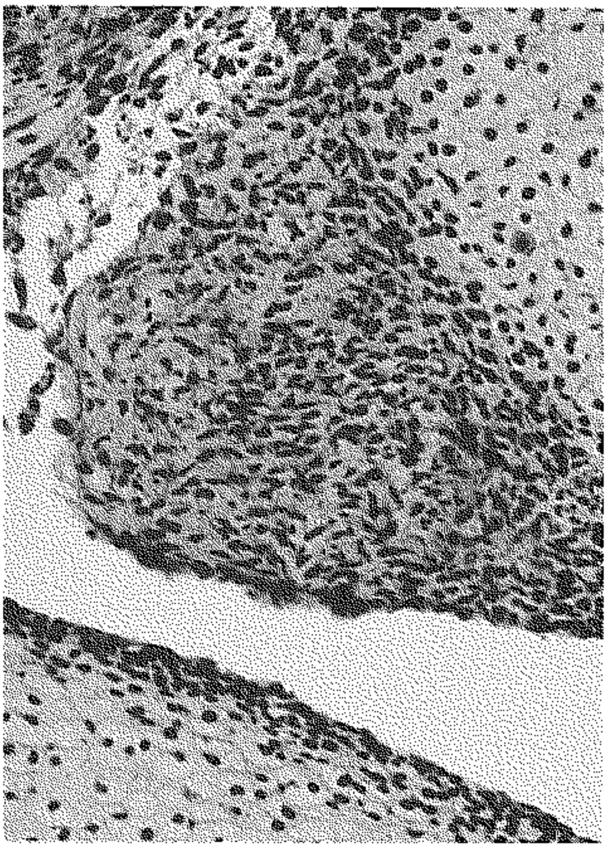

Fig. 1. — Frontal section through the middle of the acetabulum, right hip, 10 weeks of gestation. The labrum is clearly delineated and made of fibrocartilage. A small part of the femoral head is visible below it. Above, the capsular insertion can be seen, located along the junction between the labrum and the acetabular cartilage (Toluidine blue staining, × 300).

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Fig. 2. — Frontal section through the middle of the acetabulum, left hip, 10 weeks of gestation. The femoral head ligament and the joint cavity are very well differentiated (Toluidine blue staining, × 85).

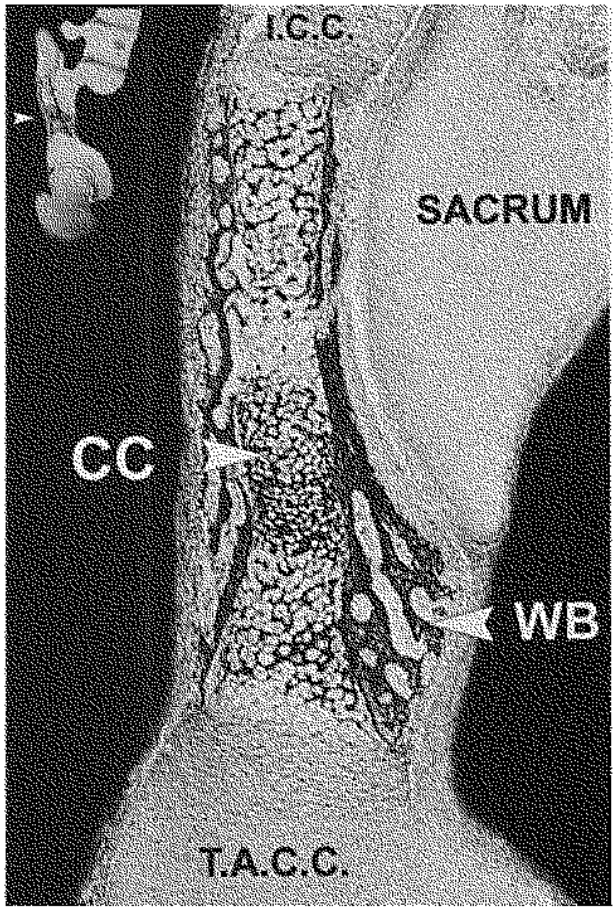

Fig. 3. — Frontal section through the middle of the acetabulum, right hip, 10 weeks of gestation. Endochondral ossification of the ilium. I.C.C. : Iliac Crest Cartilage. T.A.C.C. : Triradiated-Acetabular Cartilage Complex. CC : Calcified Cartilage. WB : Woven Bone (Toluidine blue staining, × 50).

The fetal period is a period of growth. One of its early steps is the beginning of ossification, which starts at nine weeks in the ilium (5, 11), and which is of endochondral type (fig. 3). It means that the ilium grows exactly like long bones (11, 12, 18). It also means that all its ossification steps are highly predictable, and closely related to the local distribution of mechanical stresses (3).

Ossification of the ischium starts at about the fourth month of gestation, and a few weeks afterwards for the pubis (6, 9, 13). At that stage, all the epiphyseal centers are clearly delineated, including the well-known triradiated cartilage, at the junction between ilium, ischium and pubis (fig. 4). In reality, this triradiated cartilage is closely related to the acetabular cartilage, and it is the acetabular cartilage which is the real hip joint epiphysis (fig. 5).

As for other long bones, growth and development of these two epiphyses are closely related to mechanical stimuli, and the most influential one is the normal pressure of the femoral head (16). Nevertheless, in human congenital hip dislocation, and also in experimental conditions modifying the normal femoral head pressure, the acetabular cartilage has been found to be pathological, but the triradiated cartilage remains normal (15).

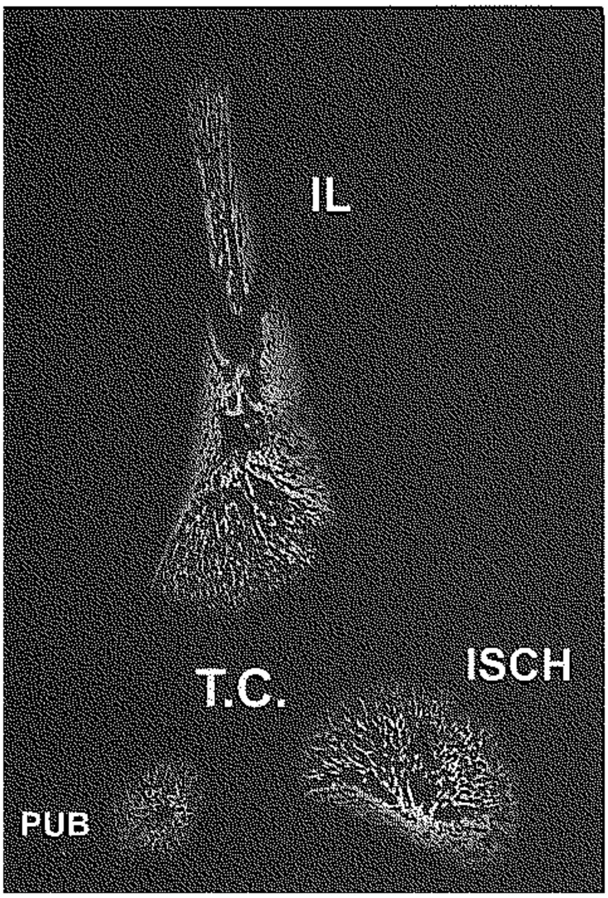

Fig. 4. — Oblique section through the triradiated cartilage. Left hip bone, 26 weeks of gestation. IL : Ilium. ISCH : Ischium. PUB : Pubis. T.C. : Triradiated Cartilage (Microradiograph, × 3.6).

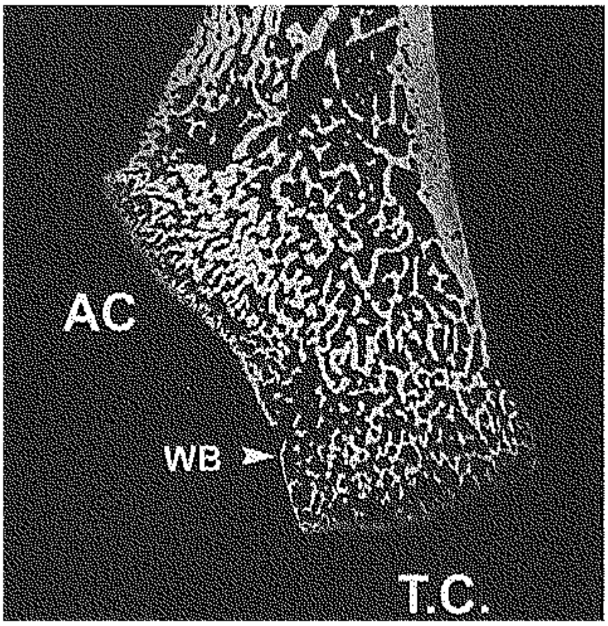

Fig. 5. — Frontal section through the middle of the acetabulum, right hip, newborn. AC : Acetabular Cartilage. T.C. : Triradiated Cartilage. WB : Woven Bone (Acetabular fossa) (Microradiograph, × 7.2).

Epiphyseal growth is also responsible for the widening of the pelvic ring. One of these epiphyses is the auricular cartilage, at the level of the sacroiliac joint. However, from the prenatal period until the eighth decade of life, this cartilage remains very thin and poorly active (1).

In fact, the main way for the pelvic ring to grow is by osteoclastic bone remodelling (5), affecting the pelvic bones in the same way as the cranial bones (4). On the microradiograph in fig. 6, bone resorption is clearly visible on the medial side of

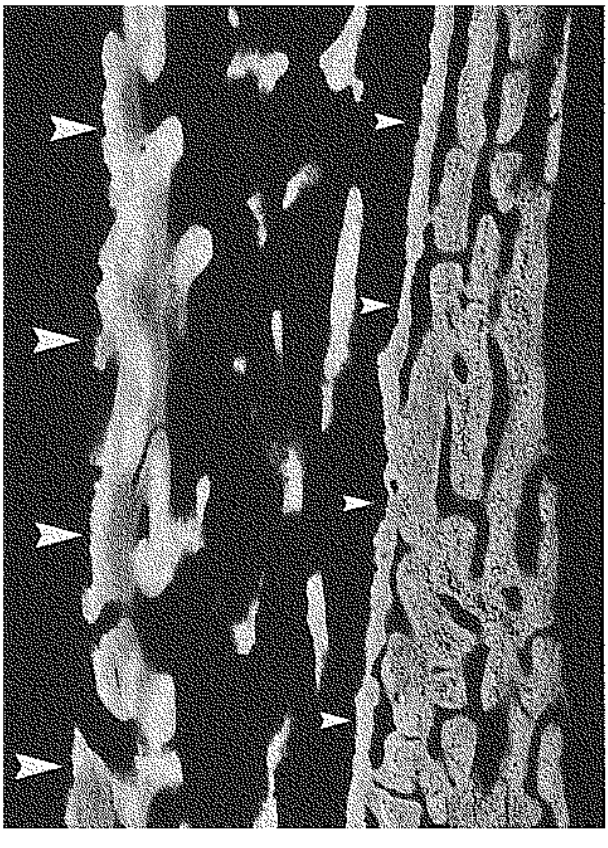

Fig. 6. — Frontal section through the greater sciatic notch, left ilium, 38 weeks of gestation. Arrowheads : bone resorption (Microradiograph, × 37).

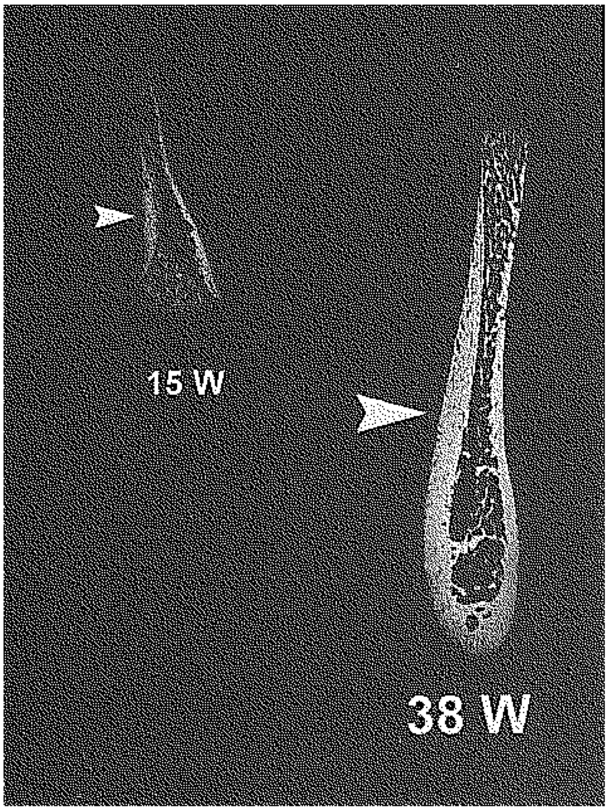

Fig. 7. — Frontal section through the right ilium, 15 and 38 weeks of gestation. The lateral iliac cortex is two or three times thicker than the medial one (Microradiograph, × 3).

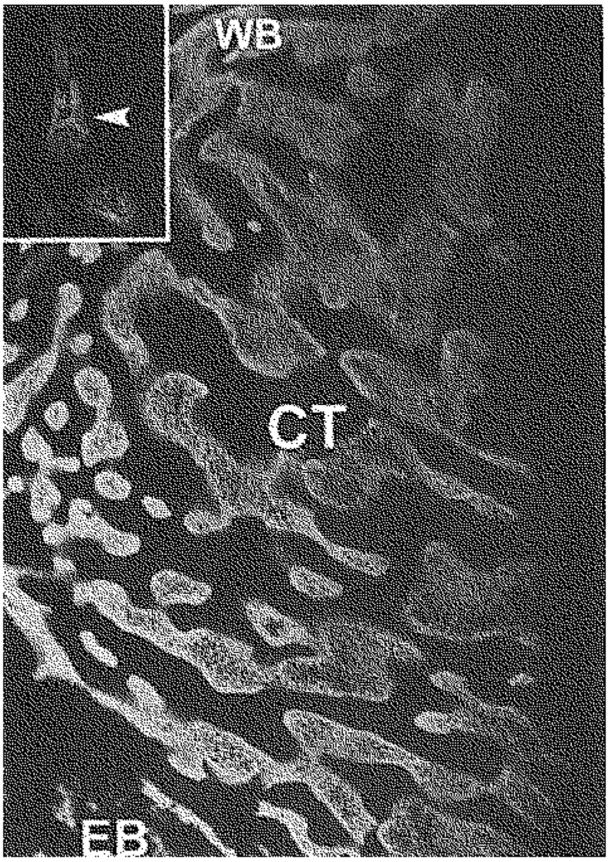

Fig. 8. — Oblique section through the triradiated cartilage. Left hip bone, 26 weeks of gestation. WB : Woven bone. CT : Chondroid Tissue. EB : Endochondral Bone (Microradiograph, × 43).

the iliac cortex, and bone apposition on the lateral side.

There are other striking features of iliac ossification. The first one is that from the fifteenth gestational week until birth, the lateral iliac cortex is always 2 or 3 times thicker than the medial one (fig. 7). One of the explanations could be an asymmetrical distribution of mechanical stresses, possibly induced by the activity of the gluteal muscles (5).

Another striking feature is the presence of another kind of calcified tissue, in a small area situated posterosuperiorly to the acetabulum, from about the sixth month of gestation (fig. 8). This calcified tissue has the microradiographic appearance of chondroid tissue : high mineral content, high cellularity and confluent cell lacunae (8). Chondroid tissue is known to be a fast-growing calcified tissue in areas submitted to specific mechanical conditions (7). Since fast-growing tissues are more sensitive to pathological factors, even such a small area could contribute to the pathological development of the acetabulum (5).

The last main feature of iliac ossification is the haversian bone remodelling, which can be visible from the twenty-eighth week of gestation (fig. 9). Haversian bone remodelling in the human fetus was described ten years ago (2), and is known to be highly influenced by mechanical stresses (10).

In the newborn, a small plate of woven bone separates the acetabular from the triradiated cartilage (fig. 5). It represents the first ossification area of the acetabulum, at the level of the acetabular fossa.

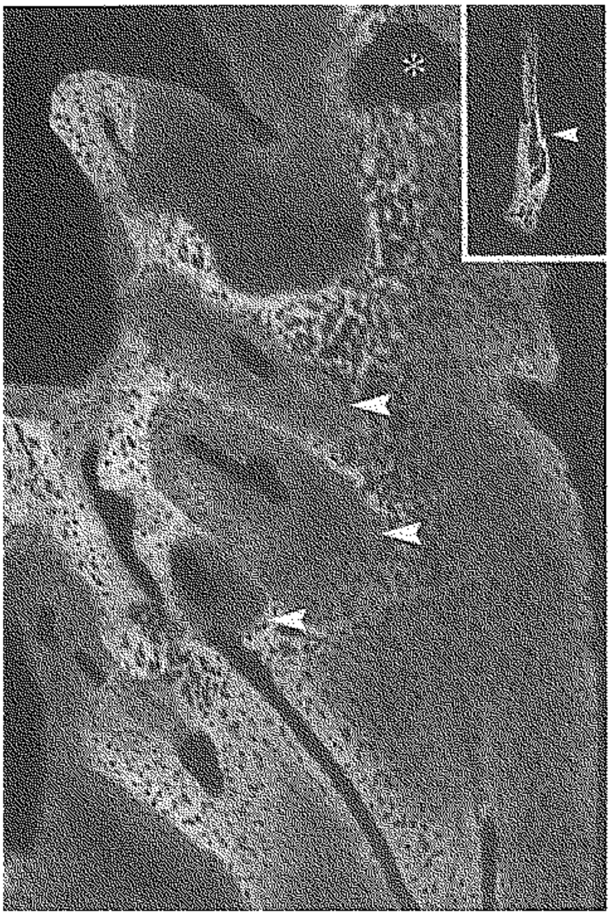

Fig. 9. — Frontal section through the posterior flange of the triradiated cartilage, right ilium, newborn. Three osteons are clearly visible (arrowheads), as well as a resorption cavity (asterisk) (Microradiograph, × 100).

Just before puberty, as in the iliac crest apophysis, secondary ossification centers develop within the acetabular cartilage ; the one in the ilium is called the acetabular epiphysis and the one in the pubis, the os acetabuli. These epiphyses contribute to increase acetabular depth until the end of adolescence (14).

In conclusion, when the prenatal acetabulum and pelvis are analyzed on a microscopic or microradiographic level, a number of arguments can be found to consider mechanical stress as the most important extrinsic factor influencing their fetal development.

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SAMENVATTING

O. DELAERE, A. DHEM. Prenatale ontwikkeling van het bekken en het acetabulum.

De prenatale ontwikkeling van het menselijk bekken en acetabulum werd bestudeerd door de klassieke histologie en microradiografieën. Tijdens de embryonale fase ontwikkelt de heup zich in de eerste 8 weken. De foetale fase is een groeifase met de volgende kenmerken : endochondrale ossificatie van het ileum vanf de 9de week, asymmetrische ontwikkeling van de iliacale diafyse vanaf de 15de week, vorming van een chondroid-achtig weefsel boven het acetabulum vanaf de 26ste week en haversiaanse beenremodellage vanf de 28ste week. Deze foetale ontwikkeling lijkt sterk beïnvloed te worden door mechanische stimuli, vnl de gluteale spieractiviteit en de simultane druk van de femurkop.

RÉSUMÉ

O. DELAERE, A. DHEM. Le développement prénatal du bassin humain et du cotyle.

Le développement prénatal de l'os coxal et de l'acétabulum humains a été étudié au moyen de l'histologie classique et de la microradiographie. La phase embryonnaire mène au développement complet de la hanche endéans huit semaines de gestation. La période foetale est une phase de croissance, pendant laquelle on retient en particulier : l'ossification endochrondrale de l'ilium à partir de la neuvième semaine, le développement asymétrique de la diaphyse iliaque à partir de la quinzième semaine, la formation d'un tissu minéralisé ressemblant au tissu chondroïde dans la région postéro-supérieure de l'acétabulum à partir de la vingt-sixième semaine et le début du remaniement haversien à partir de la vingt-huitième semaine. Le développement foetal du bassin et de la hanche semble être essentiellement influencé par des stimuli mécaniques, le plus important étant l'activité des muscles glutéaux et la pression concomitante de la tête fémorale.