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## **MORPHOGENESIS OF STRUCTURES IN HIP JOINT REGION DURING EMBRYONIC AND PREFETAL PERIODS OF HUMAN ONTOGENESIS**

**Abstract.** *On 45 series of histological sections of embryos and prefetuses and 30 prefetuses the hip joint has been studied by means of the morphological methods: histological, plastic and graphic reconstruction, ordinary and fine dissection under control of microscope «Olimpus BX-2" digital camera and software packages for digital morphometry "Video Test 5.0" "Video size 5.0".*

**Key words:** *hip joint, embryotopography, embryo, prefetus, human.*

**Introduction.** The literature data on patterns of embryonic development of the hip joint are controversial [1-10]. Based on this, we consider it appropriate to conduct a comprehensive study of the characteristics and formation of structures that form the hip joint region during embryonic and prefetal periods of human ontogenesis.

**Objective:** to study the morphogenesis and peculiarities of topography of structures of the hip joint area during embryonic and prefetal periods of human ontogenesis, with the definition of critical periods, morphologic variants and possible development of congenital defects.

**Materials and methods.** The study was conducted through a set of morphological methods: making and microscopy of 45 series of consecutive histological and 20 topographoanatomic microscopic sections, macroscopy, standard and fine dissection of 30 prefetus cadavers, under control of «Olimpus BX-2" microscope, making and studying of graphic and plastic reconstruction models, stereoscopic photography, statistical digital data processing.

**Results and discussion.** The lower limbs buds are still absent in 4.0 mm embryos of parietal-coccygeal length (PCL). The limbs' buds in the form of short projections on the lateral aspects of the body, are noticeable in embryos of 5.0 mm PCL. Initially, these germs are formed by accumulation of mesenchymal cells coated with

a single layer of epithelium. However, the latter quickly becomes multilayered. At the distal end of the limb bud, due to proliferation of the basal layer cells, this epithelium forms a bulge - "ectodermal ridge".

Lower limb of embryos with 7.0 mm PCL has the shape of an elongated ridge with a constriction at the base, without distinction between its parts. However, even at this stage a little bend, facing its bulge is laterally seen.

In 8.0 mm PCL embryos, a concentration of mesenchymal cells towards the nerve trunks in the center of extremity is clearly distinguished. Nerves have a coarse-grained structure, and their diameters are: femoral  $41.5 \pm 2$  mcm, obturator  $41,5 \pm 2,1$  mcm, sciatic  $48,5 \pm 1,7$  mcm. Ectodermal ridge in limbs' buds is more clearly defined in comparison with the embryos of 7.0 mm PCL.

Lower limbs of 9.0 mm PCL embryos look like short and flat outgrowth that end as a flat "spatula" with rounded smooth edges. However, signs of the formation of the fingers are still missing. Nerve trunks grow into the buds of the lower extremities earlier than the rudiments of the muscles appear. In 9.0 mm PCL embryos the prechondral clusters of skeletogenous mesenchyme are observed.

In prefetuses of 14,0-15,0 mm PCL, lower limb is situated almost at a ventraly open right angle to the axis of the body, pressed to the body side and elongated in the anteroposterior direction. In the limb anlage we distinguish

proximal and distal parts (future thigh and foot) and a slight gap occupies the middle section (future crural region). If we consider the entire length of the lower extremity is 100%, then 37% would stay for the hips, 22% for legs, 41% for the foot.

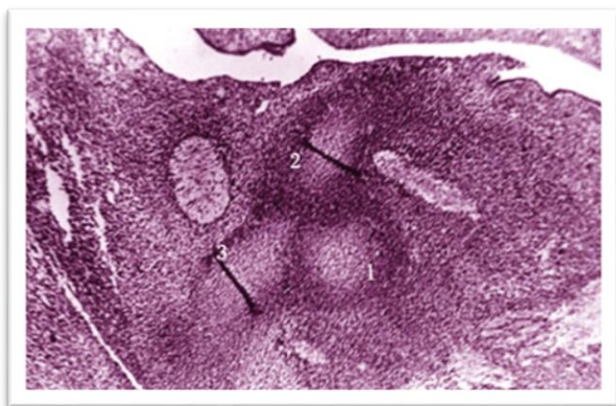
During the investigated period of ontogenesis the germs of hip bones and femur are formed of immature prechondral tissue. Germ of iliac wing is located at an angle of 20-23° to the horizontal plane and hangs above the acetabulum. The latter doesn't have clearly defined contours. Its diameter is  $460 \pm 12$  mcm, maximum depth –  $90 \pm 10$  mcm. The plane of acetabular input lies under the angle of 10° to the sagittal and 17° - to the frontal plane. The germ of femoral head has an irregular spheroid shape and is directly continues with the body of the bone. Greater trochanter and other anatomical details are not yet defined. Inclination angle is 145-150°, and the declination angle is negative (10-15°).

The first signs of differentiation of lower extremity bud manifests as condensation of mesenchymal cells in areas of relevant bones. The germ of future hip joint for the first time determines in prefetuses 14.0 mm TKD with the appearance of contours of mesenchymal condensation of femur and hip bone. The gap between the future articular surfaces of the adjacent bones is filled with mesenchymal cells (interzone of the joint). Hip joint is on the stage of continuous joint (synarthrosis) (Fig. 1).

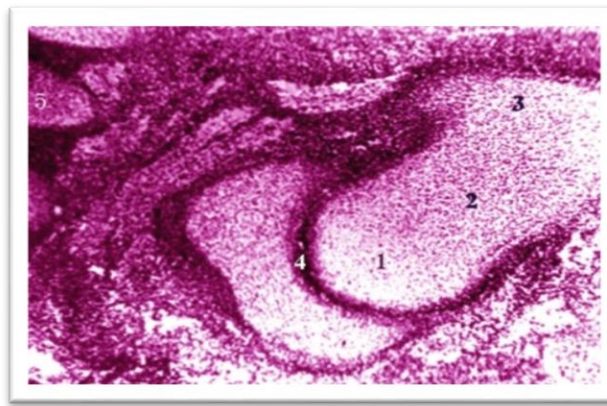
Hipbone germ is built with prechondral tissue in prefetuses of 16,0-19,5 mm (7 weeks). Iliac

wing retains its oval shape, elongated in dorso-ventral direction. At this stage a bend in pubic and sciatic bones germs is formed, but obturator's foramen is not formed yet. Acetabulum is well defined: its diameter is  $710 \pm 10$  mcm, its deepest part –  $110 \pm 5$  mcm, corresponding to its posterior-superior quadrant.

In prefetuses of 19,0-20,0 mm PCL, femoral head has spheroid shape, slightly elongated in cranio-caudal direction. Its diameter is  $705 \pm 5$  mcm. At this time, the formation of the femoral neck and greater trochanter germ begins (Fig.2.). Cervical-diaphyseal angle is 135-145°, declination angle is still negative and equals to - 7°. The maturity level of prechondral tissue in different parts of the femur varies, most differentiated it is within the central area. In prefetuses of 19,0-20,0 mm PCL (6th week of development) in the center of the intermediate zone of the hip joint, the cavity formation starts (Fig. 3, Fig. 4). Thus we have not observed cases of fusion and degeneration of cells, described in the literature. At the 7th week, the dilution of intermediate zone of the hip joint germ continues. In the center of germ an articular fissure is seen with unclearly marked borders, its width is  $27 \pm 3$  mcm. At this stage the formation of the femoral head ligament is outlined. It is represented by an accumulation of intermediate zone cells, located in the center of joints germ, and has a cone shape with the base on top of the femoral head. The ligaments length is  $30 \pm 3$  mcm, diameter of its base -  $50 \pm 2$  mm. The germ



**Fig.1.** Sagittal cut of a prefetus of 15,0 mm PCL. Stained with hematoxylin and eosin. Microphotography. Lens x 8,0. Oc. x 7,0. 1 - head of the femur; 2 - of ilium; 3 - germ of ischium.



**Fig.2.** Frontal cut of hip joint of a prefetus of 19,0 mm PCL. Stained with hematoxylin and eosin. Microphotography. Lens x8,0. Oc. x 7,0. 1 - head of femur; 2 - neck of femur; 3 - greater trochanter; 4 - acetabulum; 5 - lumbar vertebra.

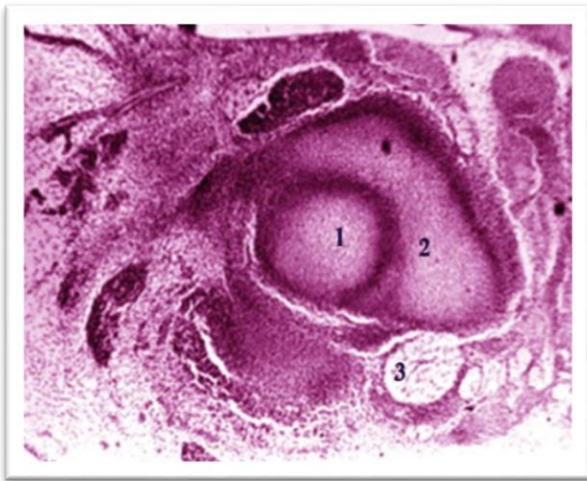


Fig. 3. Frontal cut of hip joint of a prefetus of 21,0 mm PCL. Stained with hematoxylin and eosin. Microphotography. Lens. x8,0. Oc. x 7,0. 1 – head of femur; 2 – acetabulum; 3 – sciatic nerve.

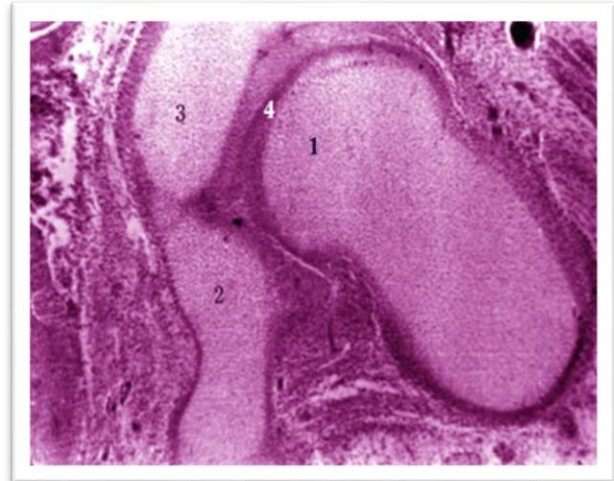


Fig.5. Frontal cut of pelvis of a prefetus of 23,0 mm PCL. Van Gieson's stain. Microphotography. Lens x8,0. Oc. x 7,0. 1 – head of femur; 2 – pubic bone germ; 3 – iliac bone germ; 4 – ligament of the head of the femur.



Fig. 4. Frontal cut of hip joint of a prefetus of 21,0 mm PCL. Stained with hematoxylin and eosin. Microphotography. Lens. x8,0. Oc. x 7,0. 1 – head of femur; 2 – acetabulum; 3 – sciatic nerve.

of the capsule of the joint is seen as a thickening of mesenchymal cells, with the width of  $18 \pm 1,2$  mcm, which distinguishes intermediate zone from surrounding regions.

The most intensive process of formation of the joint cavity is observed in the end of 7th and the beginning of 8th week of intrauterine development (prefetuses 23,0-27,0 mm PCL). In prefetuses with 23.0 mm PCL, the contours of articular fissure are clearly outlines are separated unclearly (Figure 5.). Articular surface of the acetabulum and the head of femur are uneven and are presented by accumulation of cells with large, round nuclei. In the lumen of the articular fissure, the cells sized from 4 to 8 mcm

with round nuclei are often found. The maximum width of the joint fissure is  $30 \pm 2$  mcm, minimum – 10-16 mcm. The germ of the ligament of femoral head occupies considerable space of the joint cavity, which is being formed. At the top of the femoral head and the base of acetabulum, the ligament is seen as an accumulation of mesenchymal cells.

In prefetuses of 23.0-27.0 mm the ligament of the head of the femur is expanded at the base of the acetabulum and the top of head of femur. Width of the base of the ligament is  $120 \pm 5$  mcm, central part -  $100 \pm 7$  mcm. Significant changes occur in the structure of the joint capsule. In almost all areas of the separation into two layers starts. The outer layer is more dense and consists mainly of fibroblast accumulation and collagen fibers, and the inner layer is lined with flat cells.

**Conclusions.** 1. On the early stages of embryogenesis the connection of bones germs, which form hip joint is continuous. In the region of the future joint a layer of undifferentiated mesenchymal cells - interzone of the joint is situated. Homogeneous interzona works as an obstacle to the extensive growth of neighboring cartilaginous elements and thus fulfills the role of mechanical blocking factor of further growth, and assists in modeling the shapes of articular surfaces. 2. In the region of the future hip joint,



the thickness of mesenchymal layer between the future articular surfaces is being reduced, it becomes less dense and probably forms articular cartilage. Loosening of mesenchyme occurs due to an increase of intercellular substance, where the beginning of fibrous structures – intracapsular ligaments of the hip joint - formation is observed.

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