



POSNA

The Core Curriculum

Enchondral ossification

Objectives

1. List and describe the zones of the growth plate
2. Describe the vascular supply to the growth plate
3. Describe the composition of the matrix in the different zones of the growth plate
4. Describe the activity in the primary and secondary spongiosa
5. Describe the structure and function of the groove of Ranvier and the ring of LaCroix

Discussion points

1. What type(s) of collagen is (are) found in growth plate cartilage cells?
2. What is funnelization?

Discussion

The growth plate is bounded by the epiphysis on one side and the metaphysis on the other. There are three zones in the cartilaginous component - reserve (or germinal), proliferative, and hypertrophic. Only the reserve layer has a vascular supply, via the epiphysis, with the vessels terminating at the upper end of the proliferative zone. The capillary loops of the metaphyseal vessels end at the last cartilaginous transverse septum of the growth plate at the metaphyseal interface. The periphery is supplied by metaphyseal and periosteal vessels.

The cells of the reserve zone have a well-developed endoplasmic reticulum indicative of protein synthesis but there is little cellular proliferation or matrix production. Oxygen tension is low. The proliferative zone is characterized by linear columns of chondrocytes. Cell division and enlargement (growth) along with matrix production occur here. This area is metabolically active, with the highest oxygen tension. Glycogen is synthesized aerobically and stored. There is a complex regulatory loop for conversion of proliferative cells to hypertrophic cells. Receptors for parathyroid hormone related protein (PTHrP), and parathyroid hormone in several tissues including proliferating chondrocytes.

The cells enlarge 5-10 times in the hypertrophic zone, remaining viable until the end of this layer. There is a high content of glycolytic enzymes and matrix production. The cells closest to the proliferative region the cells enlarge and begin to consume their glycogen. The mitochondria start to store calcium. In the middle zone of the hypertrophic layer, the cells start to disintegrate, oxygen tension is low, and the metabolism is catabolic, with

depletion of glycogen stores. The mitochondria in the cells adjacent to the metaphysis release calcium; calcium and matrix being essential to the zone of provisional calcification, which consists of longitudinal bars of calcified matrix. The major collagen in the hypertrophic zone is Type II, although the terminal chondrocytes also produce and secrete Type X collagen into the matrix.

In the metaphysis, the mineralized cartilaginous matrix of the zone of provisional calcification is absorbed as the lacunae of the dead chondrocytes are invaded by vessels. The vessels deliver osteoblasts, which line the calcified longitudinal septae and lay down osteoid on the calcified matrix. This region, with bone matrix on calcified septae is the primary spongiosa. When the residual calcified septae have been completely removed by chondroclasts and osteoclasts, lamellar bone forms, and this region is known as the secondary spongiosa.

The growth plate is surrounded by the fibrous perichondrial ring of LaCroix and the ossification groove of Ranvier. The perichondrial ring contains a thin extension of metaphyseal bone and circumferential collagen fibers that provide stability to the growth plate. The ossification groove is a wedge shaped collection of cells pushing into the reserve and proliferative regions of the growth plate. This structure appears to supply cells for the reserve layer, and also expands the diameter of the growth plate.

An extremely important metaphyseal function in remodeling. Osteoclasts start to remove bone from the periphery of the metaphysis virtually as soon as it is formed producing a phenomenon called funnelization. As this area is being so actively resorbed, the metaphyseal bone here is more porous than the diaphyseal bone where the cortex is thickened by appositional bone growth.

References

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