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Dr Jekyll and Mr Hyde: the bipolar nature of the epiphyseal plate

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The epiphyseal plate is essentially a cartilage layer sandwiched between two bony segments at the end of long bones. On the epiphyseal side, the chondrocytes are small and rounded and form a stable, resting zone; toward the diaphysis, they gradually enlarge and blend into a proliferating area and then a hypertrophic zone, where they express type I and type X collagen easing the cartilage transition into bone. The molecular mechanisms underlying these processes are partially known (1), and these tissues' structural biology is even less documented (2).

In the present research, the epiphyseal plates from ovine proximal femoral epiphyses were investigated by histological sections, ground sections, scanning electron microscopy, thermal deproteination (3) and micro-tomography. Images were obtained with a Nikon Eclipse 300 photomicroscope, a FEI XL-30 FEG SEM and a Stratec XCT-Research SA+ microCT.

On the epiphyseal side, the chondrocytes are widely dispersed, rounded and stable; toward the diaphysis, they become progressively hypertrophic, and the interposed territorial matrix undergoes mineralization. This latter process takes place very actively, forming a continuous bony surface at the mineralization front but leaving behind a constellation of small cartilage islets interspersed in a delicate meshwork of cancellous bone. Both tissues are then remodelled together, as shown by frequent Howship lacunae. Matrix vesicles initiate the calcification process and, differently from other hard tissues, proceed to completion with no visible involvement of the collagen fibrils.

In stark contrast, the other interface of the epiphyseal plate shows no trace of an active ossification process. All techniques consistently confirm a mature, stable, wide-spaced cancellous bone that is visibly different from the bone left behind by the mineralization front on the diaphyseal side. The cartilage involvement is limited to impressions of chondrocytes lying on the very bone/cartilage interface.

The two sides of the epiphyseal plate show a surprisingly opposite structure, with endochondral ossification proceeding very actively on the diaphyseal face of the cartilage layer but not at all on the epiphyseal front. The blood and nutrient supply on the two faces seem equivalent. Yet even the two bony surfaces enclosing the cartilage are diametrically different from each other and the subchondral bone under the articular cartilage.

Other research is underway to elucidate the cause of such divergent behaviors occurring a few micrometers apart on the opposite faces of the same tissue.

References

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[3] Raspanti et al., Biomaterials 15 (1994) 433-437.