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Report:

The purpose of this work was to define the staging of the axial skeleton development in normal fetus by analysing a series of vertebral bone samples from fetus with different gestational ages using microtomography. A synchrotron radiation computed microtomography (SRCMT) system allowing high resolution three-dimensional imaging of bone samples is available at ESRF. The system uses a high resolution 2D detector based on a CCD camera coupled to a fluorescent screen through light optics. For this study, the choice of the optics lead a pixel size of 10.13 microns, which is well adapted to the imaging of bone structure, while ensuring a reasonable field of view size.

Two vertebrae from two different 40-week-old fetus were imaged in three dimensions. On the first one, five different $(5mm)^3$ sub-samples were extracted within the third lumbar vertebra and embedded in methyl methacrylate. They were imaged on a $(512)^3$ grid, at an energy of 20 kev. Figure 1 shows orthogonal cross-sections (512 x 512) through a reconstructed volume. Different gray levels can be observed within bone, indicating a change in composition. Trabeculae and cortical bone are clearly contrasted. The global structure appears very dense and does not seem to present as many privilegiated orientations as adult bone does. From a qualitative point of view, it is interesting to note the differences in distribution and thickness of the trabeculae within the bone samples.

Close to the external surface, trabeculae become thinner and tighter. This particular aspect seems in accordance with the hypothesis that the vertebral body results from the growth of a central bony nucleus. From the first results, it appears that the structure of the fetus vertebra is quite different from the adult bone structure both in terms of density and organization. The bone volume ratio is approximately 2.5 to 3 times higher compared to young adult. The same observation holds for the number of trabeculae per unit length. In our previous observations using quantitative computed tomography (CT)[1], it was found that the mean vertebral density value was also 2.5 times higher in the fetus vertebra than the mean maximum density value measured in young normal adults. Therefore, the present results are in good agreement with the CT measurements, providing that the fetus bone composition is the same as the adult one. Considering the thickness of trabeculae, the mean value is about 110±10 microns, a value very close to the mean value found in adult trabecular bone. However we have to be aware of the limits of the computation. First, the derived trabecular thickness is an approximation valid for a plates and rods model of bone, which may not be appropriate here. Second, we have observed that the trabeculae thickness is dependant on the choice of the direction of analysis. Third, as may be seen on the images, in some very dense regions it is not obvious to define what the thickness of the trabeculae is.

Little is known about the mechanism of the vertebral ossification, the high resolution images obtained by SR CMT will be of great help for a better understanding of the formation of bone.

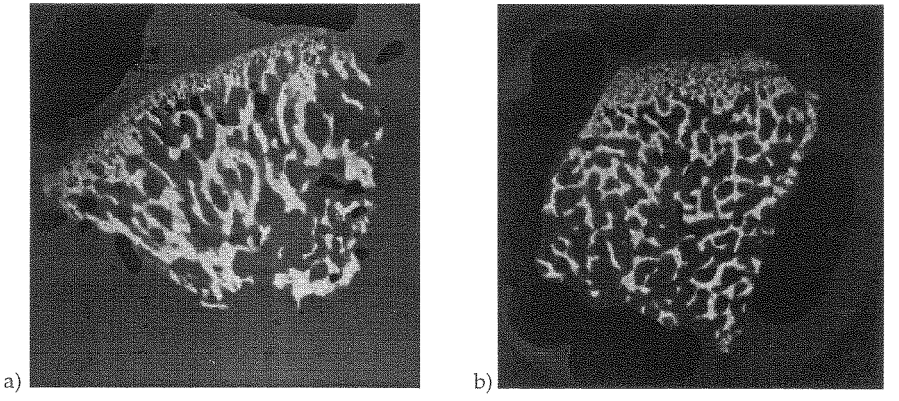

Fig. 1: 512 x 512 reconstructed images of a fetus vertebra sample, energy 20 keV, pixel size 10 μm x 10μm, slice thickness : 10 μm : a) vertical cross-section, b) horizontal cross-section.

References :

[1]**P. M. Braillon, A. Lapillonne, P. S. Ho, R. Bouvier, M. Bochu, B. L. Salle, « Assessment of the bone mineral density in the lumbar vertebrae of newborns by quantitative computed tomography », Skeletal Radiology, vol 25,** p. **711-715,1996.**