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Mineralization process of developing long bones

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Cutting-edge imaging methods were used with unprecedented resolution to measure amount of calcium and mineral crystal in long bones from mice embryos. The calcium content increased during embryonic development and the crystals experienced slight reshaping.

Our skeleton begins to mineralize already in the late stages of fetal development. The mineral contains mainly calcium apatite. Before that, our bones consist of a soft cartilage template. While the mineralization process during adult bone development have been investigated, few studies have been conducted on developing fetal bones and not with high resolution. As the macroscopic mechanical properties are dependent on the structure-composition-function relationship on all length scales, it is significant to assess all these length scales.

This study used high-powered X-rays at a synchrotron facility to study long bones from mice embryos with high spatial resolution. Fluorescence helped to quantify the calcium content and scattering to study the mineral crystals. It was found that the calcium content increased with age with up to 400% from the first sign of mineralization to shortly before birth (Fig. 1.B). This all happened in 3-4 days.

The amount of mineral crystals increased during development and they underwent slight reshaping over time. At the start of mineralization, the mineral crystals were bulky particles, with similar length and width. As development progressed, the mineral crystals got more rectangular (smaller width while keeping the same length) (Fig. 1.C). There was no difference between mineralized bone in the new parts of the growth plate and the older bone in the center of the long bone.

In developmental bone diseases, such as Cerebral Palsy, abnormal or lack of muscle function leads to dysfunctional bones. In order to understand and treat these kinds of diseases, one must first understand normal bone development. The results found here will help future studies on the role of muscle loading on bone mineralization during fetal development.

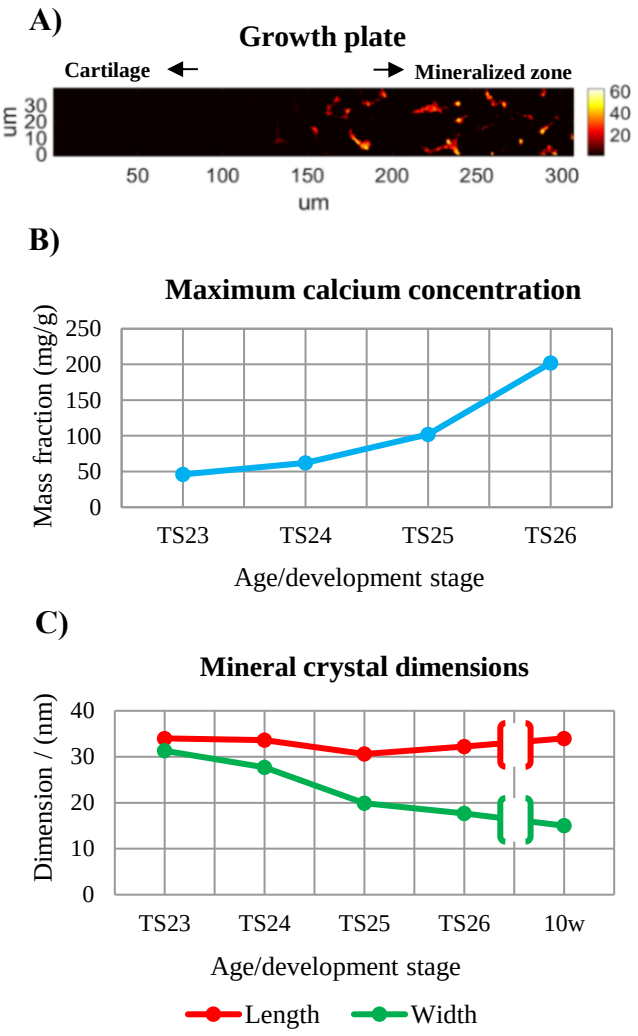

Figure 1.

A) Fluorescence image of the calcium distribution across the growth plate of an embryonic mice forelimb. The brighter the pixel, the higher the concentration. Concentrations are given in mg/g.

B) Evolution of maximum calcium concentration over time.

C) Evolution of mineral crystal dimensions with age. Included is a reference value from 10w old rats (Turunen et al. (2016), Struct Biol, 195).