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Magnesium-Supported Continuous Growth of Rodents' Incisors

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A great variety of functional mineralized composite materials are formed by different living organisms. Typically, simple inorganic and organic components are arranged in optimally designed nanoarchitectures that show outstanding performance and fulfill different functions in animal bodies. The constantly growing incisors of rodents are a perfect example of natural complex organic-inorganic composite material. The front part of the incisors is covered by hard and resistant enamel, while softer dentin forms the bulk of the tooth and provides the mechanical support for enamel. Dentin can be considered as heterogeneous material due to the presence of numerous dentinal tubules (DT) that are separated by intertubular dentin (ID) that is forming the matrix [1]. Dentin is composed of approximately 70 wt% of inorganic material, 10 wt% of water and 20 wt% of organic matrix consisting mainly of type-I collagen fibrils [2].

In this study [3], upper and lower continuously growing incisors of adult and young coypu (*Myocastor coypus* Molina) were investigated. In addition, coypu´s molars were investigated for comparison. Thin electron transparent sections were prepared from several different positions within the dentin by using ultramicrotomy. The microstructure and chemistry of intertubular dentin (ID) and dentinal tubules (DT) were investigated using advanced imaging and analytical transmission electron microscopy (TEM) techniques. High-angle annular dark-field (HAADF) scanning TEM (STEM) images of DT cross-sections separated by ID are shown in Figure 1a,b. The DT appears to be partially filled with flake-like amorphous material (Fig. 1c). Characteristic D-banding (Fig. 1a,b) is clearly observable in ID which is consisting of elongated needle-like hydroxyapatite crystals and collagen fibrils. We measured an unprecedentedly high amount of Mg in the amorphous flake-like material within the incisors' DT (Fig. 2a-c), while in the surrounding ID the Ca signal predominates (Fig. 2b). Our energy-dispersive X-ray spectroscopy (EDX) and electron energy-loss spectroscopy (EELS) measurements suggest the presence of an amorphous (**Mg**,Ca)-phosphate phase within the DT. Through an uncommonly high amount of Mg found in the DT of incisors, we indirectly determined a tremendously high influx of Mg into the dentin of incisors, which could also explain much higher Mg values measured in ID of constantly growing incisors compared to the values measured in molars. The constant growth of incisors implies that they can be considered as early stage dental tissues. Relatively constant concentrations of Mg observed in only the continuously growing incisors (but not in molars with terminated growth) could imply that higher levels of Mg are necessary during the initial growth stages of all teeth, and not only for constantly growing teeth.

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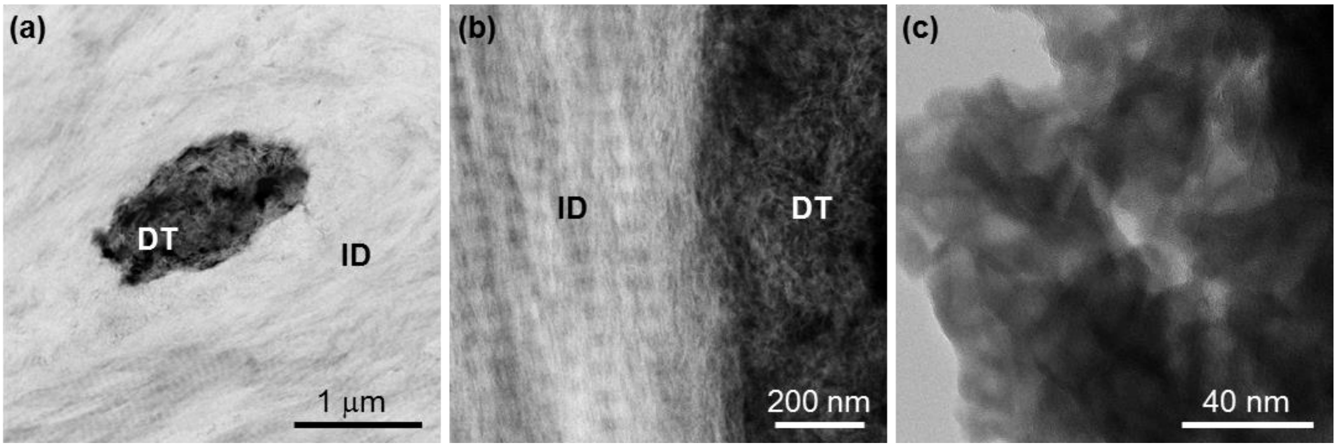

Figure 1. (a,b) HAADF-STEM images of dentinal tubules (DT) and surrounding intertubular dentin (ID). (c) HRTEM image of flake-like material filling the DT of incisors.

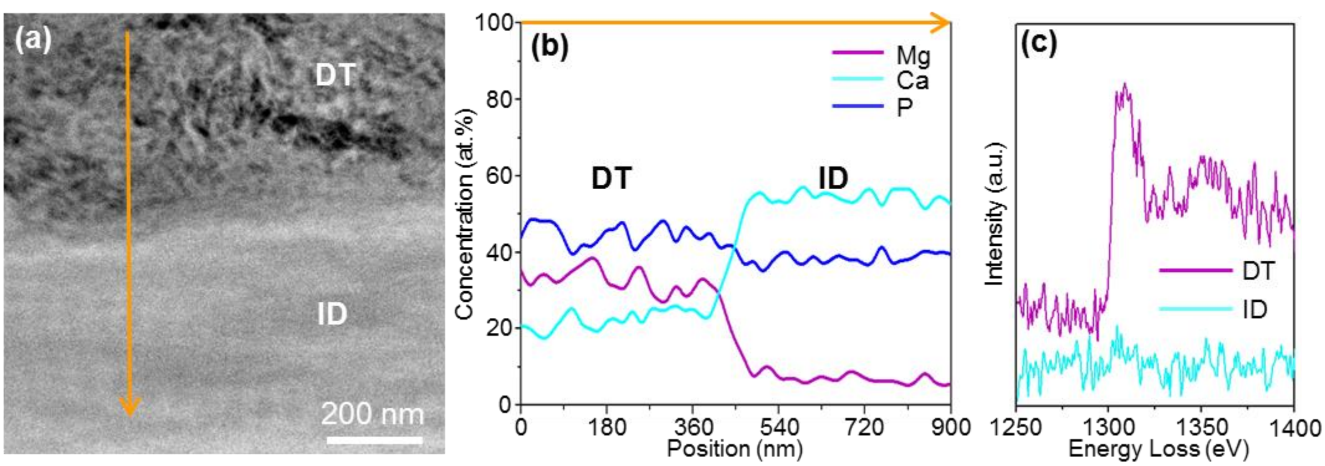

Figure 2. (a) HAADF-STEM image of the contact between ID and material that is filling the DT in incisors. (b) Corresponding EDX linescan (b) showing Mg, Ca, and P compositional profiles. (c) Mg-K ELNES measured from DT and ID.

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