Calcif Tissue Int (1990) 46:406–414

Calcified Tissue International

Changes in the Mode of Calcium and Phosphate Transport during Rat Incisal Enamel Formation

Tadafumi Kawamoto and Masaharu Shimizu

Department of Biochemistry, School of Dental Medicine, Tsurumi University, Yokohama, Japan

Summary. The distribution of ^{45}Ca, $^{32}PO_4$, ^{22}Na, and calcein in the freeze-dried sections of rat lower incisor was examined. Also, the ratio of ^{45}Ca to $^{32}PO_4$ transported into the enamel at various developmental stages was studied after the simultaneous injection of ^{45}Ca and $^{32}PO_4$. The distribution of calcein fluorescence indicated the presence of an extracellular route from capillary to enamel in the areas of both the secretory and smooth-ended ameloblasts. Autoradiograms showed that the ^{45}Ca incorporation into the enamel in the smooth-ended ameloblast region was higher than that into the secretory enamel, and a remarkably high incorporation was observed in the enamel of the apical two-thirds of the ruffle-ended ameloblast region. Although the ^{32}P incorporation into the enamel of the smooth- and ruffle-ended ameloblast region was higher than in the secretory enamel, the differences between these two regions were not so evident as that observed in the case of ^{45}Ca. The high labeling of ^{45}Ca and ^{22}Na was observed in the apical two-thirds of the ruffle-ended ameloblasts. The $^{45}Ca/^{32}PO_4$ ratio in the secretory enamel was significantly lower than that in the blood, but in the enamel of the smooth-ended ameloblast region the ratio was not significantly lower. Contrarily, the ratio in the enamel of the ruffle-ended ameloblast region was much higher than that in blood. These results indicate that the mode of transport of these ions into enamel is altered in relation to the morphological changes of the ameloblasts.

Key words: Enamel formation — Autoradiography — Calcium — Phosphate — Sodium.

Send reprint requests to T. Kawamoto, Department of Biochemistry, School of Dental Medicine, Tsurumi University, Yokohama, Japan.

It is well accepted that the mineralization of enamel proceeds in two phases involving the matrix-forming (secretory) and the maturation phase. In the secretory phase, the mineralization begins shortly after an organic matrix is secreted by the ameloblasts, and further mineralization proceeds rather slowly. After the entire thickness of enamel matrix is laid down, maturation phase takes place wherein there is a sudden and large influx of calcium and phosphate, and a marked increase of mineralization occurs. It is very important for a thorough understanding of the mechanisms of enamel formation to clarify the control system of calcium and phosphate transport by the enamel-forming cells and the pathway of these ions into enamel. Autoradiographic results [1, 2] showed that the calcium ion passed into developing enamel via the enamel organ, and the entry of the ion into enamel is controlled by the cells of enamel organ [3–5]. In order to define the control system and the pathway of calcium transport from the blood to the mineralizing enamel, the location of calcium in the enamel organ has been studied with histochemical methods [6–10], energy-dispersive X-ray spectrometry [9, 11–14] and autoradiography [3, 4, 14–18]. Also, the presence and localization of the Ca-ATPase activity in ameloblasts and the possible role of the enzyme in calcium transport has been intensively examined [19–24]. On the other hand, there is little information with regard to the phosphate transport [4, 25–27], and the findings vary. The difference between the calcium and phosphate control systems and their transport pathway through the enamel-forming cell layers are still inconclusive.

The object in the present study was to investigate the mode of ion transport and the pathway from the blood to the mineralizing enamel. In order to accomplish this, we examined (1) the possible existence of an extracellular route using calcein as a tracer; (2) the distribution of radioactive calcium,