Evagination and Invagination of the Oral Epithelium during Tooth Development in Alligator Mississippiensis

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Abstract: The early development of alligator odontogenesis shows embryological 'the Biogenetic law'. The swelling of the oral epithelium formed in the medial nasal process. It contained many cell deaths without teeth development at (Ferguson) stage16. This stage compared to the horny teeth of Lamprey. At stages 17-19, the dental lamina developed from the oral epithelium and the enamel organ-like structure raised from it. The teeth developed just under the organ is composed of only collagen, so called dentine teeth. This stage compared to the fish tooth with the absence of enamel organ. After stage 27, the enamel organ completely developed and formed the tooth crown with the enamel and dentine. The completed teeth had long roots about 2 to 3 times longer than the crown height. Hertwig's epithelial sheath grew opposite to the enamel organ. All these observations suggested that the crown forming enamel organ and Hertwig's epithelial sheath developed in the symmetry through evagination (swelling) and invagination of the oral epithelium, respectively, based on the concept of the body plan.

Key words: Alligator odontogenesis, Phylogeny in tooth development, Body plan

Aims and Materials

The process of evagination and invagination is a fundamental developmental phenomenon of the body. The authors aim to clarify the functional aspect of the evagination and the invagination in the odontogenesis. For this aim, we observed the early developmental stage of tooth germ in the embryo of Alligator mississippiensis from stage 16 (18D) to 27 (63D)[1)] (Ferguson 1987).

Results

At stage 15, the cells of mid-oral epithelium in the medial nasal process proliferated and formed a swelling, which included many cell deaths, and then disappeared (Fig.1). At stages from 15 to 19, the growing medial epithelial thickening also formed swelling and infolded into the mesenchyme to form the dental lamina (Fig.2, 3). It developed from medial side to the distal. The first generation tooth germs developed from the dental lamina. The teeth germs formed tooth-like structures consisting of collagen fibers without enamel organ, so-called the dentine teeth, which are free from the jawbone, and also disappeared before eruption. Many cell deaths were also observed in the epithelium. At approximately 60PD , the dental lamina, from which the second and third generation tooth germs were developed at the same position as earlier, elongated from the medial side to the distal side The enamel organ completely developed the tooth crown carrying the enamel and dentine (Fig.3). When the crown formation was completed, Hertwig's epithelial sheath elongated into the mesenchyme opposite to the epithelium, and resulted in formation of the root, which is about 2 to 3 times longer than the crown (Fig.4). These teeth were implanted in the tooth socket with the long roots.

Discussion

The epithelial swelling (evagination) at stage 15 was formed by a small group of oral epithelial cells, which disappeared following many cell deaths after temporary appearance (Fig.1). At stage 15 and stages 16-19, the dentine tooth was left as a rudimentary organ, because the dental lamina led the next generation tooth germs (second and third) in the same area at later stages. The epithelial swelling at stage16-19, also including many cell deaths, was similar to the enamel organ because the basal cells showed slightly columnar shape resembling the ameloblasts with the absence of stellate reticulum, and mesenchymal cells just under the swelling formed the dentine tooth. This dentine tooth is also free from the jawbone and disappeared before eruption.

From the viewpoint of phylogeny or evolution, the swelling at stage 16 compared to the horny teeth of Lamprey (Fig.5), because the tooth was formed by a small group of oral epithelial cells, followed by rhythmical replacement. The dentine tooth at stages 17-18 is also similar to the fish tooth with the dentine covered by the enameloid. The fish tooth develops in the mesenchymal area under the influence of the epithelium of similar enamel organ. The enameloid tooth, including the collagen fiber, is similar to the dentine teeth of these alligators.

All these observations and data suggest that the teeth at these two stages are the precursors of tooth as the rudimental organ of ancestor that were lost during the evolution, and also suggest that the tooth formation is initiated by the swelling.

After these stages, the tooth germs developed from the dental lamina formed the complete tooth with the crown composed of the enamel and dentine and the root implanted into the tooth socket. Hertwig's epithelial sheath elongated opposite to the direction of the crown and formed the long tooth root (Fig.4). The sheath growth, opposite to the direction of the tooth crown, showed the invagination at the enamel organ development. The developments of crown (enamel organ) and root (Hertwig's epithelial sheath) were based on the symmetrical body plan (Fig.5, 6).

The human body starts to take shape during the earliest stages of embryonic development by the cell plan, which describes proliferation and grouping of the cells with rhythmical function

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and play. The cell grouping constitutes the functional unit of tissues, organs and individuals. These grouped cells are arranged fundamentally in symmetry in various directions such as cephalo-caudal (oro-anal), dorso-ventral, right-left in the body. The crown and root is also in a symmetrical plan (Fig. 6). The cell and body plans play important roles in the formation of enamel and dentine structures during odontogenesis, such that 'ameloblast dancing and grouping' develops the enamel structure and 'odontoblast grouping and dancing' formed the striation of Ivory [3](Yokota 2005, Kozawa 1991).

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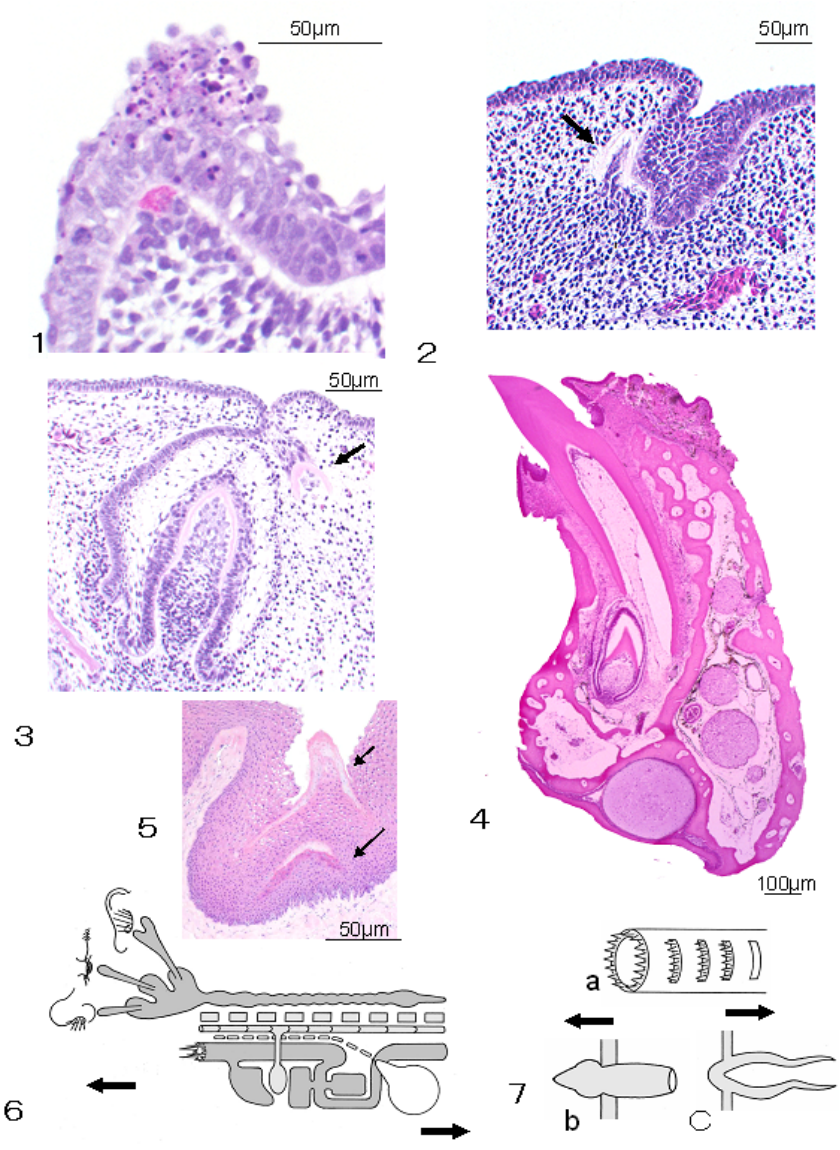

Fig. 1. The swelling of oral epithelium at stage 15 (18D). A small swelling appeared at medial side of the oral epithelium. It contained many cell deaths, and then disappeared. Basal cells with columnar shape differentiated into the ameloblasts. Hematoxylin and Eosin staining,

Fig. 2. At stage 16 (21D), the dentine tooth (arrow) with the absence of enamel tissue, was formed just under the swelling of the oral epithelium. The swelling is similar to the enamel organ due to the columnar shape of the basal cells and the death of many cells. The tooth is stained by Eosin. Hematoxylin-Eosin staining.

Fig. 3. At stage 19 (27D), the dentine tooth attached to the oral epithelium but is free from the jawbone. This tooth disappears before becoming functional (arrow shows the dentine tooth).

Fig. 4. Mature and next generation teeth. The tooth root developed about 2 to 3 times longer than the crown height.

Fig 5. The teeth of Lamprey Small groups around oral cavity keratinized and replaced with certain rhythms.

Fig. 6. Schema of the body plan. The nerve system and the genital organs develop in the symmetry of cephalo-caudal direction. The body has also right-left and dorso-ventral symmetry (arrow shows developmental direction).

Fig. 7. Schema of the tooth plan in the oral cavity. The tooth develops from the oral epithelium to cephalic direction (a). The swelling of the epithelium is shown (evagination). The tooth crown and root is in the symmetrical plan of the tooth caused by the evagination (swelling, b) and invagination (c) of the oral epithelium.