

# Dental formula of elephant by the development of tooth germ

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**SUMMARY:** The authors try to clarify the dental formula and morphogenesis of complex molar form of modern elephant molar from the developmental aspect. Four embryos of African elephant (*Loxodonta africana*) between 1 to 4 months old and two Indian elephant (*Elephas maximus*) tooth germs of the fifth molars were examined with the histologic and 3-D methods. The authors propose the following dental formula:

Milk Teeth: i 1/0 c 0/0 m (dm) 3/3. Permanent teeth: I 1/0 C 0/0 P 0/0 M 3/3.

The molar belongs to the first generation teeth, so-called milk molars series. The crown has a very complex form, but the shape fundamentally formed at the early bell stage as other mammals. The accessory factors of crown add on the calcification stage of this fundamental form.

## 1. INTRODUCTION

The aim of this study is to determine the type of tooth and dental formula in the modern elephant with the development aspect, because it is proposed that elephant has two upper incisors (ivory) and 6 molars in each side of each jaw throughout life. The two incisors are composed of milk and permanent replacement tooth. However there are two proposals on the composition of these molars, one is three deciduous and three replacement premolar teeth, other one is three deciduous teeth and three molars. On the molar, crown shape was very complex developed along the Proboscidean evolution. However, there are a few reports on the morphogenesis of the molar and it is not known how to develop the molar crown form (Bolk 1919; Ijiri *et al.* 1949; Kozawa 1978, 1986). These phenomena are examined by the fossil trace, so that the authors try to find out the trace on the tooth developmental aspects.

## 2. MATERIALS AND METHODS

Four embryos of African elephant (*Loxodonta africana*) between 1 to 4 months

old and two Indian elephant (*Elephas maximus*) tooth germs of the fifth molars were examined with the histological study and discussed.

## 3. RESULTS AND DISCUSSION

### 3.1 Dental formula

A bell stage tooth germ was observed on the mesial upper jaw in each side. The tooth germs continued with the oral epithelium with the dental lamina, and also had a succession dental lamina of replacement tooth germ (Fig. 1). On the other hand, there was no tooth germ in lower jaws. It is suggested that the tooth germ was the milk incisor, so called milk tusk, and the permanent continuous tusks might develop on the replacement dental lamina. The dental lamina was observed between these tusk tooth germ and molar tooth germs in 2-3 months early embryo, but could not be found on 4 months stage. Both dental laminae of incisor and molar develop continuously in early embryo stage, but separate in developed stage (Fig. 2). There is no vestige of canine, such as cell death, on the canine position. In each side of jaws, there were two tooth germs, which

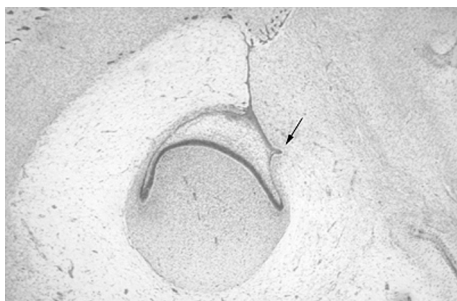


Fig.1 - The tusk tooth germ of bell stage with continuous dental lamina for replacement tooth (arrow).

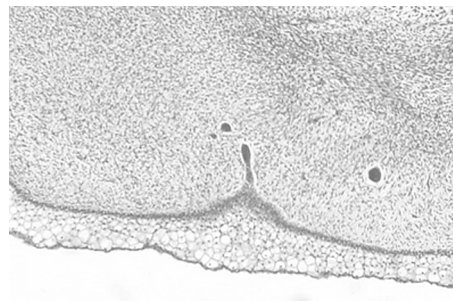


Fig.2 - The dental lamina between incisor (tusk) and molar region of the upper jaw of African elephant.

were early before calcification stage. The dental, which originated from mesial side of oral epithelium, grew to distal side in connective tissue of jaws, and two tooth germs anchors this dental lamina. The distal side of dental lamina grew to distal over the second molar tooth germ (Fig. 3). This distal dental lamina was directly connected to the oral epithelium. There was no replacement dental lamina on the molar tooth germs. It is concluded that this dental lamina come from oral epithelium and grow more distal; new molar tooth germ developed from it. It is suggested that the all molar tooth germs develop from the direct contacted dental lamina and comprise the first generation series, so-called milk or deciduous molar group. There is

no replacement molar tooth. The authors propose the following dental formula:

Milk Teeth i 1/0 c 0/0 m (dm) 3/3

Permanent teeth I 1/0 C 0/0 P 0/0 M 3/3

The molar belongs to the first generation teeth, so-called milk molars series.

### 3.2 Crown development of molars

The inner enamel epithelium already developed the form of papillae and lamellae of mature molar on the second molar tooth germ of 4 month embryo. However, the outer enamel epithelium formed a single dome shape as for human tooth germ (Fig. 4). On the other hand, both the outer and inner enamel epithelium of Indian elephant molar tooth germ (5<sup>th</sup> molar M2, about 2.5 cm long) of before calcification bell stage formed the lamellae and papilla shape same as the mature crown form (Fig.

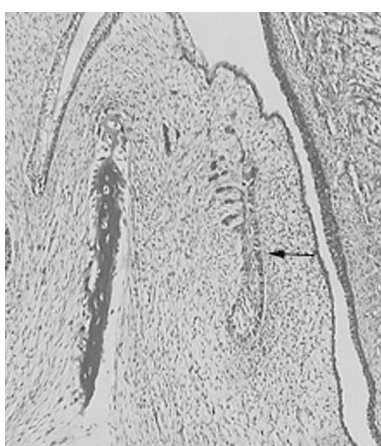


Fig.3 - The distal dental lamina (arrow) of the molar region.



Fig.4 - Horizontal section of the 2<sup>nd</sup> molar tooth germ: the inner enamel epithelium shaped papillae and lamellae form (arrow), but the outer enamel epithelium shows a dome-like shape.

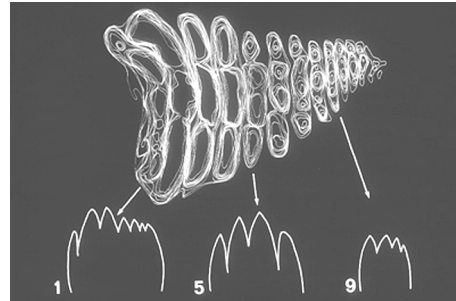
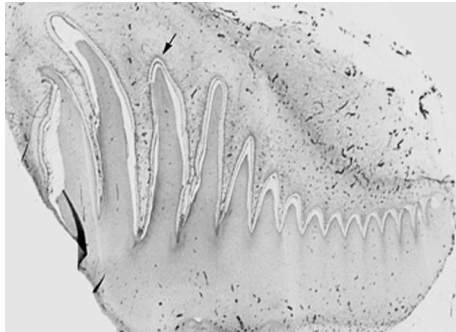


Fig.5 - 5<sup>th</sup> tooth germ of *Elephas maximus*. Both the inner and outer enamel epithelium show complex folding (arrow), about 16 folds, the same as mature molar tooth of lamellae. b: the 3D reconstruction of enamel organ showed the papillae and lamellae already formed in this early bell stage tooth germ before calcification. The number shows the lamellae number from mesial side.

5a, b). The mature 5<sup>th</sup> molar of *Elephas maximus* is about 20 to 30 cm long. The tusk tooth germ showed simple form as incisor of human teeth. These suggest that the complex molar morphogenesis initially started as the human tooth pattern, but later developed to complex form of enamel organ, which makes fundamental type of folding as mature tooth crown. Therefore the fundamental crown shape forms at the early bell stage as other mammalian tooth development. On the calcification stage, the accessory factors of crown add at this fundamental form (Tasumi 1964).

#### 4. CONCLUSION

Recent elephants, such as *Elephas maximus* and *Loxodonta africana*, have 6 molar teeth in each side of each jaw. These molars belong to first generation series, because they develop from direct dental lamina originating from the oral epithelium (Fig. 6). These molars show complex crown form, but the initial developmental patterns are similar to the other mammalian teeth (A part of this report was presented in Dental morphology in Berlin) (Kozawa *et al.* 1995).

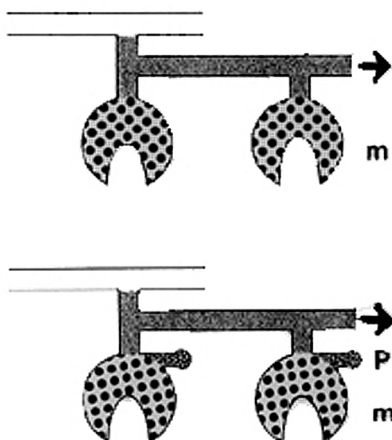


Fig.6 - Conclusion of elephant molar development. It is concluded that all molars may develop from the direct growth dental lamina from oral epithelium (upper side) so that all molars belong to the first generation such as milk molar, and replacement molar disappears along with the evolution. However, the deciduous (milk) molar in many mammals develops the permanent premolar and molars from the direct dental lamina from the oral epithelium (lower side). m shows first generation tooth germ, p shows development of premolar, and arrow shows development direction of dental lamina.

## 5. REFERENCES

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