REVISTA CIÊNCIAS e ODONTOLOGIA

DEVELOPMENT OF THE HUMAN DENTAL LAMINA

DESENVOLVIMENTO DA LÂMINA DENTÁRIA HUMANA

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Abstract

Introduction: Only a few reports exist concerning odontogenesis in the fetus. **Objective:** To describe dental lamina development in embryos and fetus. **Material and Methods:** The upper and lower jaws were prepared in serial sections in both the sagittal and frontal planes. The hematoxylin-eosin staining sections were examined microscopically. **Results:** It was observed that: (1) the first signs of dental lamina development appear at 11.5 weeks of intrauterine life; (2) the upper and lower first molar deciduous tooth germs are the first formed followed by the upper deciduous incisor; (3) the secondary dental lamina appears at 15.5 weeks for incisors and at 17 weeks of intrauterine life for canine and premolar tooth germs; and (4) the tertiary dental lamina appears at 15.5 weeks for upper molars and 18 weeks of intrauterine life for lower molar tooth germs. **Conclusion:** This observation is not in accordance with previous reports that affirmed that when the embryo is 6 weeks old, it is possible to see the first signs of dental development.

Keywords: dental lamina development, human dental lamina, histological analysis.

Resumo

Introdução: Existem poucos relatos sobre a odontogênese em fetos. **Objetivo:** Descrever o desenvolvimento da lâmina dentária em embriões e fetos. **Material e Métodos:** Os maxilares superior e as mandíbulas foram preparados com cortes seriados nos planos sagital e frontal. Os cortes corados com hematoxilina-eosina foram examinados microscopicamente. **Resultados:** Observou-se que: (1) os primeiros sinais de desenvolvimento da lâmina dentária aparecem com 11,5 semanas de vida intrauterina; (2) os germes dentários decíduos dos primeiros molares superiores e inferiores são os primeiros a se formar, seguidos pelos incisivos decíduos superiores; (3) a lâmina dentária secundária aparece com 15,5 semanas para os incisivos e com 17 semanas de vida intrauterina para os germes dentários de caninos e pré-molares; e (4) a lâmina dentária terciária aparece com 15,5 semanas para os molares superiores e com 18 semanas de vida intrauterina para os germes dentários de molares inferiores. **Conclusão:** Esta observação não está de acordo com relatos anteriores que afirmavam que quando o embrião tem 6 semanas de idade, é possível ver os primeiros sinais de desenvolvimento dentário.
Palavras-chave: desenvolvimento da lâmina dentária, lâmina dentária humana, análise histológica.

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Introduction

The first signal of dental development is an intense proliferation of buccal epithelium basal cells, establishing an epithelial band on the future dental arch surfaces, the dental lamina. At some points of the dental lamina, some ectodermic cells show a more rapid proliferation, giving rise to small buds that grow into the adjacent ectomesenchyme. Each of these buds represents one of the ten maxillary or mandibular deciduous teeth [(1).]

Dental lamina development occurs during three phases: the first occurs in the whole deciduous dentition; the second occurs during the successors of the deciduous teeth, developing as an epithelial proliferation on the lingual side of each deciduous tooth; and the third occurs as a distal extension of the primary dental lamina, the tertiary dental lamina responsible for the permanent molar teeth [(2)].

Each dental element develops as one individual structure that starts because of the interaction between the oral epithelium and the underlying mesenchyme. A tooth germ has three parts: one ectodermic-derived structure, the dental

organ, which is responsible for enamel formation, and two ectomesenchyme-derived structures, the dental papilla, which is responsible for dentin and dental pulp formation, and the dental sac, which is responsible for cement, dental ligament, and alveolar bone formation. Dental germs undergo the following stages of development: bud, cap, bell, crown, and root. The specific formation of the various tissues that constitute the tooth and their supporting structures begins at the bell stages of development [2-4].

Only a few reports exist concerning odontogenesis in the fetus. The first reports describing human teeth development were published by Pierce (1887) [5] and sometime later by Legros and Magiot (1927) [6]; however, these reports presented a great number of differences in relation to the age of the individuals studied. Schour and Massler (1940) [7] performed a similar study and changed the date of the dental calcification table proposed by Logan and Kronfeld (1933) [8], which has been universally used to date. It is important to consider that studies that have analyzed tooth formation in humans, as well as the tables available for tooth mineralization, were not performed in Brazilian embryos, fetuses or children and did not apply the most accurate method for estimating gestational age.

This study reports a histological analysis of tooth development in human beings during intrauterine life at different gestational ages determined by bidimensional ultrasonography.

Material and methods

Fourteen human embryos and fetuses from the collection of cadaveric material from the Department of Morphology of the Faculty of Dentistry in Araraquara, University of the State of São Paulo were analyzed (Ethic committee # 179/2002). The embryos and fetuses were stored individually in glass containers with formal buffer at pH 7.2.

The gestational ages (6 to 20 weeks) were determined by macroscopy evaluation, considering the external characteristics of the embryo or fetus [9], and by bidimensional ultrasonography examinations. For ultrasound diagnostic, at least two measurements were used to determine the gestational age: crown-rump-CR [10]; femoral length-FL [11]; cranial circumference-CC [12] and biparietal diameter- BPD [13].

The upper and lower jaws of embryos and fetuses were fixed in 10% formalin solution and sectioned through the mid-sagittal plane. One-half of each jaw was prepared in a serial section in the sagittal plane, whereas the other half was prepared in the frontal plane. The pieces were cut, and 6 um-thick sections were stained with hematoxylin and eosin (HE) for light microscopy analysis.

Results and Discussion

The first studies that described the formation and calcification of human teeth were described in the form of tables [5-8,14], and they presented several limitations regarding the sample number and the calculation of the age of embryos and fetuses.

Fetuses and embryos used in this study aged between 6 and 20 weeks, as fetuses over 20 weeks of gestation, must be sent to the necropsy service and a death certificate issued (law number 6,216, of June 30, 1975).

The chronology of human teeth development is important information for the clinician because the clinical characteristics of enamel development defects are related in addition to the degree, intensity, and duration of the insult to the developmental phase of the tooth. Therefore, this is one of the reasons for the dentist to know the most exact gestational age to identify the possible risk factors related to tooth enamel anomalies.

The tooth development reference tables are from 1993 and 1940 [7,8,14], when gestational age was calculated by the date of the last menstrual period and with varying precision and limitations [15-18]. Nowadays, ultrasound measurement of the embryo or fetus in the first trimester is considered the most accurate method for estimating gestational age and presents greater precision depending on the date on which it is performed and is based on fetal measurements, varying according to the technology used and the date of the exam [19].

The estimated age of embryos and fetuses and the measurements obtained using ultrasonography are recorded in Table 1. In the first trimester, gestational sac diameter and crown-rump length measurements have become the primary means of evaluating gestational age. Both parameters are useful because each measures a different aspect of the first-trimester pregnancy and may be used at different times during the first trimester [20-22]. In the second and third trimesters, the parameters most measured include biparietal diameter [13,23-25], head circumference [12,26],

abdominal circumference [12,27-29], and femur length [11, 30-32].

Table 1: Equivalence of embryo and fetus ages and the measures obtained in mm through ultrasonography examination.

Specimens	Measurements in mm			Age	
*	BPD	CRL	FL	Days	Weeks
1	-	6.0	-	± 42	6
3	-	43.4 - 47.5	-	± 77 to ± 81	11-11.5
3	17 -18.8	47.5 - 58.0	-	± 84 to ± 89	12-12.5
1	24.0	66.5	12	± 96	13.5
1	31.0	78.5	18.5	± 110	15.5
1	36.8	-	24.7	± 119	17
1	40	-	27	± 126	18
1	43.8	-	30.4	± 133	19
2	47.5- 50.5	-	33.5- 36.5	± 140 to± 147	20

* BPD - biparietal diameter
CRL - crown-rump length
FL - femur length

In the human embryo at 6 weeks of intrauterine life, the epithelium covering the stomodeum, the primitive oral cavity, was undifferentiated without signs of dental lamina formation at the 6-week-old embryo (Figure 1). This observation is not in accordance with previous reports that affirmed that when the embryo is 6 weeks old, it is possible to see the first signs of dental development, with the lower anterior teeth being the first to appear [4,33]. In these studies, the authors used the last menstrual period as an age reference, and it has been well documented that there are somewhat large (>7 days) discrepancies between the last menstrual period and ultrasound based on the gestational age estimation method, which could explain these observed differences [34, 35].

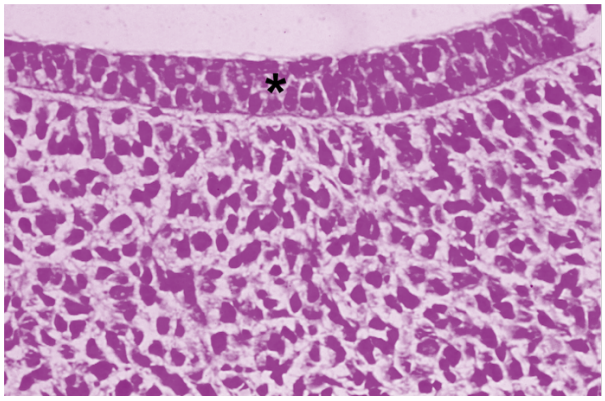

Figure 1- Lining epithelium of the oral mucosa * in 6 weeks of intrauterine life embryo without signs of dental lamina formation. HE 400X.

Bone matrix formation surrounding the Meckel cartilage was observed in the mandible of the 11 and 11.5-week-old embryos, and no signs of tooth formation were identified in the maxilla, as well as the mandible, which showed a large concentration of fibroblasts and slight thickening near the edge in the anterior region. This observation did not corroborate previous reports that affirmed to be possible to detect either cell proliferation or the presence of dental buds during the 6th – 8th weeks of intrauterine life of the human embryo [2,4,5,33]. However, it is in line with Vedtoft and Mathiessen, 1981 [36] that before the 10th week of intrauterine life, there is no presence of tooth germs. Using histochemical methods for the analysis of bud cell and dental sac growth factors in human fetuses with ages ranging from 11 to 21 weeks, tooth germs were observed only after the 11th week [37].

Connective cell condensation at two points of the posterior alveolar region corresponding to the dental papilla of upper and lower deciduous molar tooth germs was identified in the 12 and 12.5-week-old embryos (Figure 2; Table 2). These results are not in agreement with previous publications stating that germ formation begins at an earlier time in intrauterine life and with those that affirm that central incisor tooth germ formations are the first to occur [2,4,33].

Table 2 –Ages of the first sign and mineralization of deciduous teeth

Arch	Tooth									
	CI		LI		C		DFM		DSM	
	Sign	Min	Sign	Min	Sign	Min	Sign	Min	Sign	Min
Upper	13,5	19	13,5*	19*	13,5	-	12,0	20	12,5	20*
Lower	15,5	17	15,5	17	13,5*	-	12,0	17	12,5	17*

*Slight delay

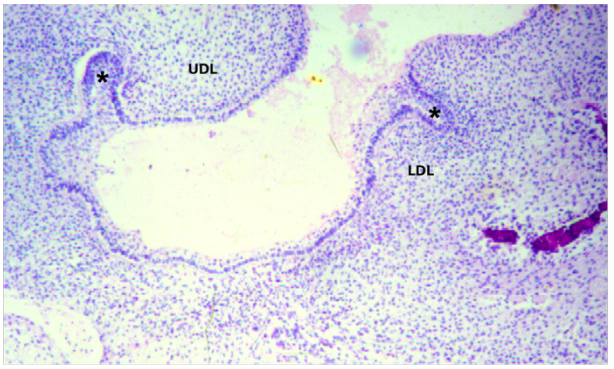

Figure 2 - Oral cavity of 12 weeks of intrauterine life fetus showing the upper (UDL) and lower (LDL) dental lamina coming from the lining of the oral epithelium. HE 10x.

Each of these small proliferations of the dental lamina represents one of the ten maxillary or

mandibular deciduous teeth. The dental organ, in addition to being responsible for the formation of enamel, exerts a cellular induction function necessary for the formation of dentin, junctional epithelium, and Hertwig's epithelial sheath, which is related to root formation [1]. The maxilla demonstrated eight deciduous tooth germs only in the 13.5-week-old fetus. The central and lateral incisors, the canine, and the first molar on each side were attached to the primary dental lamina (Figure 3). The incisors were at the initial bell stage and the canine was at the cap stage of development. The first and second molar deciduous tooth germs were obliquely positioned and attached to the dental lamina close to the surface of the buccal cavity. The dental lamina distal to the second deciduous molar tooth exhibited intense cell proliferation, which was beginning to form the tertiary dental lamina.

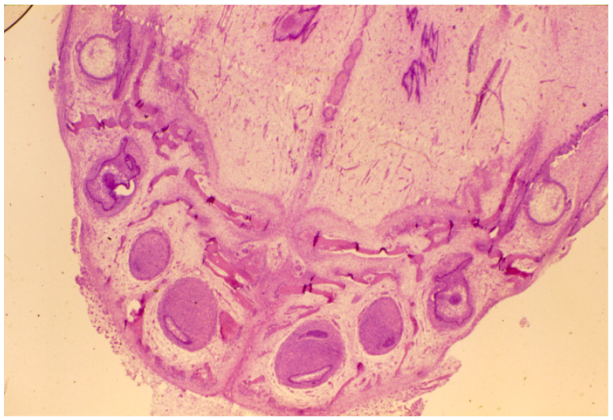

Figure 3 - General view of the maxilla showing eight deciduous tooth germs in 13,5 weeks of intrauterine life of the fetus. HE 32x.

In the mandible, the lower central deciduous incisor tooth germs were in an initial bell stage of development, the lateral incisors were at the cap stage, and the canines were at the bud stage, and all were attached to the primary dental lamina. The first and second deciduous molars were at the cap stage and attached to the primary dental lamina, which showed a distal extension, the future tertiary dental lamina (Figure 4).

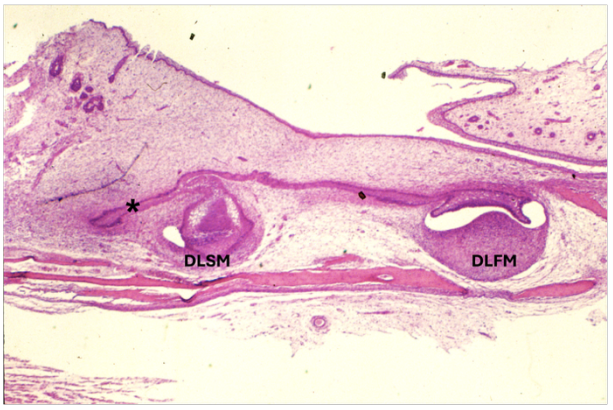

Figure 4 - Deciduous lower fist molar (DLFM), deciduous lower second molar (DLSM), and distal extension of the dental lamina (*) formation at 13 weeks of intrauterine life. HE 400x.

The maxillary incisors were at the initial bell stage and the canines at the cap stage, all attached to the buccal epithelium through the primary dental lamina in the 15.5-week-old fetus. Lingually to the central incisor tooth germ, cellular proliferation indicated secondary dental lamina formation. The first and second molar tooth germs were connected to the upper primary dental lamina and lingual to the first molar, and successional lamina (secondary lamina) formation was observed. In the anterior region of the mandible, the central incisors were in the initial bell stage. The primary dental lamina connected the lateral incisor tooth germ to the structures lining the oral cavity, showing disorganization in its structure beginning at the central epithelial cells and formation of secondary dental lamina (Figure 5).

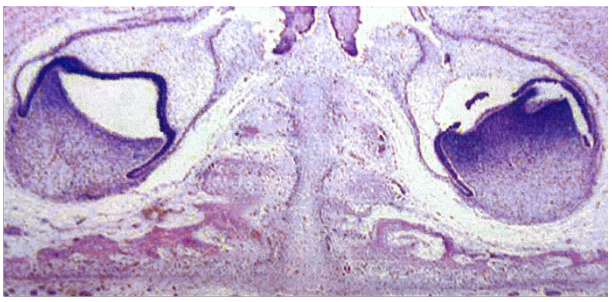

Figure 5- Deciduous lower central incisors in the initial bell stage. HE 32x.

In the maxilla of the 17-week-old fetus, central, lateral, and canine tooth germs were observed, and the initial formation of successor teeth was noted on the lingual side of them (Figure 6).

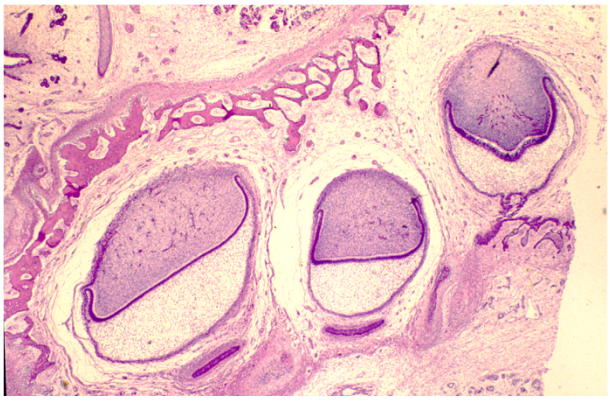

Figure 6 - Three deciduous upper tooth germs: central incisor, lateral, and canine, and the beginning of central and lateral incisor successor tooth germ formation at 17 weeks of intrauterine life in the fetus. HE 32x.

It was observed that the enamel and dentin matrices formed occurred only on the distal margin of the tooth germ of the central incisor (Figure 7). The presence of enamel and dentin in the lower incisors was observed at the 17th week of intrauterine life, which differs from the findings of Avery et al, 2001 that identified mineralized structures from 12 to 16 weeks and corroborates the findings of Schour,1960 [7,14] and Bhaskar, 1989 [4], who observed these teeth around the 17th and 18th week of intrauterine life. However, it differs from those authors in the fact that in our study, the mineralization of the lower teeth was always more advanced than that of the upper teeth, a fact that seems more appropriate since the eruption of the lower teeth occurs before the upper ones. (Table 2).

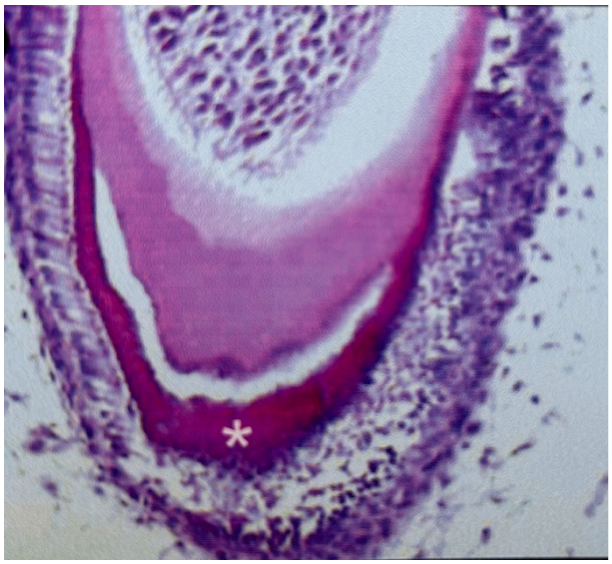

Figure 7 - Enamel (*) and dentin matrices formed only on the distal margin of the tooth germ of the central incisor. HE 400x.

At this age, the lower first and second molars presented cusps with two layers of dentin and a thin layer of enamel, characteristics also observed by Sunderland (38) et al. in 1987 in fetuses of 16 and 19 weeks and disagreeing with Schour, 1960 [7] , who stated that only after the 20th week is it possible to identify mineralized structures in deciduous first molars and ten Cate, 2001 [1], which describes the beginning of the mineralization of these teeth between the 12th and 15th week of intrauterine life.

In the 18-week-old fetus, it was possible to observe in the maxillary deciduous first molar the dentin matrices covered by enamel matrices, and in the distal position of the upper deciduous molars, the tertiary dental lamina was under development, an agglomerate of epithelium cells surrounded by a condensation of connective cells constituting the future permanent first molar tooth germ (Figure 8).

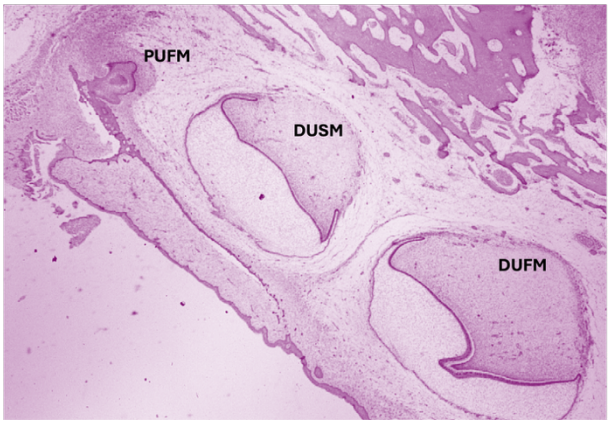

Figure 8 - Permanent upper first molar tooth germ (PUFM) connected to the tertiary dental lamina, HE 100x. Deciduous upper second molar (DUSM) and deciduous upper first molar (DUFM)

At this age (18 weeks), there were no signs of mineralization of the lower canines (Table 2), a fact that corroborates the findings of ten Cate, 2001 [1] , who observed the mineralization of canines only from the 20th week onwards. However, Avery et al. [33] in 2002 reported that canine mineralization occurs from the 16th week of intrauterine life, and Schour, 1960 [7], reported that it occurs around the 20th week.

The 19-week-old fetus presented with central incisor tooth germs in the crown formation stage that were still connected to the primary dental lamina in both the maxilla and mandibula. Only in the 19th week of intrauterine life was it possible to demonstrate the presence of dentin and enamel in the upper incisors (Table 2). Schour [7, 14] in 1989

reported that the mineralization of enamel and dentin begins at the 16th week and Bhaskar [4] in 1989 reported that the beginning of dentin formation for the central and lateral incisors occurs around the 17th and 18th week, differences that can be attributed to the methods of fetal age calculation used. On the lingual side of the deciduous lateral incisors, which had a thin layer of dentin matrix, the secondary dental lamina was observed. In this stage, the canine tooth germ was connected to the dental lamina, which was longer than those of the incisor tooth germs and had already started a disorganization process, while the secondary dental lamina appeared intact.

A 20-week-old fetus demonstrated upper deciduous canines in the bell phase without the presence of enamel and dentin matrix. Schour in 1960 [3], Bhascar in 1989 [4], and Avery et al. in 2001[33] identified the presence of canines in fetuses older than 20 weeks. On the distal side of the upper second deciduous molar tooth germ, the tertiary dental lamina and permanent first molar is formed in a solitary primary socket surrounded by the dental sac (Figure 9).

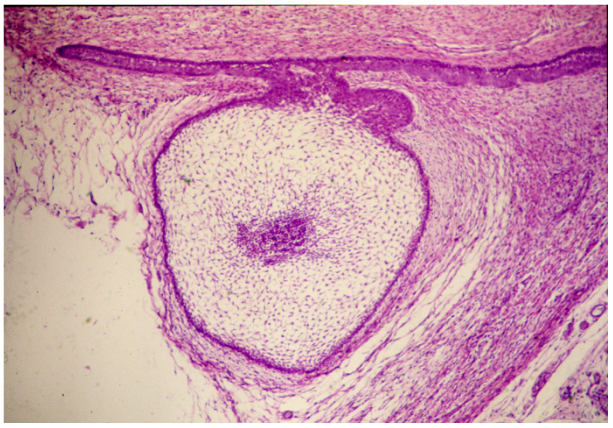

Figure 9 - Tertiary dental lamina and permanent first molar formation in a solitary primary socket

Conclusion

Consider the limitations of this study and based on the results found in this study, it is possible to conclude that:

1-The first signs of dental lamina development appear at 11.5 weeks of intrauterine life,

2-The upper and lower first molar deciduous tooth germs are formed first, followed by the upper deciduous incisor.

3-The secondary dental lamina appears at 15.5 weeks for incisors and at 17 weeks of intrauterine life for canine and premolar tooth germs.

4-The tertiary dental lamina appears at 15.5 weeks for upper molars and 18 weeks of intrauterine life for lower molar tooth germ

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