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Effect of the birth process on the neonatal line in primary tooth enamel

Ilana Eli, DMD Haim Sarnat, DMD MS Eliezer Talmi, DMD

Abstract

The neonatal line is a histologic landmark in primary tooth enamel corresponding to the event of birth. The average width of the neonatal line (NNL) in primary tooth enamel of 147 children was measured. In children with normal birth histories the width of the NNL was found to be 11.9 ± 4.8 μm.

It was wider (18.6 ± 5.7 μm) in children born by difficult operative delivery and thinner (7.6 ± 1.5 μm) in children born by Caesarean section.

The data suggest that concomitant with the change from intrauterine to extrauterine environment, the birth process itself also contributes to the width of the NNL.

The incremental nature of enamel and dentin development has been known and described for more than a century. Retzius (1837) reported brown lines observed in the enamel which were caused by periods of enamel formation and rest — the incremental lines (striae) of Retzius. The distance between the lines of Retzius was measured and found to be about 16 μm (Schour and Hoffman 1939).

When the very sensitive ameloblasts are subjected to a noxious episode of either internal or external origin, a temporary change in the rhythmic enamel matrix formation may occur, causing some striae of Retzius to appear more prominent than normal. One such accentuated Retzius line corresponds to the event of birth and is known as the "neonatal line" (NNL; Fig. 1). Schour (1936) described the NNL and estimated its distance from the dentinoenamel junction for the various teeth. He indicated the absence of the NNL in teeth of unborn fetuses. By injecting sodium fluoride into rats, Schour and Poncher (1937) were able to estimate the average rate of enamel formation as 4 μm/24 hr. The NNL was described as a border between the prenatal enamel created during gestation and characterized by its regularity and high degree of calcification, and the postnatal enamel created after birth which is less regular and less homogeneously calcified (Schour 1936, 1938; Massler et al. 1941; Orban 1980). The ultrastructural basis for the NNL was believed to be a localized change in configuration of enamel prisms along with possible reduction in crystal concentration (Weber and Eisenmann 1971).

The formation and accentuation of the NNL were attributed to the abrupt change in the environment and nutrition of the newborn (Schour and Kronfeld 1938; Massler et al. 1941; Orban 1980). Norén (1984a) described a wider NNL in children born to diabetic mothers and hypothesized that the wider NNL is a structural response to neonatal hypocalcemic stress (Norén 1984b). Except for the influence of maternal diabetes, no other factors (asphyxia, low birth weight, or intrauterine malnutrition) were identified as being associated with a wider NNL (Magnusson et al. 1978; Norén et al. 1978; Norén 1983).

The diagnostic possibilities of microscopic examination of enamel, using the NNL as a marker together with the known mean rate of enamel deposition to determine the timing of noxious events, was shown by Levine et al. (1979). A significant association between case histories of brain damaged children and histologic enamel findings was reported by Judes et al. (1985) and Jaffe et al. (1985a, b). These studies concentrated on the identification of any prominent Retzius striae as a sign of interference with the developing fetus' tissues, an interference which could be the cause of the brain damage. To

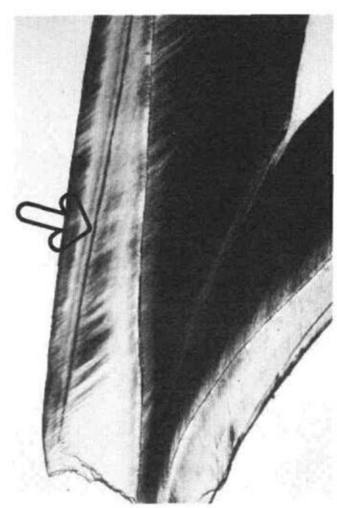

Fig 1. Histologic representation of NNL (arrow) in a 100-μm sagittal ground section of a primary tooth.

assess damage caused to the newborn during the birth process, the authors assumed a width of about 8 μm to be normal, while any line wider than 15 μm was interpreted as indicating a complicated birth or a disturbance in the perinatal period (Jaffe et al. 1985a, b).

In other studies the average NNL width in permanent first molars was suggested to be about 10 μm (Jackobsen 1975). Magnusson et al. (1978) and Norén et al. (1978) cited 10-12 μm as the normal NNL width in microradiographic measurements of primary incisors, but no data concerning the measurements were presented. Jaffe et al. (1985a, b) indicated the need for acquiring more accurate data regarding the NNL width, a value which could be used when the effect of the trauma of the birth process needs to be assessed.

In the present study, an attempt was made to measure accurately the average NNL width in children with normal birth histories. The effect of the birth process on the NNL was investigated by comparing the NNL width in children with normal and complicated birth histories.

Materials and Methods

Primary teeth collected from 147 normal children were examined—one tooth from each child. Normal children were defined as those with no history of systemic disorders related to pregnancy and/or labor and who had birth weight not less than 2500 g. Birth histories were obtained from hospitals including type of delivery and condition of the newborn. The teeth were divided into 3 groups (Table 1):

1. Normal delivery—125 teeth
2. Complicated (operative) delivery—17 teeth (Operative delivery was determined whenever active outside intervention took place, e.g., breech, forceps, or vacuum delivery; Bensor 1982.)
3. Elective Caesarean section (no active birth process)—5 teeth.

Ground serial sections were cut sagittally in the buccolingual direction (100 μm thick) using a low-speed saw (Isomet™—Buehler; Lake Bluff, Illinois) and examined under a light microscope. Since the appearance of the NNL apparently can be affected by the inclination of the line relative to the plane of sectioning (Weber and Eisenmann 1971), all teeth were mounted on the cutting machine and sectioned exactly in the mid-sagittal plane. The NNL was identified in all specimens and its nature defined in terms of direction, continuity, and uniformity of accent. The NNL width was measured by an eye piece (Filar®—Bausch and Lomb; U.S.A.), accuracy up to 0.1 μm. To consider the effect of the different angle of the enamel rods at different regions of the tooth, 3 separate measurements were made at each of the 3 different levels of the anatomic crown (incisal, middle, and gingival). Mean and standard deviations were computed for each level. Thirty specimens were remeasured by another investigator with negligible discrepancies.

Table 1. Teeth According to Type of Delivery

Tooth/Delivery	*Normal*	*Operative*	*Caesarean Section*
Incisors	23	2	3
Canines	62	7	1
Molars	40	8	1
Total	125	17	5

Results

The NNL was identified in all teeth examined on at least 1 crown level. The microscopic evaluation of the NNL showed that it appears to be mostly straight (85% in teeth from children born by normal delivery and 85.7% in teeth from children born by operative delivery), continuous (60 and 78.6%, respectively) and uniformly accentuated (78 and 57.1%, respectively). No significant differences were found between the 2 groups.

The mean NNL width in children born by normal delivery was found to be between 11.9 and 12.4 μm at the various crown levels (Table 2). A significant increase ($P < 0.05$) in the NNL width in children born by operative delivery was found for each level (Table 3).

No significant difference (according to one-way analysis of variance) was found within the values acquired for the 3 different levels of the anatomic crown of either normal or operative delivery. Since the only data acquired for the group born by elective Caesarean section were from the gingival level, this level was chosen for comparison among the 3 groups (Fig 2). The values were markedly lower (7.6 ± 1.5 μm) for children born by elective Caesarean section.

Table 2 Width of NNL (μm) in Children Born by Normal Delivery

Level of crown/Tooth	*Incisors* N = 23		*Canines* N = 62		*Molars* N = 40		*Mean**	
	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*
Incisal	–	11.3	6.1	12.2	5.1	12.1	5.1	
		(N = 4)		(N = 36)		(N = 40)		
Middle	11.6	6.5	12.1	7.0	16.5	9.0	12.4	7.0
	(N = 6)		(N = 36)		(N = 4)		(N = 46)	
Gingival	13.3	4.5	10.9	4.9	–		11.9	4.8
	(N = 17)		(N = 22)				(N = 39)	

Total children N = 125

[d] No difference between groups accordig to one-way analysis of variance.

TABLE 3. Mean Width of NNL (μm) in Children Born by Normal Delivery Compared to Children Born by Operative Delivery

Level of crown/Delivery	Normal N = 125 $\bar{x}$	SD	Operative* N = 17 $\bar{x}$	SD	Statistical Significance†
Incisal	12.1	5.1	17.4	6.4	$P < 0.05$
	(N = 40)		(N = 6)		
Middle	12.4	7.0	18.3	5.7	$P < 0.05$
	(N = 46)		(N = 8)		
Gingival	11.9	4.8	18.6	5.7	$P < 0.05$
	(N = 39)		(N = 3)		

* Operative delivery - breech, vacuum, forceps.
† According to *t*-test.

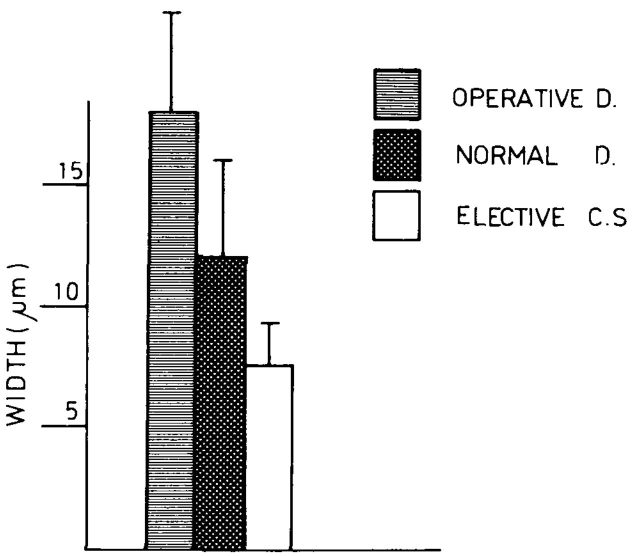

Fig 2. Average width of NNL (gingival level) in children with various birth histories: normal delivery, difficult (operative) delivery, and elective Caesarean section. The NNL in children born by operative delivery was significantly wider than that in children born by normal delivery. A much lower value was found in the elective Caesarean section group.

Discussion

Transient metabolic or environmental disturbances during the fetal or early newborn period are likely to affect the physiological functions of various body systems adversely. The ameloblasts (and odontoblasts) are unique in that the cell layers continue their steady retreat from the dentinoenamel junction, and any abnormal tissue produced by the disturbance becomes part of the tooth structure and is permanently recorded (Orban 1980).

In the present study, the NNL was identified in all teeth examined, a result which is higher than that reported in primary dentition by Magnusson et al. (1978) and Norén (1984a). This finding may be due to the detailed protocol of measurements performed in this study (3 measurements at 3 levels of each tooth crown). Since only 60-78% of the NNL examined were found to be continuous, the lower percentage of the NNL identified in other studies may be due to lack of appearance of the NNL in some areas of the tooth crown.

The present findings suggest that the normal NNL width in primary teeth is about 12 μm. This is in agreement with Jackobsen (1975) as to the NNL width in first permanent molars and those cited by Magnusson et al. (1978) and Norén et al. (1978) for primary incisors. Unlike Jackobsen (1975) who claimed that the NNL width is highly dependent upon the distance of the section from the cusp tip, the present data demonstrate that the level at which the sample is obtained (incisal, middle, or gingival) has little influence on the value obtained. As the NNL apparently is created by the trauma caused to the newborn during or immediately following the birth process, this trauma simultaneously affects all ameloblasts at the different tooth levels, establishing a basically uniform line. The fact that the NNL width increases significantly in children born by operative delivery and decreases in children who have undergone no active birth process, suggests that the change from the intrauterine to the extrauterine environment is responsible for only part of the arrest of the ameloblast function, and that the trauma of the birth process itself also has a major impact on the newborn's cells.

If we refer to the NNL width in children born by elective Caesarean section as indicating the effect on the ameloblast of the transition from intra- to extrauterine life (without active birth process), this transition is responsible for only about 63% of the NNL width (7.6/11.9). The magnitude of such transitional effect on the ameloblasts may vary under different environmental conditions. Schour and Kronfeld (1938) suggest that the NNL should be more prominent in teeth of prematurely born children, due to the relatively greater nutritional difficulties usually encountered by premature infants. Thus, the fact that the NNL width was assessed by Weber and Eisenmann (1971) to be about 20-30 μm probably is due to the fact that most of their specimens were acquired from a prematurely delivered child. The effect of premature delivery on the NNL width and prominence is under investigation.

Tooth enamel can serve as a sensitive diagnostic tool, permanently recording various pre-, peri-, and postnatal events. The accurate definition of 12 μm as a "normal" NNL width, which is partly caused by the environmental shock to the newborn (about 63%) and partly by the birth process itself (about 37%), may be of value when investigating causes to various pathologic conditions. Further research in this field will broaden our understanding of the changes occurring in the fetus during the birth process.

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Dr. Eli is a lecturer, operative dentistry, Dr. Sarnat is an associate professor and chairman, and Dr. Talmi is an instructor, pediatric dentistry, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel. Reprint requests should be sent to: Dr. Ilana Eli, Dept. of Operative Dentistry, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.

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Oral cancer inhibited by orange seeds

A bitter-tasting chemical found in orange seeds appears effective in inhibiting the development of certain oral cancers, say researchers at Baylor College of Dentistry in Dallas.

In animal studies, the application of a 2.5% concentration of the chemical *limonin* to the buccal pouch of hamsters produced a 60% reduction of a tumor mass. Tumors in limonin-treated animals appeared later than those in a control group and in those treated with another chemical found in orange seeds, *nomilin*.

Limonin's chemical structure is similar to kahweol, a cancer-inhibiting substance isolated from green coffee beans.