Clinical Article

Enamel Defects in the Complete Primary Dentition of Children Born at Term and Preterm

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Abstract: ***Purpose:*** *This study's purpose was to compare the frequency of enamel defects (ED) in the complete primary dentition (CDD) of term children (TC) and preterm children (PTC) and to analyze neonatal factors associated with ED in PTC.* ***Methods:*** *The study group was formed by 45 PTC, cared for at the Follow-up Clinic for Preterm Children of the Federal University of São Paulo, Brazil. The control group included 46 schoolchildren born at term.* ***Results:*** *ED was more frequent in PTC (87%) than in TC (44%; P<.05). All 34 PTC with tracheal intubation at birth presented ED, showing a strong association between both. The variable was not included in the regression model. To analyze neonatal factors associated with ED in PTC, a model of logistic regression was adjusted. Malnutrition at term-corrected age increased the risk of ED in PTC 7.8 times. Opacity (white/cream) and hypoplasia (missing enamel) were frequent types of ED in this series. PTC and TC presented with high ED frequencies.* ***Conclusions:*** *The frequencies of enamel defects were elevated in term and preterm children, but were higher in the latter. Tracheal intubation was strongly associated with enamel defects, and extrauterine growth restriction significantly increased the risk for enamel defects in preterm children. (Pediatr Dent 2011;33:171-6)*
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Preterm births (occurring prior to the 37th week of gestation) are increasing around the world, and approximately 13% of US births are preterm. The incidence of most short-term major medical complications associated with prematurity has remained relatively stable, but advances in perinatal medicine in the last 2 decades has increased survival after very preterm birth. The increasing number of preterm births, along with the reduction in mortality, is resulting in more children who graduate from intensive care units, requiring follow-up care in specialized clinics.[1,2]

Very low birthweight (<1.5 Kg), especially extreme low birthweight (<1.0 Kg, is highly associated with: respiratory distress; cardiac disease (patent ductus arteriosus); sepsis; necrotizing enterocolitis; metabolic disorders such as hiperbilirrubinemia; hypoglycemia; hypocalcemia; metabolic bone disease; and nutritional and neurological disorders.[2] Such conditions have been associated with defects of dental enamel (**DDE**) in the primary dentition. DDE can also be the response of developing teeth affected by local traumas in the tooth buds caused by the laryngoscope blade during tracheal intubation, frequently necessary in preterm newborns with perinatal asphyxia or respiratory distress. In humans, dental calcification starts at the 15th week of intrauterine life and is completed only a few months after birth. Disorders that compromise preterm newborns occur in this period and can affect dental enamel development.[3]

Preterm children (**PTC**) are particularly susceptible to developing DDE resulting from multifactorial causes, and it is well established that DDE are especially associated with low birthweight PTC and children submitted to orotracheal intubation and/or laryngoscopy.[4]

The preterm dentition was first studied by Stein in 1947,[5] who observed enamel hypoplasia in 25% of PTC. Grahnén et al. (1974)[6] observed DDE in 21% of PTC and 2% of term children (**TC**). More recently, Seow et al. (1984)[7] reported DDE in 100% of PTC with neonatal rickets; Rugg-Gunn et al. (1998)[8] reported it in 56% of poorly nourished children vs 43% in the general population; and Aine et al., (2000)[3] registered DDE in the complete primary dentition of 78% of PTC and 20% of TC.

DDE have been demonstrated as a predisposing factor for a higher prevalence of caries,[4,9] because hypoplasic and hypocalcified teeth have higher porosity and can increase the dental plaque retention. Therefore, dental caries can be more frequent in PTC vs TC, and carious disease can develop faster and cause a more severe destruction of the compromised teeth in PTC.[4,9,10] This highlights the importance of determining the caries risk in these patients in order to plan personal preventive actions.

The aim of this study was to analyze the frequencies of defects of dental enamel and caries in the complete primary

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dentition of PTC cared for in neonatal intensive care units in recent years vs the frequencies in TC and to evaluate perinatal factors possibly associated with DDE in PTC.

Methods

This study was conducted between June 6, 2005 and March 30, 2007 and included 45 PTC and 46 TC with complete primary dentition. The Research Ethics Committee of the Federal University of São Paulo, São Paulo, Brazil, approved the study, and parents/guardians signed written consents.

PTC (gestational age <37 weeks)[11] with birth weights less than 2 Kg were invited to participate in the study at the Follow-up Clinic for Preterm Children of the Federal University of São Paulo. TC (gestational age between 37 weeks and 41 weeks and 6 days)[17] with birth weights greater than 2 Kg were invited to participate in the study at the Children Education School of the Federal University of São Paulo.

Exclusion criteria included major congenital anomalies, genetic syndromes, symptomatic congenital infection at birth, and cerebral palsy with deglutition disorder.

PTC data were collected from the records available at the follow-up clinic and confirmed and completed with information of birth from the files of the respective hospitals of birth. Control group data were collected from the children's discharge record.

For both groups, the mothers' data included: age; marital status; number of pregnancies and deliveries; prenatal evaluation; number of prenatal appointments; and type of delivery. Newborns' data included: gender; gestational age; weight; length and head circumference at birth; Apgar scores[12] at the first and fifth minute; and classification by weight for gestational age.[13] According to the World Health Organization, children were classified as small for gestational age (**SGA**) when birth weights were less than the 10[th] percentile and appropriate for gestational age (**AGA**) when birth weights were between the 10[th] and 90[th] percentile of the intrauterine growth curve.[13] Children classified as small for gestational age can have intrauterine malnutrition or intrauterine growth restriction.

For the PTC group, the following clinic-obstetric outcomes of the mothers were analyzed (chronic arterial hypertension, pregnancy-related hypertensive disease, premature rupture of membranes, urinary tract infection, and chronic fetal distress). Laboratory and clinical data collected only for PTC included: level of indirect bilirubin (considering >10 mg/dL for diagnosis of pathological jaundice); sepsis characterized by the presence of at least 1 of the signs and symptoms (fever, hypothermia, apnea, and/or bradycardia) without any other apparent cause for infection and independent from positive culture; need for and duration of intermittent mechanical ventilation through orotracheal tube; and bone metabolic disease identified by serum levels of phosphorus (<5.7 mg/dL or alkaline phosphatase >900 UI/L).[14]

Children were classified as small for term postconceptual age (**SGA-term**) when their weights between 37 weeks and 41 weeks and 6 days of corrected age were less than the 10[th] percentile of the intrauterine growth curve.[13] The corrected age is the gestational age at birth added to the days of postnatal life.

The dental examination was conducted by the same examiner in a dental office. After bacterial plaque control (biofilm), the patients received orientation on oral health techniques. Teeth were professionally cleaned with a low rotation tool and prophylactic paste, Robinson brush, and rubber cup. Biofilm and extrinsic stains masking dental changes or lesions were removed with periodontal curettes. Enamel surfaces were evaluated by using a magnifying glass and optimal placement of the light focus. Every tooth was dried with a threefold syringe air jet and individually examined using an intraoral hand mirror. The probe was not used. All children received topical fluoride application, and the excess solution was removed with dry gauze. Each child had all the surfaces (labial, lingual, buccal, mesial, distal, and occlusal) of the 20 primary teeth examined. The decayed, missing, and filled teeth index (DMFT) was used to estimate the prevalence of caries in primary teeth, and the evaluation included initial carious lesions (active white spots).[15]

DDE were registered according to the protocol of the Defects of Dental Enamel Index proposed by the Commission on Oral Health, Research and Epidemology of the

Table 1. DATA FROM MOTHERS OF PRETERM AND TERM NEWBORNS

Variables	Preterm (N= 45)	Term (N=46)	*P*-value
Age (ys) (mean)	29.5±6.8	32.0±4.8	.043*
Married N (%)	37 (82)	45 (98)	>1.00†
Prenatal N (%)	41 (91)	46 (100)	<.06†
Prenatal appointments (median)	4 (0-11)	6 (3-12)	.001‡
No. of pregnancies (median)	4 (0-11)	6 (3-12)	<.61‡
No. of deliveries (median)	1 (1-7)	2 (1-3)	>.01‡
Cesarean section N (%)	38 (84)	27 (59)	.01†

* Student's *t* test. † Fisher's exact test. ‡ Mann-Whitney test.

Table 2. DATA AT BIRTH OF PRETERM AND TERM CHILDREN

Variables	Preterm (N=45)	Term (N=46)	*P*-value
Female N (%)	25 (56)	23 (50)	<.60*
Gestacional age (wks) (mean)	31.0±2.8	38.8±1.2	<.001†
Weight (g) (mean)	1365.0±368.4	3287.9±415.6	<.001†
Length (cm) (mean)	38.1±3.4	48.6±2.1	<.001†
Head circumference (cm) (mean)	27.8±2.4	34.5±1.2	<.001†
Apgar first minute (median)	7 (1-9)	9 (2-10)	<.001‡
Apgar first minute <7 N (%)	18 (40)	3 (7)	<.001*
Apgar fifth minute (median)	9 (4-10)	9.5 (7-10)	<.001‡
Apgar fifth minute <7 N (%)	3 (7)	0 (0)	<.12§
Small for gestational age N (%)	28 (62)	1 (2)	<.001§

* Chi-square. † Student's *t* test. ‡ Mann-Whitney test. § Fisher's exact test.

working Group of Finland and New Zealand,[16] including type, location, surfaces, number, and demarcation of the defects.

Sample size was estimated at 42 children in each group, considering an 80% power to detect a difference of 0.30 between the null hypothesis, in which the DDE ratio in both groups was 0.60 vs the alternative hypothesis in which ratios in TC were 0.30, using a 2-sided chi-square test with a significance level of 0.05.

The groups were compared using chi-square or Fisher tests for categorical and student *t* or Mann-Whitney tests for continuous variables. To analyze the factors associated with DDE in PTC, a multivariate analyses was conducted and the odds ratio and 95% confidence intervals were calculated using the exact binominal method. The neonatal and maternal variables that presented a *P*-value lower than 10% in the bivariate binomial analysis were selected for the multivariate model.

Results

Mothers' data were similar (Table 1) in relation to marital status, prenatal follow-up, and number of pregnancies in both groups. TC mothers, however, were significantly older (*P*>.04) and had a higher number of deliveries (*P*>.01). PTC mothers had a smaller number of prenatal appointments (*P*=.001) and a higher frequency of Cesarean sections (*P*=.01).

The most frequent obstetric disease for PTC mothers was the premature rupture of membranes (38%), followed by pregnancy-related hypertensive disease (22%), urinary tract infections (18%), chronic fetal distress (13%), and chronic arterial hypertension (9%).

At birth (Table 2), the groups were similar only in relation to gender (*P*<.60). As expected, term newborns presented significantly higher values of gestational age, weight, length, and head circumference at birth. Median Apgar scores at the first and fifth minutes were also higher for TC (*P*<.001). Term newborns were more frequently AGA, while preterm newborns were more frequently SGA (*P*<.001).

The age at evaluation was different (*P*=.001) between PTC (3.1±0.8 years) and TC (3.7±0.8 years). DDE were significantly more frequent (*P*<.001) in PTC (87%) than in TC (44%). Caries were more prevalent in PTC (~33%) than in TC (~17%), but the difference was not significant (*P*<.11).

In the TC group, there were no differences at all between children with and without DDE according to all analyzed variables, except for a higher frequency of DDE in boys (65%) than girls (38%).

PTC with and without DDE (Table 3) showed no difference in relation to gestational age, weight, length, and head circumference at birth. At SGA-term, however, the weight values were significantly lower (*P*<.03) and the frequency of SGA-term was higher (*P*<.04) in the PTC group with DDE. All children with tracheal intubation in the neonatal period presented DDE and approximately

Table 3. DATA AT BIRTH AND AT TERM POSTCONCEPTUAL AGE OF PRETERM CHILDREN DISTRIBUTED ACCORDING TO THE PRESENCE OF ENAMEL DEFECTS

Variables	Enamel defects		*P*-value
	Yes (N=39)	No (N=6)	
Gestational age (wks) (median)	30.9 (25.4-36.9)	32.1 (31.1-35.6)	<.08*
Birthweight (g) (median)	1,260.0 (620.0-1,910.0)	1,645.0 (1,350.0-1,785.0)	<.11*
Length at birth (cm) (median)	38.0 (30.0-45.0)	40.0 (37.5-41.5)	>.09*
Head circumference (cm) (median)	27.5 (22.5-35.0)	29.0 (28.5-30.0)	<.05*
Small for gestational age N (%)	24 (62)	4 (67)	>1.00†
Term postconceptual age (wks) (median)	39.3 (37.6-41.3)	39.0 (38.0-40.9)	>.68*
Weight at term postconceptual age (g) (median)	2,340.0 (1,115.0-4,240.0)	3,142.0 (2,060.0-3,335.0)	<.03*
Length at term postconceptual age (cm) (median)	45.0 (34.0-55.0)	49.0 (43.0-58.0)	>.05*
Head circumference at term postconceptual age (cm) (median)	34.0 (21.0-39.0)	35.0 (33.0-37.0)	<1.00*
Small at term postconceptual age N (%)	31 (80)	2 (33)	<.04†

* Mann-Whitney test. † Fisher's exact test.

Table 4. DISTRIBUTION (%) OF LOCATION OF ENAMEL DEFECTS IN THE TEETH OF PRETERM CHILDREN (PTC) AND TERM CHILDREN (TC)

Teeth	Incisal half		Gingival and incisal halves		Occlusal		Cuspal	
	PTC	TC	PTC	TC	PTC	TC	PTC	TC
A	58*	0	11	2	0	0	0	0
F	0	0	13†	2	0	0	0	0
O	4	0	9	4	0	0	0	0
P	9	0	4	4	0	0	0	0
D	38†	0	13	0	0	0	0	0
G	76*	0	7	0	0	0	0	0
N	0	0	4	0	0	0	0	0
Q	0	0	0	0	0	0	0	0
C	4	0	11	6	0	0	0	0
H	5	0	18*	6	0	0	0	0
M	4	0	13†	6	0	0	0	0
R	2	0	7	6	0	0	0	0
B	0	0	0	0	7	4	9	0
I	0	0	0	0	9††	2	13*	4
L	0	0	0	0	4	0	11†	4
S	0	0	0	0	7	0	4	4
A	0	0	0	0	7	11	16*	6
J	0	0	0	0	7	9	9	6
K	0	0	0	0	18*	2	7	6
T	0	0	0	0	9††	11†	11†	9

**P*<.02. †*P*>.01. ††*P*<.05.

87% of PTC had DDE. The children without enamel defects had not undergone orotracheal intubation in the neonatal period.

Variables included in the logistic regression model were maternal age, gestational age, and classification by weight at the postconceptual age of term. The variable intubation could not be included in the model since the association was 100%. Logistic regression analysis evidenced that the only variable independently associated with DDE was SGA-term. The chance of developing DDE was 7.8 times higher in infants classified as SGA-term vs well-nourished infants (P>.03; 95% confidence interval=1.198, 50.127).

DDE evaluated according to location, surfaces, type, number, and demarcation are presented in Tables 4 to 7. According to Table 4, the location of defects in PTC was more frequent in the incisal half of the maxillary left central incisor (76%) and maxillary right central incisor (58%). These children also presented significantly higher frequencies of defects in the gingival and incisal halves of the maxillary right lateral incisor (PTC=13%; TC=0%; P>.01) and in the occlusal of the mandibular left second molar (PTC=18%; TC=2%; P<.02).

DDE in the labial and buccal surfaces (Table 5) of the 4 maxillary incisors were much more frequent in the PTC group. Concerning types of defects, Table 6 shows that white/cream opacities in PTC were more frequent than in TC in all maxillary incisors. The same was observed with yellow/brown opacities, but the differences were not significant. The frequencies of hypoplasia characterized as pits or missing enamel in the maxillary incisors were significantly higher in the PTC group, except for pits in the maxillary left lateral incisor. The frequencies of horizontal grooves were similar in both groups, and no other type of defect was found in this study.

Table 7 shows that single DDE were significantly more frequent in all maxillary incisors and mandibular right central incisors of PTC, while the frequency of multiple defects was higher only in maxillary right central incisors. The frequencies of diffuse defects characterized as patchy and fine white lines were higher in all maxillary incisors and in maxillary right second molars (22% vs 6%, P<.04) in the PTC group.

Table 5. DISTRIBUTION (%) OF ENAMEL DEFECTS ON TEETH SURFACES OF PRETERM CHILDREN (PTC) AND TERM CHILDREN (TC)

Teeth	Facial		Lingual		Buccal		Mesial		Distal	
	PTC	TC	PTC	TC	PTC	TC	PTC	TC	PTC	TC
E	64*	2	0	0	18†	2	4	0	4	0
F	80*	2	0	0	27‡	2	7	0	9	0
O	13	4	9	2	0	0	2	2	24	0
P	9	4	7	2	0	0	2	0	0	0
D	38*	2	0	0	13§	0	4	0	2	0
G	69*	0	0	0	18‖	0	7	0	4	0
N	4	0	0	0	0	0	0	0	0	0
Q	4	0	0	0	0	0	0	0	0	0

* P<.001. † P<.02. ‡ P=.001. § P>.01. ‖ P=.003.

Table 6. DISTRIBUTION (%) OF TYPES OF ENAMEL DEFECTS IN TEETH OF PRETERM CHILDREN (PTC) AND TERM CHILDREN (TC)

Teeth	Opacities				Hypoplasia					
	White/ cream		Yellow/ brown		Pits		Horizontal grooves		Missing enamel	
	PTC	TC	PTC	TC	PTC	TC	PTC	TC	TPC	TC
E	24*	2	2	0	11‡	0	7	0	20§	0
F	33†	0	9	0	24†	0	7	0	33†	0
O	4	0	2	0	-	0	0	0	0	0
P	4	0	4	0	-	0	0	0	2	0
D	13	0	9	0	9	0	4	0	24*	2
G	22†	0	0	0	24†	0	4	0	29†	2
N	2	0	0	0	0	0	0	0	4	0
Q	2	0	0	0	0	2	0	0	2	0

* P=.002. † P<.001. ‡ P<.03. § P=.001.

Discussion

Our findings have confirmed the higher prevalence of DDE in the primary dentition of PTC (87%) vs TC (44%), as reported in other studies.[7-17] Our frequencies, however, were greater than those reported by Seow et al.[7] (62% for PTC; 13% for TC), but ratified those reported by Fearne et al.[18] and Aine et al.[6] (PTC=77% and 78% and TC=37% and 20%, respectively).

The major progress of perinatal care in the last 20 years has fostered the survival of more and more premature children with low birthweight presenting severe neonatal complications, including: metabolic disorders (hypoglycemia, hypocalcaemia, hypophosphatemia, and hyponatremia); respiratory distress; sepsis; and neurological disorders.[1,2] All these conditions may interfere with odontogenesis. Thus, with improvements in neonatal care and survival of severely preterm newborns, an increase in the prevalence of DDE should be expected, since teeth are true biologic chemographs,[19] and alterations caused by neonatal diseases will persist in the primary dentition. Moreover, the higher frequencies observed in our study can be justified by the clinical examination carried out in a dental office with ideal conditions and by only 1 examiner. Most studies evaluating DDE in PTC were performed under natural light using a dental mirror and explorer and after drying the surfaces only with gauze.[20]

DDE cause greater retention of biofilm and higher adherence of *Streptococcus mutans* on the wrinkled enamel surface, resulting in early colonization by cariogenic bacteria, and may predispose to a higher incidence of white spots and caries.[21] In our study, we found a higher prevalence of caries in PTC (~33%) vs TC (~18%), but the difference was not significant (P=.08). The nutritional status in the neonatal period, evaluated by the weight at term, and frequency of children classified as SGA-term, was compromised in PTC with DDE. This finding suggests that nutritional deficiency in the neonatal period affects dental enamel mineralization and maturation processes, and highlights the impact of neonatal malnutrition in the genesis of DDE.

Postnatal growth failure is extremely common in very low birth weight infants. A study comprising 4,438 infants weighing between 501 and 1,500 g showed that intrauterine growth restriction was present in 22% of the cohort at birth. At 36 weeks, 97% of them had growth failure, characterized by weight lower than the 10th percentile.[22] Considering that neonatal growth failure in very low birthweight infants is not preventable and increases the risk of DDE, we should observe an increasing number of PTC with alterations of the primary dentition who deserve specialized care.

Table 7. DISTRIBUTION (%) OF NUMBER AND DEMARCATION OF ENAMEL DEFECTS IN TEETH OF PRETERM CHILDREN (PTC) AND TERM CHILDREN (TC)

Teeth	Single		Multiple		Diffuse			
					Fine white lines		Patchy	
	PTC	TC	PTC	TC	PTC	TC	PTC	TC
E	51*	4	9¶	0	11§	0	33*	0
F	44*	4	11§	0	27*	0	40*	0
O	27†	6	7	0	9	0	7	2
P	7	6	2	0	4	0	4	0
D	24‡	6	7	0	13†	0	13†	0
G	44*	2	9¶	0	17‖	0	29*	0
N	2	0	2	0	0	0	0	0
Q	7	4	4	2	0	0	2	0

* P<.001. † P>.01. ‡ P>.02. § P<.03. ‖ P=.006. ¶ P<.04.

Local traumas resulting from orotracheal intubation and use of laryngoscopes in the neonatal period are well established risk factors for DDE[4,8,17,23-25] In this study, all children who needed tracheal intubation at birth developed DDE, and the defects were observed in the incisal half from 76% of the left and 48% of the maxillary right central incisors. Our studied children were born with gestational ages between approximately 25 and 37 weeks, when enamel mineralization of maxillary incisors begins (around the 28th week of intrauterine life) in the incisal half and progresses to the root. Since lesions were more frequently observed in the incisal half, we have to consider the impact of local traumas caused by laryngoscope or endotracheal tubes.

Facial surfaces of anterior teeth were the areas most affected by DDE. Maxillary central incisors were the most affected teeth in PTC, and very small defects in the incisors were observed in TC. These results suggest the local effects of traumatic forces in the anterior teeth of premature infants caused by laryngoscope during tracheal intubation.

Hypoplasia is the clinical expression of insults imposed during the formation of the organic matrix. When insults occur in the maturation or calcification phases, opacities surrounded by normal enamel are the clinical expression[21]. Opacities were the most frequent clinical expression in our series, indicating that teeth were primarily affected in the enamel maturation or calcification period. This finding agrees with the gestational age of the newborns included in this study.

These findings allow us to recommend to neonatal support teams a less traumatic use of the laryngocope and a protocol for orotracheal intubation, including the use of protective support made of resilient material.[26] It also highlights the importance of optimal nutritional support in the neonatal period.

Conclusions

Based on this study's results, the following conclusions involving the complete primary dentition can be made:

1. Preterm children presented with a higher prevalence of defects of dental enamel vs term children.
2. All children with tracheal intubation in the neonatal period presented with DDE.
3. The risk of DDE was 7.8 times higher in PTC small at term postconceptual age (malnourished).
4. DDE affected mainly the incisal half of the facial surfaces of maxillary central and lateral incisors in PTC and maxillary second molars in term children.
5. For both PTC and TC, the most frequent DDE were opacity (white/cream) and hypoplasia (missing enamel).

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