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The Impact of Birth Weight on Enamel and Dentin Thickness of Mandibular First Molars

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Abstract

Background: Early-life factors such as birth weight influence dental development. However, the effect of birth weight on enamel and dentin thickness in permanent mandibular first molars has not been fully elucidated.

Aim: This study quantitatively evaluated the association between birth weight and enamel and dentin thickness in 7- to 8-year-old children.

Methods: Panoramic radiographs of 75 children were analyzed. The participants were stratified into very low (VLBW), low (LBW), and normal birth weight (NBW) groups. The enamel and dentin thicknesses were measured manually and using computer-assisted image analysis. Statistical comparisons were performed using ANOVA and post hoc tests.

Results: Enamel thickness did not differ significantly among the VLBW, LBW, and NBW groups ($P > 0.05$). In contrast, dentin thickness differed significantly in Region D ($F=3.36$, $P= 0.043$, partial eta squared = 0.116) and Region X ($F = 6.89$, $P= 0.002$, partial eta squared = 0.213) with greater values observed in the VLBW and LBW groups compared with the NBW group. Molar width was significantly greater in the VLBW and LBW groups than in the NBW group ($P = 0.005 – 0.047$). Manual and computerized measurements showed good agreement. No significant sex differences were observed, except for slightly greater enamel thickness in Region C in boys ($P = 0.020$).

Conclusions: Birth weight was not associated with enamel thickness but was associated with increased dentin thickness and molar width. These findings may reflect alterations in postnatal dentin deposition; however, causal inferences cannot be drawn from this cross-sectional design.

Keywords: Infant; Low birth weight; Very low birth weight; Dental enamel; Dentin; Permanent dentition; Molar

Introduction

Dental enamel is the hardest and most mineralized tissue in the human body. Its complex formation processes are governed by genetic factors and influenced by epigenetic and environmental conditions [1]. The formation of deciduous teeth begins early in pregnancy (approximately week 12), with enamel formation completing approximately 12 months after birth. Enamel development in the first permanent teeth starts at week 28, whereas mineralization begins at birth and continues through the first three years of life. As a result, the calcification of permanent first molars is particularly vulnerable to environmental factors around birth. Any disturbances during amelogenesis can cause either quantitative or qualitative defects. Qualitative defects, such as hypomineralization, can lead to conditions such as first molar incisor hypomineralization (MIH) in permanent teeth or hypomineralized second primary molars (HSPM) in primary teeth [2].
Premature birth and low birth weight can lead to severe dental problems, such as hypomineralization and hypoplasia, in both primary and permanent teeth [3]. Compared with children with normal birth weights, infants born prematurely or with very low birth weights present a greater prevalence of enamel defects in their first permanent molars and incisors [1, 4]. Dentin, which makes up the majority of teeth, is classified into three categories: primary, secondary, and tertiary (or reparative) dentin [5]. Primary dentin forms during odontogenesis, whereas secondary dentin begins to form before eruption and continues to grow after tooth eruption. The formation of both primary and secondary dentin is regulated by odontoblasts, which are responsible for the majority of dentin production [6].

Few studies in the literature have examined the factors affecting dentin formation on the basis of birth weight. To the best of our knowledge, only one case report has investigated the histopathological features of dentin in preterm children [7]. Conflicting results have been reported regarding the size of permanent teeth. Some studies reported that the tooth crown dimensions of primary teeth and the mesiodistal dimensions of the permanent first molar were smaller by 4–9% in extremely preterm infants [8-10], whereas others reported larger mesiodistal crown dimensions in permanent first molars in prematurely born children [11].

Since mineralization of permanent first molars occurs around birth and considering that infants with lower birth weights tend to experience delayed tooth development compared with those

with normal birth weight, the weight of the child at birth is one of the environmental factors most likely to influence the development of permanent first molars [12, 13].

Permanent first molars typically erupt at approximately age seven, and panoramic radiographs are routinely available at this age for orthodontic evaluation. Given the contradictory findings in the literature regarding tooth dimensions in low birth weight infants [14], the aim of this study was to investigate the impact of birth weight on enamel and dentin thickness in the first permanent molars of 7- to 8-year-old children, as measured via panoramic radiographs. For increased accuracy, measurements were performed both manually and via computer-assisted methods.

Materials and methods

This retrospective cross-sectional study was approved by the appropriate institutional ethics committee in 2021 and was conducted in accordance with the ethical principles of the Declaration of Helsinki and its later amendments. Data were collected from children born at … Hospital between 2012 and 2013.

Participants and grouping

Birth weight data were obtained from official hospital medical records and neonatal files. No information was collected through parental self-report. Gestational age in our institution is routinely estimated using second-trimester ultrasonography; however, this method may have an error margin of approximately 2–4 weeks. Considering this potential variability, birth weight was selected as the primary grouping variable, as it represents a more consistently recorded and relatively stable clinical parameter.

To minimize confounding factors that could affect the relationship between gestational age and birth weight, infants born to mothers with diabetes, fetal intrauterine growth restriction (IUGR), or congenital anomalies were excluded from the study. After applying these criteria, the majority of infants born before 32 weeks had birth weights below 1500 g, while those born between 32 and 36 weeks generally had birth weights between 1500 and 2500 g, and those born over 36 weeks were more than 2500 g.

A total of 75 children aged 7–8 years were included in the study. The children were divided into three groups on the basis of their birth weight:

- Very Low Birth Weight (VLBW): 1000 - 1500 g

- Low Birth Weight (LBW): 1500 - 2500 g
- Normal Birth Weight (NBW): ≥2500 g

[13].

Families were contacted and invited to participate when the children were 7-8 years old.

The inclusion criterion was adequate cooperation during orthodontic examination and panoramic radiography procedures

The other exclusion criteria were as follows: chronic systemic diseases affecting bone or dental mineralization, severe jaundice requiring transfusion, craniofacial anomalies, congenital anomalies, missing, restored, or decayed mandibular molars, poor-quality radiographs, or improper head positioning.

Maternal and Perinatal Data:

A neonatologist extracted maternal data from medical records, including age, parity, delivery mode, socioeconomic status, and ethnicity.

Dental Assessment:

Parents received detailed information about the study objectives and procedures. Written informed consent was obtained prior to participation. Dental examinations were performed at the Faculty of Dentistry, Bojnurd University, by a single orthodontist. Panoramic radiographs were obtained as part of routine clinical orthodontic evaluation in mixed dentition. International radiographic practice supports the use of panoramic imaging in children after the eruption of the first permanent tooth (typically around age 6-8) to assess dental development, eruption patterns, and potential developmental anomalies. Panoramic radiography was performed only when clinically indicated, and radiation exposure was minimized following the ALARA principle.

The sample size was calculated using Cochran's formula [15, 16]. Based on the sample size calculation, the required number of participants was 67. After applying the correction factor for multiple groups, the sample size was increased to approximately 75 children. Therefore, 25 children were allocated to each group.

Panoramic radiographs were obtained using the Carestream CS 9000C device (serial number: FIBI032, product number: GEN-36914, Carestream Health, Rochester, New York, USA) at the

dental faculty. Enamel thickness was measured using linear distances at points C, B, A, Y, and Z, while dentin thickness was measured at points F, E, D, and X, as shown in Figure 1. The width of the tooth was calculated by adding the values of the X, Y, and Z distances. The researcher used a caliper to measure enamel and dentin thickness in mandibular first molars based on panoramic radiographs. To assess intra-examiner reliability, 20 randomly selected radiographs were re-evaluated after a two-week interval by the same examiner. The Intraclass correlation coefficient (ICC) was calculated and was 0.84, indicating good measurement reproducibility. To enhance accuracy, MATLAB Ver. 2017A software, along with the Image Processing Toolbox, was used to analyze the thickness measurements from selected images. A specific region of interest was chosen from all images using the toolbox, and the enamel and dentin thicknesses were calculated accordingly. After processing the images, the obtained measurements were compared between the groups using the software. The use of computerized analysis minimized human error, and the resulting graphs and tables, generated through MATLAB, were clearer and more accurate due to image preprocessing, which increased the validity of the results.

Statistical methods

Data distribution was assessed using the Kolmogorov–Smirnov test. To compare enamel and dentin thickness between different weight and gender groups, we employed independent t tests, paired t tests, and analysis of variance (ANOVA). Post hoc tests were used for pairwise group comparisons. All statistical analyses were performed using SPSS software version 26. P values less than 0.05 were considered statistically significant.

Results

The data were normally distributed, as determined by the Kolmogorov–Smirnov test ($P > 0.05$); thus, analysis of variance (ANOVA) was employed.

Table 1 presents the mean enamel thickness in the first mandibular molar, which was measured via both manual and computerized methods. No significant differences were detected in any of the specified regions (Y, C, B, A, and Z) when grouped by the birth weight of the children ($P > 0.05$).

Table 1: Mean enamel thickness (mm) at different points in the first mandibular molar in 7–8-year-old children, categorized by birth weight, via both manual and computerized measurements.

Group	THICKNESS	VLBW	LBW	NBW	F	Eta square	P
		Mean (SD)	Mean (SD)	Mean (SD)			
MANUAL	**A**	2.13 (0.62)	1.89 (0.49)	1.79 (0.42)	1.94	0.071	0.154
	B	2.75 (0.89)	2.63 (0.62)	2.66 (0.62)	0.13	0.005	0.879
	C	2.13 (0.72)	1.95 (0.37)	2.18 (0.34)	1.18	0.044	0.314
	Y	1.63 (0.39)	1.92 (0.45)	1.84 (0.44)	2.17	0.078	0.125
	Z	1.50 (0.37)	1.76 (0.31)	1.58 (0.34)	2.85	0.101	0.067
COMPUTER	**A**	2.17 (0.78)	1.85 (0.65)	1.73 (0.43)	2.22	0.080	0.119
	B	2.76 (0.84)	2.55 (0.64)	2.61 (0.63)	0.38	0.015	0.681
	C	2.04 (0.79)	1.99 (0.48)	2.25 (0.35)	1.14	0.043	0.327
	Y	1.63 (0.41)	1.89 (0.74)	2.01 (0.50)	2.00	0.073	0.145
	Z	1.56 (0.41)	1.64 (0.68)	1.55 (0.44)	0.19	0.007	0.829

*The P value is considered significant at the 0.05 level.

Table 2 presents the mean dentin thickness in the first mandibular molar, which was measured via both manual and computerized techniques. In the manual technique, the mean dentin thickness in Regions D (F=3.36; p=0.043; partial eta squared =0.116) and X (F=6.89; p=0.002; partial eta squared = 0.213) was significantly different. In the computerized technique, regions E (F=3.34; partial eta squared = 0.116; p=0.042) and X (F=5.68; partial eta squared =0.182; p=0.005) also exhibited significant differences, when the three birth weight groups were compared.

Table 2: Mean dentin thickness (mm) at different points in the first mandibular molar in 7–8-year-old children, categorized by birth weight, via both manual and computerized measurements.

Group	THICKNESS	VLBW	LBW	NBW	F	partial η^2	P
		Mean (SD)	Mean (SD)	Mean (SD)			
MANUAL	**D**	4.56 (0.85)	3.95 (0.76)	4.05 (0.60)	3.36	0.116	0.043 *
	E	4.13 (0.53)	3.76 (0.63)	3.92 (0.51)	1.80	0.066	0.175
	F	4.47 (0.64)	4.34 (0.62)	4.26 (0.81)	0.38	0.015	0.687
	X	11.34 (0.89)	11.11 (1.05)	10.24 (0.87)	6.89	0.213	0.002 *
COMPUTER	**D**	4.66 (0.91)	4.08 (0.96)	4.14 (0.84)	2.13	0.077	0.128
	E	4.13 (0.77)	3.58 (0.74)	3.99 (0.63)	3.34	0.116	0.042*
	F	4.41 (0.77)	4.43 (0.74)	4.44 (0.83)	0.00	<0.001	0.992
	X	11.31 (1.10)	11.38 (1.09)	10.38 (0.84)	5.68	0.182	0.005*

*The P value is considered significant at the 0.05 level.

On the basis of the LSD post hoc test, in the manual technique, the mean dentin thickness in Region D was significantly greater in the VLBW group than in both the LBW group (Mean difference= 0.32; P = 0.018) and the NBW group (Mean difference= 0.81; P = 0.047). In Region X, the mean dentin thickness in the VLBW group (Mean difference= 1.106; P = 0.001) and the LBW group (Mean difference= 0.868; P = 0.006) was significantly greater than that in the NBW group, as shown in Table 3.

Table 3: Comparison of average dentin thickness in the first mandibular molar via manual measurement.

Areas	Groups	Groups	Mean difference	p value	Upper extreme	Lower Extreme
	VLBW	LBW	-0.32*	**0.018**	0.111	1.118

D		NBW	0.81*	**0.047**	0.006	1.013
	LBW	NBW	-0.105	0.662	-0.586	0.375
X	VLBW	LBW	0.238	0.459	-0.403	0.880
		NBW	1.106*	**0.001**	0.464	1.749
	LBW	NBW	0.868*	**0.006**	0.254	1.482

*The mean difference is significant at the 0.05 level.

In the computerized technique, the LSD post hoc test revealed that in Region E, the mean dentin thickness was greater in the VLBW group than in the LBW group (Mean difference= 0.550; P = 0.018). In Region X, the mean dentin thickness was greater in the VLBW group (Mean difference= 0.927; P = 0.009) and the LBW group (Mean difference= 1.003; P = 0.004) than in the NBW group, as shown in Table 4.

Table 4: Comparison of average dentin thickness in the first mandibular molar via computerized measurements.

Areas	Groups	Groups	Mean difference	p value	Lower extreme	Upper Extreme
E	VLBW	LBW	.55023*	0.046	.0087	1.0917
		NBW	.14602	0.793	-.3955	.6875
	LBW	NBW	-.40421	0.154	-0.9220	0.1136
X	VLBW	LBW	-.07609	0.973	-0.9038	0.7517
		NBW	.92707*	0.025	0.0993	1.7548
	LBW	NBW	1.00316*	0.010	0.2117	1.7946

*The mean difference is significant at the 0.05 level.

The mean width of the first mandibular molar was compared among the three groups via the post hoc LSD test. The results revealed that the first mandibular width was significantly greater in the VLBW (Mean difference= 0.810; P = 0.047) and LBW (Mean difference= 1.131; P = 0.005) groups than in the NBW group. No significant difference was found between the VLBW and LBW groups (Mean difference= 0.320; P = 0.425). In the computerized technique, the mean width of the first mandibular molar did not differ significantly between the weight groups (P = 0.094).Overall, there was no significant difference in the mean enamel thickness in the Y, B, A, and Z regions between boys and girls (P > 0.05). However, the mean enamel thickness in the C region was significantly greater in boys than in girls (P = 0.020). There was no significant difference in the mean dentin thickness between boys and girls in any region (P > 0.05).

Discussion

In this study, we investigated enamel and dentin thickness of permanent mandibular first molars in 7–8-year-old children with different birth weights. Our findings showed that dentin thickness in certain regions was significantly higher in very low birth weight (VLBW) and low birth weight (LBW) children compared to normal birth weight (NBW) children, while enamel thickness did not differ significantly among groups. These results are generally consistent with previous studies reporting alterations in dental hard tissue dimensions in children born with low birth weight or prematurity [17]

The observed effect sizes for dentin thickness in Regions D and X were in the moderate-to-large range (partial eta squared = 0.116 - 0.213), suggesting that birth weight accounted for a meaningful proportion of the variance in dentin thickness.

Importantly, while many studies have focused on deciduous teeth [18, 19], this study specifically evaluated permanent teeth. Additionally, previous research has often concentrated on hypoplasia [18-21], whereas the present study assessed sound tooth structure. The increased dentin thickness observed in VLBW and LBW children could reflect a compensatory or catch-up growth mechanism during postnatal development, which can continue until approximately three years of age in LBW infants. This phase is influenced by several factors, including growth factors, thyroid hormones, insulin, sex steroids, and insulin-like growth factor 1 (IGF-1). These factors are known

to influence developmental traits and may accelerate mineralization in bones and connective tissues, which could help explain the observed differences in dentin thickness [22, 23]. However, this interpretation remains speculative, as other factors such as differences in eruption stage and secondary dentin deposition could also contribute to these findings.

Changes in tooth crown size may reflect general growth disturbances during both prenatal and postnatal development [11].

Previous studies have documented variations in tooth growth across different sexes and racial groups. Other influencing factors include poor maternal health during pregnancy, such as thyroid dysfunction, diabetes, high blood pressure, and maternal smoking [11, 24]. Furthermore, the first permanent molars are the only teeth that begin mineralization at birth, which is why our study focused exclusively on the first molar, assessing both dentin and enamel dimensions.

In this study, the mean width of the first molar was significantly greater in the very low birth weight (VLBW) and low birth weight (LBW) groups than in the normal birth weight (NBW) group. Harila-Kaera et al. reported significant increases in the mesiodistal (MD) and intercuspal distances of the first permanent molars in white preterm boys compared with normal children of certain racial backgrounds, which aligns with the findings of the present study [11].

Apps et al. evaluated 436 twins, divided them into NBW and LBW groups, and reported a positive correlation between tooth dimensions and birth weight. Although they reported no reduction in tooth size in boys with LBW, a 2–3% decrease in tooth size was noted in both deciduous and permanent incisors in girls with LBW [9]. This finding contrasts with our study, which focused on measuring the permanent mandibular molar—the only tooth that begins calcification at birth. As such, birth weight may have a more pronounced effect on this tooth.

Our results also differ from some previous studies reporting reduced crown dimensions in preterm or growth-restricted children [17, 24], which may be explained by differences in study design, population characteristics, racial background, and measurement methods.

In a systematic review, Paulsson suggested that, owing to insufficient evidence on the relationship between premature birth and tooth-crown dimensions, further research is needed to clarify this association.

The source of birth weight data was extracted from official hospital records, minimizing potential recall bias associated with parental reporting. A major limitation of the present study is the absence of gestational age as an independent analytical variable. Although birth weight is strongly correlated with prematurity, it does not completely distinguish between preterm birth and growth-restricted term infants. Despite excluding cases with IUGR, maternal diabetes, and congenital anomalies, residual confounding related to neonatal maturity cannot be entirely ruled out. Future studies incorporating precise gestational age data are needed to clarify the independent effects of prematurity and birth weight on dental tissue development.

Regarding measurement methodology, we employed both manual and computer-assisted techniques on panoramic radiographs. Although digital image analysis may allow improved edge detection and standardized magnification, minor differences between techniques may occur due to pixel resolution and image processing parameters.

Manual measurements showed slightly higher dentin thickness in some regions compared to computer-assisted measurements, but overall differences were small. Although dental cast models provide accurate three-dimensional assessment of external crown morphology, they do not allow evaluation of internal dental structures such as enamel and dentin thickness. Nevertheless, panoramic imaging is subject to magnification, distortion, and focal trough limitations, and slight buccolingual positioning differences may influence linear measurements. Although good intra-examiner reliability was observed in this study (ICC = 0.84), supporting the internal consistency of the measurements, these factors may influence absolute linear measurements; however, relative comparisons between groups remain informative when standardized imaging protocols are applied. In the present study, panoramic radiographs were used because they permit visualization of the enamel–dentin interface without additional radiation exposure, as these images were already available for orthodontic diagnostic purposes. Previous studies have demonstrated acceptable validity and reproducibility of radiographic measurements for evaluating crown dimensions [25,

26]. Future investigations using higher-resolution modalities such as CBCT or micro-CT (when ethically feasible) would provide more precise structural assessment.

The study also explored sex differences, revealing that boys had slightly greater enamel thickness in some regions compared to girls, whereas dentin thickness did not differ significantly by sex. These findings align with reports of modest sexual dimorphism in dental hard tissue dimensions [27].

Genes influencing tooth crown size are located on both the X chromosome and the Y chromosome, and the effects of the Y chromosome differ from those of the X chromosome [10, 24]. Additionally, the enamel and dentin thicknesses in both boys and girls, when stratified by weight, were similar in the majority of the measured areas. No major sex-specific differences were observed, suggesting similar patterns across genders in this sample.

Finally, it should be noted that the suggestion that normal enamel thickness in underweight children implies no increased susceptibility to early tooth decay should be interpreted with caution. In the present study, no clinical assessment of caries was performed; therefore, enamel thickness alone cannot be considered a direct indicator of caries risk. Dental caries is a multifactorial disease influenced by enamel quality, oral hygiene, dietary habits, socioeconomic status, and access to dental care, in addition to enamel thickness. This limitation has been explicitly acknowledged, and future studies are warranted to investigate caries status in conjunction with early-life growth parameters.

Conclusion:

This study highlights potential differences in dentin thickness of mandibular first molars according to birth weight, while enamel thickness appears unaffected. The findings contribute to understanding the relationship between early-life growth and dental development, but they should be interpreted within the methodological limitations discussed above.

Abbreviations

- **VLBW**: Very low birth weight

- **LBW**: Low birth weight
- **NBW**: Normal birth weight
- **MIH**: Molar Incisor Hypomineralization
- **HSPM**: Hypomineralized second primary molars

Declarations

Ethics approval and consent to participate

This retrospective cross-sectional study was approved by the Ethics Committee of North Khorasan University of Medical Sciences (Approval Code: IR.NKUMS.REC.1400.130). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and its later amendments. Written informed consent was obtained from the parents or legal guardians of all participating children prior to participation.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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No funding was received for this study.

Authors' contributions

Y.B. and N.R. conceived and designed the study. S.M. contributed to the study methodology. S.D. and N.R. performed the investigation. M.N. curated the data. M.Y. performed the software implementation and formal statistical analysis. Y.B. and N.R. supervised the study. Y.B. and S.D. validated the findings. M.Y. and S.M. contributed to data visualization. N.R. and S.D. drafted the original manuscript. N.R. and S.D. reviewed and edited the manuscript. All authors read and approved the final manuscript.

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Figure 1: Schematic representation of the measured areas in enamel and dentin.