

## Comparison of methods for estimating the timing of linear enamel hypoplasia formation: Clinical validation against a known systemicevent

Chuan-Hang Yu

Follow this and additional works at: <https://jds.ads.org.tw/journal>

---

### Recommended Citation

Yu, Chuan-Hang () "Comparison of methods for estimating the timing of linear enamel hypoplasia formation: Clinical validation against a known systemicevent," *Journal of Dental Sciences*: Vol. 21: Iss. 2, Article 69.

Available at: <https://jds.ads.org.tw/journal/vol21/iss2/69>

This Short Communication is brought to you for free and open access by Journal of Dental Sciences. It has been accepted for inclusion in Journal of Dental Sciences by an authorized editor of Journal of Dental Sciences. For more information, please contact [cpchiang@ntu.edu.tw](mailto:cpchiang@ntu.edu.tw).



Available online at <https://jds.ads.org.tw/journal/>

Digital Commons

journal homepage: <https://jds.ads.org.tw/journal/>



Short Communication

# Comparison of methods for estimating the timing of linear enamel hypoplasia formation: Clinical validation against a known systemic event

Chuan-Hang Yu <sup>a,b\*</sup>

<sup>a</sup> School of Dentistry, Chung Shan Medical University, Taichung, Taiwan

<sup>b</sup> Department of Stomatology, Chung Shan Medical University Hospital, Taichung, Taiwan

Received 20 December 2025; Final revision received 21 December 2025

Available online 1 April 2026

## KEYWORDS

Linear enamel hypoplasia;  
Age estimation;  
Febrile convulsion

**Abstract** *Background/purpose:* Linear enamel hypoplasia (LEH) provides a permanent record of developmental disturbances during amelogenesis. This study compared four LEH age estimation methods against a documented systemic event.

*Materials and methods:* A 12-year-old Taiwanese girl with visible LEH on her maxillary central incisor had experienced a febrile convulsion at 1 year 7 months of age (1.58 years). Crown height (10.5 mm) and LEH distance from incisal edge (4.0 mm) were measured. Four methods were applied: chart method, Goodman and Rose regression equation, and Reid and Dean models (Northern European and Southern African).

*Results:* The Goodman and Rose regression method (1.55 years) demonstrated highest accuracy with only 1.9 % deviation from actual timing. The chart method (2.5–3.0 years) and Reid and Dean models (2.7–3.1 years) overestimated by 58–96 %.

*Conclusion:* The Goodman and Rose regression method provided superior accuracy for estimating LEH formation timing. Appropriate method selection is crucial for accurate age estimation in pediatric dental practice.

© 2026 Association for Dental Sciences of the Republic of China. Publishing services by Digital Commons. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

\* School of Dentistry, Chung Shan Medical University, No. 110, Sec. 1, Chien-Kuo N. Rd, Taichung, 402306, Taiwan.  
E-mail address: [tao2008@csmu.edu.tw](mailto:tao2008@csmu.edu.tw).

<https://doi.org/10.1016/j.jds.2025.12.025>

1991-7902/© 2026 Association for Dental Sciences of the Republic of China. Publishing services by Digital Commons. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## Introduction

Linear enamel hypoplasia (LEH) represents a permanent record of systemic physiological stress during tooth development, manifesting as horizontal bands, grooves, or lines on the tooth crown surface.<sup>1</sup> These defects result from disruption of ameloblast activity during enamel formation and can be attributed to nutritional deficiencies, infectious diseases, and febrile episodes.<sup>2</sup> Unlike other biological tissues, enamel does not remodel after formation, making LEH a stable chronological indicator of developmental disturbances.<sup>3</sup>

Several methods have been developed to determine the age at which LEH occurred retrospectively. The chart method assigns LEH to six-month age intervals based on distance from the cemento-enamel junction (CEJ).<sup>4</sup> The Goodman and Rose regression equations assume linear crown growth and calculate age as a function of LEH distance from the CEJ.<sup>1</sup> Reid and Dean's models incorporate non-linear growth patterns and account for cuspal enamel formation time, providing population-specific estimates.<sup>5</sup>

Despite widespread application in bioarcheological research,<sup>6</sup> few studies have validated these methods against documented systemic events in living individuals. Ritzman et al. demonstrated significant methodological differences when comparing age estimates, particularly for early-forming LEH.<sup>7</sup> However, direct clinical validation against known medical events remains limited.

This study compares these estimation methods using a documented febrile convulsion as the etiological event. A 12-year-old girl with a visible discolored band on her maxillary central incisor experienced a febrile convulsion at 1 year 7 months of age. By applying four estimation methods and comparing results with the known timing of systemic stress, we evaluated which approach most accurately estimated the age of defect formation in a clinical pediatric context.

## Materials and methods

A 12-year-old Taiwanese girl presented with discolored bands on her maxillary central incisors. Medical history revealed a febrile convulsion at 1 year 7 months of age (1.58 years) during an acute febrile illness with body temperature exceeding 39 °C, requiring emergency medical attention and anticonvulsant medication. No other significant systemic diseases, nutritional deficiencies, or prolonged drug use were reported during early childhood. The family history was non-contributory, with no hereditary enamel defects or metabolic disorders.

Intraoral examination revealed a well-aligned permanent dentition. A distinct horizontal discolored band was observed on the labial surface of the right maxillary central incisor, appearing as a white-yellow line approximately 4 mm from the incisal edge. The defect extended circumferentially around the tooth crown, perpendicular to the long axis, consistent with LEH. Similar but less pronounced defects were observed on the contralateral central incisor. After obtaining informed consent from the patient's father, clinical photographs and measurements were taken.

The right maxillary central incisor was selected for analysis. Two measurements were obtained using a caliper: (1) total clinical crown height from the incisal edge to the gingival margin, measured at the labial midline; and (2) distance from LEH to the incisal edge. The height was recorded as 10.5 mm, and the LEH distance from the incisal edge as 4.0 mm (Fig. 1). The distance from LEH to CEJ was calculated as 6.5 mm, representing 61.9 % of the crown height from the CEJ.

Four established methods were applied to estimate the age at LEH formation (Table 1). Each method was used independently, and estimated ages were compared with the documented time of the febrile convulsion (1.58 years).

## Results

The four estimation methods yielded markedly different age estimates for LEH formation (Table 1). The Goodman and Rose regression method provided an estimate of 1.55 years, which is closest to the documented febrile convulsion at 1.58 years, with a difference of only 0.03 years.

The chart method estimated LEH formation at 2.5–3.0 years, which overestimates the actual time by 0.92–1.42 years. The Reid and Dean models produced higher estimates: the Northern European model estimated 2.9–3.1 years (an overestimation of 1.32–1.52 years), while the Southern African model estimated 2.7–2.9 years (an overestimation of 1.12–1.32 years).

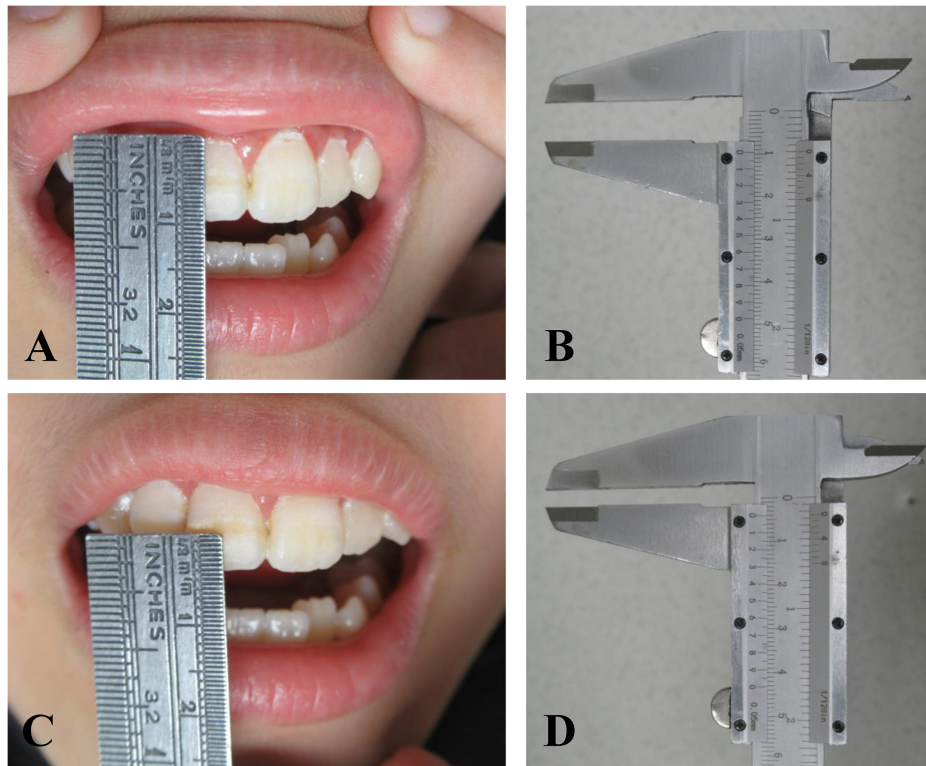
The Goodman and Rose regression demonstrated the highest accuracy, with only 1.9 % deviation from the actual age. The chart method showed a deviation of 58–89 %, while the Reid and Dean models showed deviations of 84–96 % (Northern European) and 71–84 % (Southern African) (Table 1). All methods identified that LEH formed during early childhood; however, the magnitude of the discrepancy varied substantially between methods.

## Discussion

This study validated LEH age estimation methods against a documented systemic event in a living patient. The striking concordance between the Goodman and Rose regression method (1.55 years) and the actual timing of febrile convulsions (1.58 years) supports the clinical utility of this approach for estimating developmental disturbances during early childhood. In contrast, the chart method and both Reid and Dean models substantially overestimated LEH formation age by approximately 1–1.5 years, raising questions about methodological assumptions and their applicability in pediatric clinical contexts.

The superior accuracy of the Goodman and Rose regression equation may reflect its mathematical foundation, which is based on developmental standards derived from American children of European descent. Although this method assumes linear crown growth, a simplification challenged by histological studies,<sup>5</sup> the minimal deviation (0.03 years) suggests reasonable accuracy for maxillary central incisors in early childhood.

The systematic overestimation by the chart method and Reid and Dean models warrants careful consideration. Reid and Dean's incorporation of cuspal enamel formation time



**Figure 1** Clinical and measurement documentation of linear enamel hypoplasia (LEH) on the maxillary central incisor. (A) Intraoral photograph showing the measurement of the total height of the clinical crown. (B) Caliper measurement of total clinical crown height from the incisal edge to the gingival margin (10.5 mm). (C) Intraoral photograph showing a horizontal discolored band (LEH) on the right maxillary central incisor, measured at 4.0 mm from the incisal edge. (D) Caliper measurement of the distance LEH from the incisal edge (4.0 mm).

**Table 1** Methods and results of linear enamel hypoplasia (LEH) age estimation compared with documented systemic event.

Method	Methodology	Estimated age (years)	Actual event age (years)	Difference <sup>a</sup> (years)	Deviation (%)
Chart method <sup>4</sup>	Assigns LEH to six-month age intervals based on distance from CEJ using developmental charts	2.5–3.0	1.58	+0.92 to +1.42	58–89 %
Regression equation <sup>1</sup>	Calculates age using linear regression formula for maxillary central incisors	1.55	1.58	–0.03	1.9 %
Reid & Dean - Northern European <sup>5</sup>	Assigns LEH to crown height deciles with population-specific enamel formation rates; includes cuspal enamel time	2.9–3.1	1.58	+1.32 to +1.52	84–96 %
Reid & Dean - Southern African <sup>5</sup>	Same methodology as Northern European model using Southern African population data	2.7–2.9	1.58	+1.12 to +1.32	71–84 %

<sup>a</sup> Negative deviation indicates underestimation; positive deviation indicates overestimation.

and non-linear growth patterns theoretically provides more accurate age estimates. However, accounting for cuspal development time paradoxically resulted in substantially older estimates than the documented event. This discrepancy may reflect population-specific differences in enamel formation rates, as our Taiwanese patient may not conform to either the Northern European or Southern African reference populations. Previous studies have documented ethnic variation in tooth development timing,<sup>8</sup> suggesting that population-specific calibration may be necessary for optimal accuracy.

The chart method's six-month interval approach yielded an age range (2.5–3.0 years) that overestimated the actual event by nearly one year, consistent with previous methodological comparisons,<sup>6,7</sup> demonstrating systematic overestimation when cuspal formation time is included or interval-based approaches are applied to early-forming defects.

Understanding the timing of LEH formation has practical implications for pediatric dentistry. Febrile convulsions, which occur in approximately 2–5 % of children aged 6 months to 5 years,<sup>9</sup> represent significant physiological

stress that can disrupt ameloblast function. The permanent recording of this event in dental enamel provides an objective marker for reconstructing a child's medical history, particularly when detailed records are unavailable.

In conclusion, the Goodman and Rose regression method demonstrated superior accuracy in estimating the timing of LEH formation in this clinical case. LEH serves as a permanent chronological record of developmental disturbances, and the selection of appropriate methods is crucial for accurate age estimation in pediatric dental practice. Future studies with larger sample sizes across diverse populations are needed to establish population-specific calibration factors.

### Declaration of competing interest

The author has no conflicts of interest relevant to this article.

### References

1. Goodman AH, Rose JC. Assessment of systemic physiological perturbations from dental enamel hypoplasias and associated histological structures. *Am J Phys Anthropol* 1990;33:59–110.
2. Garot E, Rouas P, Somani C, Taylor GD, Wong F, Lygidakis NA. An update of the aetiological factors involved in molar incisor hypomineralisation (MIH): a systematic review and meta-analysis. *Eur Arch Paediatr Dent* 2022;23:23–38.
3. Hillson S, Bond S. Relationship of enamel hypoplasia to the pattern of tooth crown growth: a discussion. *Am J Phys Anthropol* 1997;104:89–103.
4. Goodman AH, Armelagos GJ, Rose JC. Enamel hypoplasias as indicators of stress in three prehistoric populations from Illinois. *Hum Biol* 1980;52:515–28.
5. Reid DJ, Dean MC. Variation in modern human enamel formation times. *J Hum Evol* 2006;50:329–46.
6. Dabrowski P, Kulus MJ, Furmanek M, Paulsen F, Grzelak J, Domagała Z. Estimation of age at onset of linear enamel hypoplasia. New calculation tool, description and comparison of current methods. *J Anat* 2021;239:920–31.
7. Ritzman TB, Baker BJ, Schwartz GT. A fine line: a comparison of methods for estimating ages of linear enamel hypoplasia formation. *Am J Phys Anthropol* 2008;135:348–61.
8. Liversidge HM, Speechly T, Hector MP. Dental maturation in British children: are Demirjian's standards applicable? *Int J Paediatr Dent* 1999;9:263–9.
9. Steering Committee on Quality Improvement and Management, Subcommittee on Febrile Seizures American Academy of Pediatrics. Febrile seizures: clinical practice guideline for the long-term management of the child with simple febrile seizures. *Pediatrics* 2008;121:1281–6.