LEHs in MEDIEVAL SCANDINAVIA: PRELIMINARY ANALYSIS

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ABSTRACT The development of enamel defects is a topic of considerable interest among skeletal biologists. Linear enamel hypoplasias (LEHs) are commonly studied, as they are generally thought to represent stress-induced growth disruptions. The present research uses the frequency of LEH in spatially dispersed but chronologically compact samples to document regional differences in growth stress.

Analysis of 1,068 teeth representing the permanent dentition of 921 individuals from six medieval sites in Denmark, Norway, and Greenland showed that the highest frequency of LEH occurred in the mandibular canine (29.13%) followed by the maxillary central incisor (27.51%). Comparison of these results with developmental charts, showing that maxillary incisor and mandibular canine crowns are completely formed between 4 and 7 years of age, indicated that early childhood was likely a stressful time for medieval Scandinavians. Overall, LEHs were more common in maxillary teeth than in mandibular teeth. Although statistically significant differences in LEH frequencies were not found between males and females, locations did differ significantly.

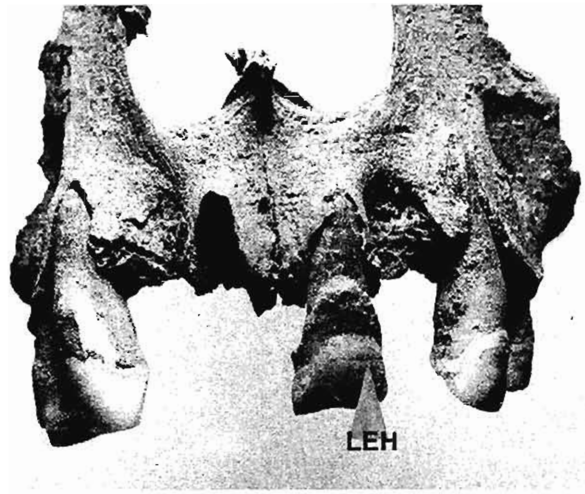

Fig. 1. LEH on maxillary incisor.

INTRODUCTION

Linear enamel hypoplasias (LEHs) are defects in enamel thickness resulting from disruptions of amelogenesis. While the specific etiology of LEHs is unknown, they are generally considered to be sensitive markers of developmental stress. Many types of stressors, such as nutritional deprivation, poor pre- and neonatal conditions, or illness can provoke growth arrest and LEH. Therefore LEHs are indications of nonspecific stressors. However, unlike bone which also exhibits the scars of developmental stressors, dental enamel does not remodel once formed (Goodman et al., 1985a,b). Thus LEHs bequeath a permanent record of developmental trauma . Furthermore, LEHs have the advantage of being macroscopically observable and recordable without expensive equipment under often difficult field situations.

MATERIALS AND METHODS

LEHs were operationally defined as lines or bands of decreased enamel thickness (Fig. 1). All defects included in this study were distinguished macroscopically and scored as "present" or "absent" by the senior author. A score of present denotes one or more obvious hypoplastic lines. In an attempt to control for loss of observability due to attrition or incomplete crown exposure, only teeth having reached the occlusal plane and with less than Stage 4 attrition (Brothwell, 1981) were included in the present analyses.

The samples represent medieval Scandinavian populations from Norway (Trondheim, Bergen and Oslo), Denmark (Viborg), and Greenland (Herjolfsnes, Gardar, and Sandnes) (Fig. 2). The maximum temporal range for these samples is from 1150 to 1624 AD, although the majority of the teeth date from 1150 to 1381 AD.

The sizes and sex distributions of the samples are presented in Table 1. All age and sex determinations were done by the senior author and corroborated with earlier publications: Greenland (Hansen, 1924; Fischer-Møller, 1942; Nørlund, 1924, 1929; Bröste and Fischer-Møller, 1944); Viborg, Denmark (Vellev, 1978); Bergen (Hanson, 1986), Trondheim (Hanson, 1986), and Oslo (Haugen, 1976), Norway.

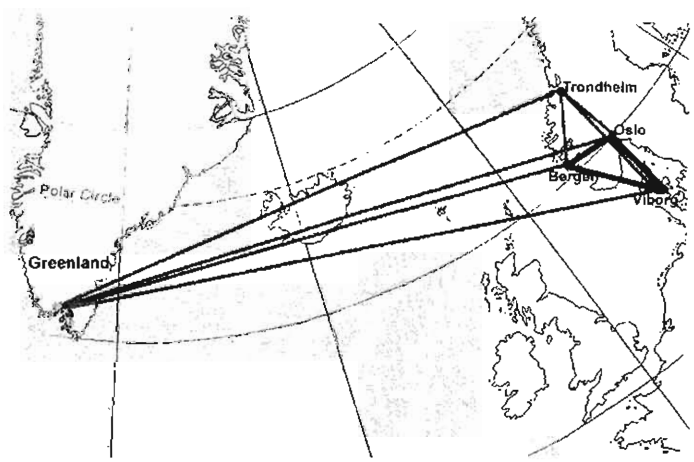

Fig. 2. Map showing sample locations. Lines connect sites between whom LEH frequencies differed significantly. Dark lines connect sites between whom LEH frequencies did not differ significantly (Oslo, Bergen, Viborg).

TABLE 1. Size and sex distribution of individuals and number of teeth.

Samples	n	% of total	Males	Females	Unknown
Bergen	68	6.67	22	26	23
Trondheim	527	49.43	71	90	366
Oslo	228	21.35	117	109	2
Viborg	50	4.68	19	27	4
Greenland	48	4.49	7	5	36
Number of teeth	1068		285	306	477

No statistically significant differences between males and females were found in either tooth presence or in the presence LEH frequencies per antimere (Chi-square tests, $\alpha=.05$, df=1). Thus, the sexes and "unknown" individuals were pooled in the comparative analyses.

The current research found high association of presence or absence of LEHs between antimeres (McNemar's Test for Significance of Changes, $\alpha=.01$). Thus, only one side, either right or left depending on presence, was used for analysis. This was necessary as the archaeological material was, as is usually the case, fragmentary.

RESULTS

The current research found LEH frequencies that were much lower than those reported by Scott et al. (1992), even though some of the same individuals were included in both studies. This may be attributed to interobserver error, a persistent and perfidious problem in LEH studies (personal communication, Jacobi, Dental Workshop, PPA meeting, Denver CO, 1994; Danforth et al., 1993). Since the present research found low frequencies, these must be considered as the conservative end of the range and the LEH relatively more pronounced in order to be scored as present. However, intraobserver error in the current investigation has been established as relatively low (Hanson, 1986).

Although any tooth can exhibit a LEH, it is most common on the maxillary central incisor and mandibular canine and least common on the maxillary third molar (Table 2, Fig. 3). This is a widespread pattern reported by many other authors (Goodman and Armelagos, 1985a,b; Goodman et al., 1987; Goodman, 1988; Duray, 1996).

Wilcoxon Rank Sum Tests examined the null hypothesis of no significant differences in LEH frequency by tooth type. Not surprisingly, the LEH frequency differed by tooth ($\alpha=.05$). Goodman and Armelagos (1985a) also found distinct LEH susceptibilities for different teeth. They found that the earlier-developing tooth crowns tended to have more hypoplasias than did later-developing crowns. Significant differences in LEH frequencies also occurred among tooth crowns that develop at the same time. These workers discovered that the maxillary central incisors were 1.7 times as susceptible to LEH as were the first molars, even though the crowns are all developing between birth and 3.5 years.

TABLE 2. Frequencies of one or more hypoplastic lines for each tooth class.

Tooth classes	Bergen	Trondheim	Oslo	Viborg	Greenland	Overall
Maxillary teeth						
Central incisor	7.69	38.10	28.43	23.08	0.00	27.51
Lateral incisor	6.25	22.67	8.26	2.44	0.00	10.86
Canine	16.67	24.22	14.94	10.20	0.00	15.79
First premolar	3.33	12.64	8.24	2.04	0.00	7.39
Second premolar	3.57	10.59	6.01	0.00	0.00	5.66
First molar	3.03	10.09	4.55	0.00	2.78	5.20
Second molar	13.33	12.50	4.02	0.00	0.00	6.04
Third molar	0.00	4.41	3.45	0.00	0.00	2.73
Mandibular teeth						
Central incisor	7.14	21.92	6.35	6.98	0.00	10.14
Lateral incisor	11.11	26.04	9.63	11.11	0.00	14.02
Canine	15.00	43.62	25.87	33.33	0.00	29.13
First premolar	9.09	24.75	10.20	14.58	0.00	13.92
Lateral premolar	9.52	9.00	2.70	6.38	0.00	5.23
First molar	0.00	11.76	1.54	2.27	0.00	4.57
Second molar	0.00	14.55	2.04	0.00	0.00	5.23
Third molar	0.00	6.33	2.59	2.63	0.00	3.23

A similar pattern was found among the Scandinavian samples. Early developing crowns showed relatively high incidences of LEH and not all crowns developing at the same time have equal LEH frequencies. For example, maxillary central incisors were 2.8 times more vulnerable to LEH than first molars, notwithstanding the fact that all the crowns are forming at the same time. This confirms the caveat issued by Goodman and Armelagos (1985b) against comparing results of LEH studies which do not use the same tooth.

Figure 4 shows the distribution of LEHs by age of crown development, taking into account that the permanent enamel does not record the timing of stressor events until about 12 months after crown initiation (Skinner and Goodman, 1992). Estimates of age of occurrence show peak LEH formation occurs between 4.5 and 5.5 years of age. This is later than ranges reported for prehistoric samples (2-6 years), historic samples (2.5-4 years), and modern groups (0-3) (Lanphear, 1990). It is also later than the age of 2, which was the presumed age of weaning during the Middle Ages (Flandrin, 1976). It is even later that the maximum limit (22.5 to 34.5 months) of breast feeding proscribed by the *Borgathing* laws (Benedictow, 1985). It would seem that weaning was not chief among the myriad of LEH causal factors in medieval Scandinavia.

Of course an individual can exhibit a LEH on more than one tooth, and many do. Across all samples 24.9% of individuals have at least one maxillary LEH and 30.8% have at least one mandibular LEH. Multiple expressions of LEH affecting a number of teeth are considered as indications of severe systemic disturbances acting over a period of time, rather than acute stressors (Sciulli, 1978).

One-way ANOVA tests assessed statistically significant differences in LEH frequencies among samples. All samples differed significantly ($\alpha = .05$) from one another with the exception of a Oslo-Bergen-Viborg triad. (Fig. 2). The Trondheim sample is characterized by the highest LEH frequencies. Remarkably, given the general history of the Norse colonies, the Greenland samples show uniformly low frequencies. This may be an artifact of preservation (the Greenland samples are very fragmentary) or due to the nature of LEH formation. LEHs in this study represent adults who were exposed to childhood stressors and recovered. A low LEH frequency may represent either a low level of developmental stress or a high childhood mortality rate. Studies of LEH in deciduous dentition have found a relationship between hypoplastic frequency and relatively lower mean longevity; individuals with multiple LEH tended to die young (Cook and Buikstra, 1979; Goodman and Armelagos, 1988). Conversely, the comparatively high frequency of LEH in medieval Trondheim adults might be interpreted as a mark of survivorship and adaptation. That which does not kill you, makes you strong. Given this interpretation, the low frequencies from Greenland might indicate failure to survive long enough for LEH to form while high frequencies would indicate recovery and resumed growth.

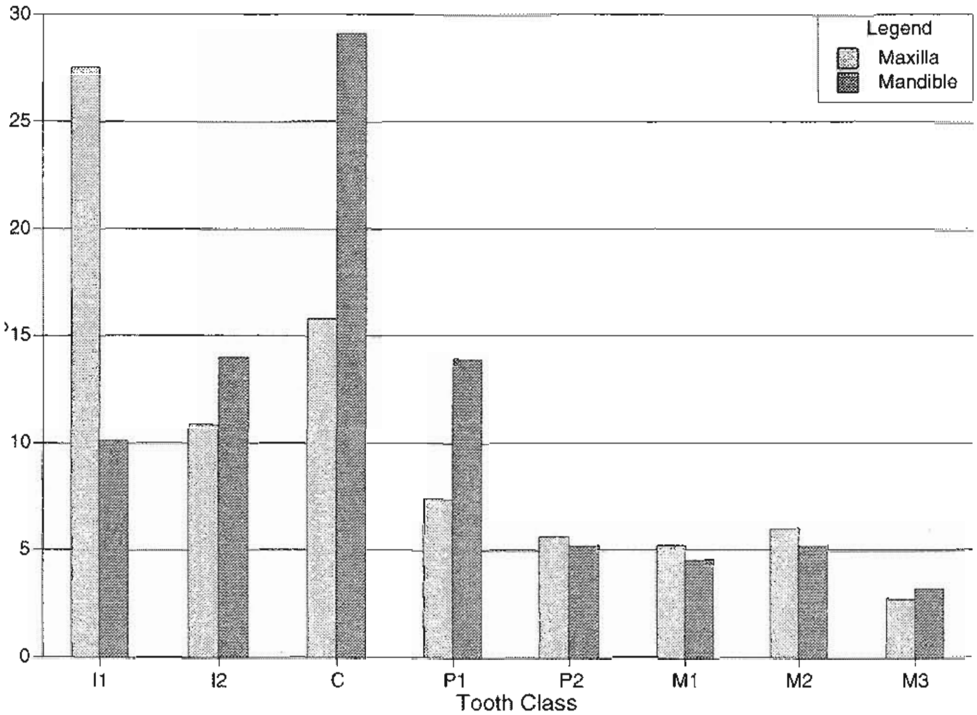

Fig. 3. Comparison of maxillary and mandibular LEH by tooth class.

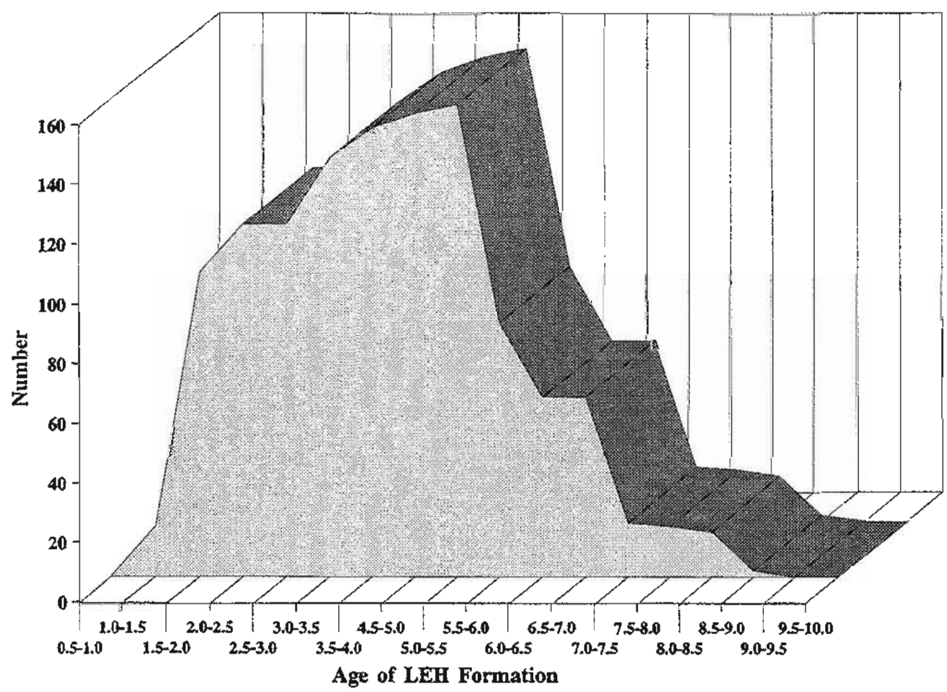

Fig. 4. Distribution of age for LEH formation.

Nonsignificant differences among the Oslo, Bergen, and Viborg samples need to be researched further. Possible areas to explore may be in the more southerly aspects of the three localities. Environmental factors such as resource availability, climate, or resource utilization may play a role in LEH frequency. Genetic factors may also be important. Previous research has shown Oslo and Viborg to be virtually indistinguishable based on craniometrics (Hanson, 1986). Or the answer may lie in cultural practices, such as nursing and weaning (Benedictow, 1985). All three localities are known to have been more influenced by continental Europe than the more remote areas of Scandinavia.

SUMMARY

Comparing and contrasting LEH frequencies in medieval Scandinavian samples revealed: 1) antimeres did not differ significantly in LEH frequency; 2) males and females did not significantly differ in LEH frequency; 3) the maxillary central incisor and mandibular canine were the most common sites of LEH; 4) between 24.9% and 30.8% of the samples have at least one LEH; peak LEH formation occurs between 4.5 and 5.5 years of age; 5) all samples were statistically different from one another except for a Bergen-Oslo-Viborg triad; 6) Trondheim had the highest overall frequencies of LEH and Greenland had the lowest of those in the study.

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