Dental caries in relation to nutritional stress in early English child populations

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Abstract

This research studied an association between dental caries prevalence in the primary dentition and cribra orbitale, an indicator of nutritional stress in archeological populations. Skeletal remains of 221 British children (Pre-Roman to Late Medieval) were examined, of whom 100 had orbital material available. Dental caries, as dmfs, was related to the presence of cribra orbitale (none, slight, moderate, or severe). Thus, data for 50 children showed a statistically significant association ($P < 0.005$) between caries prevalence and cribra orbitale using the Fisher Exact Test, suggesting that nutritional stress is an associated factor in caries etiology in children. (Pediatr Dent 14:26–29, 1992)

Introduction

Many studies on the dental state of early populations have been conducted, but only a few have given information on the primary dentition.[1] This may be due to the scarcity of infant remains or to the generally poor state of infant skeletal material. In living populations, levels of dental caries experience usually are given as the average number of decayed, missing and filled teeth per individual.[2] However, studies on archeological material are difficult, since samples may be small and teeth may be lost or scattered. Many archeological studies simply have reported numbers of individuals, as skulls and proportions of carious teeth, without specifying tooth types. This approach can lead to bias, as more multirooted posterior teeth will be present since incisors readily are lost postmortem. It is, therefore, more appropriate to conduct tooth-type studies where the caries prevalence for the molar teeth is considered separately from that of anterior teeth[3].

James and Miller[3] studied a group of Medieval English children and reported that 7.5% of primary incisors and canines, and 16.5% of primary molars were carious. Children from Saxon (5th–10th Century), Medieval (11th–15th Century) and 17th Century England had, 5.3, 7.1, and 20% respectively, carious teeth.[4–6] Similarly, Williams and Curzon[7] reported that 3% of primary canines and incisors and 15% of primary molars were carious in a Medieval child population from the Scottish Border Country.

Dental caries is related to the composition, frequency of intake and texture of the diet, the types of bacterial flora present, the buffering capacity of the saliva, the structure of the teeth[8], and also the time of exposure to a cariogenic milieu.

Hardwick[9] originally reported on changes in caries experience of English populations with changing diets as did Moore and Corbett[10], but this is only one aspect of caries etiology. There are both pre-eruptive and post-eruptive factors[11], and even nutrients in the diet can affect caries susceptibility of teeth.

Porotic hyperostosis and cribra orbitale provide useful tools for investigating nutritional stress in archeological populations.[12, 13] Cribra orbitale is a reactive hypoplasia, manifested by anemic states in the skull bones in archeological specimens. It is known to occur in iron deficiency anemia and in certain parasitic infections such as hookworm.

According to Russell[14], those populations with fewer nutritional deficiencies tend to be those having more problems with dental caries. However, McDonald[11] points out that this is not necessarily true for the primary dentition. The occurrence of dental caries in several preindustrial countries is more severe in the primary than the permanent dentitions. Nutritional stress may be an associated factor. Children recovering from third degree malnutrition in Guatemala had more dental caries in the primary dentition than those who were less malnourished.[15] In the United Kingdom, lower weight percentile values (indicative of a failure to thrive) were found to be associated with higher levels of decay.[16, 17] The availability of a substantial number of infant and child skulls of early British populations provided an opportunity to study the relationship of nutritional stress and dental caries further.

Materials and Methods

The sources of the skeletal material were various burial sites in England. The largest group was from the site known as Dorset and Winchester Cathedral Green. The remains studies were divided and dated into six broad archeological periods from prehistoric to late medieval times. All skeletal material was examined at the Department of Archeology at Bradford University

and in the Department of Paleontology of the British Museum (Natural History), London. Only remains containing some primary teeth were considered for dental examination.

For each individual, the dentition was examined and charted according to the system recommended by the World Health Organization.[18] All surfaces of the teeth were examined under strong light with the aid of a dental explorer. Only undoubted cavities, with obvious cavitation or where stickiness or softness were encountered were recorded as carious.[18] Radiographic equipment was not available for use, and, unfortunately, the skulls could not be removed from the museums.

In those cases where there was sufficient craniofacial material available in good condition, an examination was made for "cribra orbitale." This required the complete presence of both orbits. If present, the cribra orbitale (Figure) was classified[19] according to the following severity:

Slight — Fine, pin-point apertures

Moderate — Larger, but still isolated apertures

Severe — Larger apertures, which have become confluent resulting in a resemblance to bony trabeculae.

If more than one classification occurred, the most severe type of cribra orbitale on an individual skull was rated and recorded. For a comparison of caries and cribra orbitale purposes, only children with all primary first molars present were included. The caries diagnosis involving the primary first molars then was related to the presence and severity of cribra orbitale in the same individual. Before the study was conducted, calibration exercises for dental caries and cribra orbitale were undertaken on a separate group of juvenile remains, in order that diagnostic criteria were defined precisely. A high level of agreement achieved of a reproducibility of caries diagnosis of 92 and 95% on the cribra orbitale.

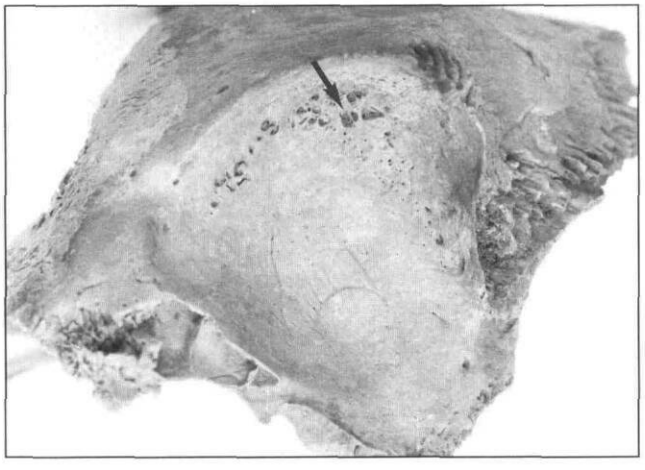

Figure. An example of cribra orbitale (severe).

Three primary teeth also were mounted in methylmethacrylate, sectioned, and ground to 100 μ. They then were examined with light microscopy to confirm the diagnosis of caries in these teeth.

Results

Dental caries occurred in a number of primary teeth and in some cases the cavities were quite large. A total of 221 infant and child skeletal remains yielded dental material for the study. Table 1 (next page) shows the period, location, and number of individuals examined in each respective archeological period. Only five children had completely intact dentitions of molars and incisors.

The age of each individual skull at death was assessed according to dental development. The largest group (48%) had the primary dentition (ages 2–5 years), while the early mixed dentition (ages 6–9 years) was 35% of the sample. In each period these percentages were comparable. A large number of missing primary teeth had either exfoliated naturally prior to death, or were lost postmortem due to their small size and single simple root shape. The total number of first primary molars available for examination and the number found to be carious are given in Table 1.

The presence and severity of cribra orbitale in the different periods were recorded in Table 2 (next page). The majority of individuals in whom the orbital bone had remained intact showed some degree of defect. The largest group exhibited a mild degree, but 73% of the children were affected to some extent, and all age groups were involved (Table 3, p 29).

In all, skull material with the orbital area intact and four first primary molars present was available for comparison in 50 children. Caries was present in 28 skulls. Cribra orbitale affected three not at all, but 25 were affected to some extent (11 slight and 14 moderate or severe). Of the 37 in whom no caries was recorded, cribra orbitale affected 20 not at all, compared with nine who had slight involvement and eight who had moderate or severe involvement. The association between caries prevalence and cribra orbitale was found to be highly statistically significant ($P < 0.005$), according to the Fisher Exact Test.

Discussion

Cribra orbitale is reported to occur with a greater frequency in children than adults and often is related to anemia (the etiology of anemia has received support from recent radiographic studies).[13] However, the severity of the anemia does not always correspond with the severity of the bone changes.

Stuart-Macadam[13] found a significant association between cribra orbitale and hypoplasia in adults and

juveniles from a Romano-British archeological site. It was not stated whether the condition was restricted to observations of the permanent teeth alone. The author considered that children stressed nutritionally and systemically might be more susceptible to cribra orbitale defects and hypoplasia of enamel due to a range of conditions or insults creating both conditions. Because of the effects of nutritional stress at the time of enamel development and maturation, it is possible that they also may be more at risk of dental caries.

Table 1. Period, location, and number of British infant and child skulls studied and the number of carious first primary molars present

Period	Source	Dates	No. of Skulls	First Primary Molars		% Caries
				Present	Carious	
Prehistoric	Various	3000 – 600 BC	15	38	4	10.5
Roman	Dorchester, Chester, Berks, Glos, Stratford	55 BC – 410 AD	65	172	28	16.3
Early Anglo-Saxon	Winchester, Kent, Somerset	5th–6th C	26	59	6	10.2
Late Anglo-Saxon	Berks, N. Hants N. Yorkshire	9th–11th C	73	186	16	8.6
Early Medieval	N. Yorkshire, Oxfordshire	11th–12th C	9	22	0	0
Late Medieval	E. Yorkshire, Winchester	13th–15th C	33	54	11	20.4

Berks = Berkshire, Glos = Glouchester.

The level of dental caries recorded in the present study was similar to that reported by previous investigators, where 20% of the first primary molars among the children of the Late Medieval Period compares with the 16% by James and Miller[3], 7% by Moore and Corbett[10], and 15% by Williams and Curzon.[7] The similarity of the results of the present study with those previously published in comparable populations tends to confirm the reliability of this finding. Cribra orbitale affected 73% of children in the present study compared with 65% for infants and children (ages 2–10 years) as reported by Stuart-Macadam.[13] This author commented that there was a probability that proportionally more anemic children were dying than those who were not anemic.

Table 2. Prevalence of cribra orbitale in English infant and child skulls from six historical periods

Period	No. of Remains	Cribra Orbitale				Not Assessible
		None	Slight	Moderate	Severe	
Prehistoric	15	3	3	3	0	6
Roman	65	12	16	6	3	28
Early A/S	26	4	1	2	1	18
Late A/S	73	8	11	12	3	39
Early Med	9	0	5	2	0	2
Late Med	33	0	2	2	1	28
Total	221	27	38	27	8	121

A/S = Anglo-Saxon, Med = Medieval.

Not assessible — Insufficient skull material to examine for cribra orbitale.

This should be taken into account when observing the higher prevalence of cribra orbitale in children compared with adults. If dental caries is associated positively with cribra orbitale, as in this study, children who die also could have had more caries than the surviving population. Most nutritional disease is the result of a combination of malnutrition and infection acting synergistically.[20] Malnutrition can be secondary to gastrointestinal disease, including acute or chronic diarrhea and severe parasitism which were both common. In children, it also can result from localized infection, such as otitis media and pharyngitis[20], and loss of body weight may be accompanied by complex losses of zinc, magnesium, potassium, and sulphur. Serum iron also drops with a resultant iron deficiency anemia. Malnutrition also affects antibody formation, tissue integrity, and inflammatory responses. A decrease in T-cell production occurs in protein/calorie deficiency, phagocytic function is decreased, and a cycle of repeating infectious episodes then may occur. Pre-eruptive influences may be important and affect the developing structure of teeth as well as maturation of the enamel. An infant stressed nutritionally may be more prone to hypoplasia[21] and dental caries.[15] Another important factor to consider is maternal malnutrition, as many of

the primary teeth calcify *in utero*. The diet would have been highly variable, and certainly would have had an important influence.

Posteruptively, the caries process may be influenced by the presence of cariogenic bacteria in plaque, the buffering capacity of saliva, and the composition, frequency of intake and texture of the diet. All these effects may be modified by infection and malnutrition which could make a cariogenic diet more of a problem. The cariogenic diet available would have included honey, fruit, gruel, and combinations thereof. As dental caries is multifactorial in origin, it is important not to anticipate simple answers in terms of diet alone. The association with cribra orbitale in the present study, and the considerable weight of evidence from animal and human studies point to a possible role of nutritional stress. It is agreed that this may be the case only in less advanced societies or subpopulations in which malnutrition is more common.

Table 3. Severity of cribra orbitale according to age of individual

Age (years)	Number (at risk)	Cribra Orbitale			Total
		Slight	Moderate	Severe	
0.5 – 2	8	1	1	2	4
2 – 4	17	10	2	1	13
4 – 6	22	8	8	1	17
6 – 8	24	9	6	3	18
8 – 10	23	8	8	1	17
10 – 12	6	2	2	—	4

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