



Wear on the deciduous molars in a Mediaeval English human population: a study using crown height



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ABSTRACT

This work comprises a study of mandibular deciduous molar wear in an archaeological population using measurement of crown height. The aims are twofold. Firstly, to investigate the nature of the relationship between wear on the deciduous molars and dental age. Secondly, to evaluate, using crown height, two existing methods of recording deciduous molar wear: the measurement of the percent of the occlusal surface made up of exposed dentine described by Clement and Freyne (2012), and the ordinal wear stage method of Dawson and Robson Brown (2013). The study material is immature skeletal remains ($N = 76$, dental age range 15 months–11.5 yrs) from a British Mediaeval site. Results show that crown height bears an approximately linear relationship with dental age for both first and second deciduous molars, and regression residuals are homoscedastic suggesting little inter-individual variation in wear rates. The second molar wears at a faster rate and its crown height bears a closer relationship with dental age. In the second molar, percent dentine exposure bears a non-linear relationship with dental age and with crown height, and for both molars the regression residuals of percent dentine exposed upon dental age are heteroscedastic. The ordinal wear stages of Dawson and Robson Brown (2013) are strongly correlated with dental age but different wear stages may correspond to dissimilar increments of crown height. Molar crown height is a sensitive and direct measure of occlusal wear, and its homoscedastic, linear relationship with dental age facilitates controlling for the effects of age when dental wear is used to study childhood diet in archaeological populations.

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1. Introduction

Dental wear is the gradual wearing away of tooth substance that occurs as a result of natural mastication. At a population level, the physical properties of consumed foods are the prime determinant of the rate of wear; diets that are more abrasive and/or require more vigorous mastication lead to higher wear rates (Sengupta et al., 1999; Antón et al., 2011). Consequently, modern Western populations, reliant on soft, refined, factory-produced foods, show minor dental wear. By contrast, in antiquity, high rates of tooth wear were universal, reflecting coarser, tougher diets. The ubiquity of dental wear in ancient skeletal remains has meant that it has long been a focus of study in physical anthropology (e.g. Broca, 1879; Keith, 1916; Ruffer, 1920; Leigh, 1925). Because of the age-

progressive nature of dental wear, much work has focused on its use for estimating adult age (Miles, 1978; Brothwell, 1989; Walker et al., 1991; Mays, 2010: 71–76), but it has also been used to study ancient diets and food preparation techniques (Powell, 1985; Larsen, 1997: 247–258; Rose and Ungar, 2001). Most publications concentrate on wear in the permanent dentition, but a few studies have begun to explore the potential of wear on deciduous teeth to shed light on childhood diet in past populations.

Skinner (1997) compared middle and upper Palaeolithic juveniles from western Europe ($N = 82$ individuals). Dental wear rates in the two periods were similar, but wear seemed to begin at younger ages in the upper Palaeolithic, suggesting earlier introduction of solid foods. Examining 37 subadult burials from 1st–3rd century AD Italy, Prowse et al. (2008) found that deciduous molar wear began in the second year of life, showing that weaning foods were significantly abrasive. Clement and Freyne (2012) studied wear in the deciduous dentition of 37 individuals dating to 12,000BC–16th century AD from Sudan. Exposed dentine on the anterior teeth was found in individuals as young as 18 months of age, suggesting early mastication of abrasive matter. Dawson and

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Robson Brown (2013) studied deciduous dentitions of 142 sub-adults from Mediaeval (11th–16th century) England, and found no difference in wear with respect to social status.

Although all the above studies found a pattern of increasing wear with age, some fundamental questions, such as the mathematical form of the relationship between wear and age, and whether the first and second deciduous molars wear at similar rates, remain to be addressed. These are significant matters, as a deeper understanding of deciduous molar wear potentially allows more detailed insights into early childhood diet in ancient populations. The studies cited above recorded molar wear using ordinal wear scales – i.e. wear stages – based on the visual appearance of enamel polishing and, in more worn teeth, dentine exposure (Skinner, 1997; Prowse et al., 2008; Dawson and Robson Brown, 2013), or else measured the proportion of the occlusal surface made up of exposed dentine (Clement and Freyne, 2012). Such techniques, whilst useful for many purposes, are not suited to addressing the above questions. Different wear stages on a given tooth may potentially correspond to unequal increments of crown substance removed and may differ on different molar teeth. The relationship between the proportion of the occlusal surface made up of exposed dentine and the amount of crown substance removed is likely to be rather inconsistent because a given decrement in crown height may correspond to different increments in exposed dentine depending upon how worn the tooth is. The principal effect of occlusal wear is loss of crown height. Crown height is thus potentially a more direct and precise measure of dental wear.

Studies in adult skeletal remains of documented age at death (Walker et al., 1991; Mays, 2002; Benazzi et al., 2008), in juvenile skeletal remains where age can be determined from dental development (Mays et al., 1995), and in living children (Molnar et al., 1983) suggest an approximately linear relationship between crown height in the permanent molars and age in populations that show appreciable dental wear. Permanent molars within the same jaw also appear to wear at fairly similar rates over the adult life course (Mays, 2002; Benazzi et al., 2008). Deciduous molars differ from the permanent molars in terms of morphology, size (Brown, 1984), structure (Bayle et al., 2009; Mahoney, 2010, 2013) and mechanical properties (Correr et al., 2007; Low et al., 2008; de Menezes Oliveira et al., 2010). These considerations, *inter alia*, mean that extrapolating the above findings for the permanent molars to the deciduous molars is problematic. Some studies have investigated loss of dental hard tissue at the occlusal surface of deciduous teeth in modern industrialised populations (Kreulen et al., 2010). However, these have used ordinal scales rather than crown heights to measure wear. Furthermore, modern Western diets are minimally abrasive and do not require vigorous mastication; the mechanism of loss of occlusal hard tissue in modern children appears fundamentally different from that likely in antiquity and appears to be mediated by dissolution by acidic components in the diet, particularly factory produced soft drinks (Milward et al., 1994; Johansson et al., 2001; Murakami et al., 2011; Gatou and Mamai-Houmata, 2012). Observations made on modern children are therefore of little relevance to palaeopopulations.

Measures of crown height are used in the current work to investigate the nature of the relationship between wear on the first and second deciduous molars and dental age, and to investigate the question of whether wear rates are similar on the first and second molars. In addition, two recently developed methodologies for studying deciduous tooth wear – the ordinal wear-scale of Dawson and Robson Brown (2013), and the method involving quantification of exposed dentine on the occlusal surfaces described by Clement and Freyne (2012) – were evaluated by investigating their relationships with crown height and with dental age.

2. Materials and methods

The current study uses juvenile skeletal remains from the churchyard at the deserted village of Wharram Percy (Mays et al., 2007). The remains date from the 10th–19th century AD, but the bulk are 11th–14th century. They are an inland, low status, rural population. A number of attributes make the Wharram Percy collection suitable for the current investigation. Study of the permanent teeth provides no evidence for secular change in the rate of dental wear during the period of use of the burial ground (Mays et al., 2007). The rate of wear on the permanent teeth, estimated using the methodology of Miles (1963), resembles that described by Brothwell (1981) as typical for Mediaeval and earlier British populations, increasing the likelihood that observations made on this population will have wider relevance. The individuals interred in the churchyard comprise inhabitants of the village of Wharram Percy and villages and farmsteads elsewhere in the parish. They therefore form a geographically and socially coherent population.

At Wharram Percy, the agrarian economy provided the dietary staples. Documentary sources, and archaeological evidence from the settlement part of the site, indicate the cultivation of cereals including wheat, barley and oats, as well as the raising of livestock for meat and dairy products (Dyer et al., 2012a,b). Stable isotope analyses of the Wharram Percy skeletons confirm a predominantly terrestrial diet (Richards et al., 2002). The isotopic results from the infants and children indicate that breastfeeding normally ceased at about 18 months of age (Richards et al., 2002), a pattern consistent with Mediaeval documentary sources (Fildes, 1986). $\delta^{15}\text{N}$ also indicates a childhood diet that was isotopically slightly lighter than adult diet (Richards et al., 2002). Whether this meant a greater reliance on plant foods or some other dietary difference was unclear, and Mediaeval written sources are largely silent concerning children's diets.

A dental age was assigned to each individual using the schedule of Massler et al. (1941), compiled from studies on mid 20th century children from the Chicago area. Due to the imperfect relationship between dental and chronological age, errors accrue when estimating the latter from the former. The current work does not attempt to do this, but is confined to investigating the relationship of molar wear to dental age. Dental development was assessed on the gross specimens, augmented with radiography as necessary for intact jaw bones. All radiographs were taken by one of us (SM) using industrial grade film at exposures of 60kv for 10s. All were taken in lateral view. No attempt was made to determine sex. Wear was studied in the mandibular first and second deciduous molars (hereafter dm1 and dm2). Mandibular teeth were selected, following Dawson and Robson Brown (2013), because mandibular elements more often survive in the burial environment. To be included in the current work, a mandible needed to have both a dm1 erupted and a dm2 present for recording (either unerupted or erupted). At Wharram Percy, eruption of dm1 occurred at a dental age of about 1–1.5 years and dm2 at about 1.5–2 years. Both deciduous molars were shed at dental ages of about 11–12 years. The study group ($N = 76$ burials) comprises juveniles with dental ages of approximately 1.5–11.5 years.

In a mandibular molar tooth, the buccal cusps are the supporting cusps; they bear the brunt of crushing and grinding and wear more rapidly (Mills, 1978; Penido et al., 1979; Osborne, 1982). Crown height measurements were taken on the buccal sides of dm1 and dm2. The small size of the deciduous molars and lack of consistent landmarks on the occlusal surface to measure from led us to suspect that it would be difficult to obtain satisfactory crown height measurements using callipers. Instead, all measurements were made from digital photographs taken in standard orientation. The deciduous molars were photographed in their sockets in lateral

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