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Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Difference in public oral health at the Spring/Autumn and Warring States periods between the Central Plains and the northern Great Wall region in China

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ARTICLE INFO

Article history:

Available online 1 April 2015

Keywords:

Paleopathology
Oral disease
Ancient China
Human skeletal remains
Sex difference

ABSTRACT

This paper examines differences in oral health between city dwellers from the Chinese dynasty heartland and agricultural soldiers at the frontier between the dynasty and northern nomads during the Spring/Autumn and Warring States periods. The two skeletal samples used in this study were excavated from the contemporary mortuary sites of Xinghong in the middle of the Henan province and Tuchengzi in the southeastern Inner Mongolia Autonomous Region. The presence/absence, type, and degree of six dental health conditions—caries, antemortem tooth loss, periapical abscess, alveolar resorption, calculus, and dental attrition—were investigated. The results of this study show that individuals from the Xinghong assemblage suffered from these oral diseases with much greater frequency than did those from the Tuchengzi assemblage, and with much greater frequency than earlier Neolithic and early dynastic groups from the same region (Henan province). Our results are consistent with two explanations based on previous archaeological and historical studies. Firstly, a dramatic decline in oral health conditions during the transition from the Neolithic Age to the Spring/Autumn and Warring States periods at the Chinese dynasty heartland coincides with the elevated productivity of millet and wheat agriculture promoted by technological innovation. Secondary, a difference in oral health conditions during the Spring/Autumn and Warring States periods between the two contemporaneous sites supports previous archaeological and historical studies indicating that agriculture was more intensive during this time in Henan province compared to southeastern Inner Mongolia. In addition to the group differences, the pattern of the sex differences of dental caries prevalence differed between the two sites. For Tuchengzi, there were much higher frequencies of dental caries for females than males. The degrees of these sex differences seem to be beyond the range of which only biological factors (e.g., those related to female reproductive function) could contribute, so cultural factors derived from the sexual division of labor or differential access to foods likely played a role. Stable isotope analysis using the corresponding human skeletal samples suggests one cultural factor, that of males preferring, or having greater access to, meat products over cereals. For the Xinghong site, unexpectedly, the frequency of dental caries is higher in males than females. Thus, the form of the sexual division of labor or differential access to food items could have differed between the city dwellers of the Xinghong site and the pioneers of the Tuchengzi site because of the urbanization of the former area.

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1. Introduction

The purpose of this study is to document differences in oral health between the Chinese dynasty heartland and the contact zone between the Chinese dynasty and nomadic tribes during a period of bureaucracy and centralization based on millet agriculture, following wheat agriculture. This study aims to examine the

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factors contributing to group and sex differences in oral disease using human skeletal remains derived from two archaeological sites dated to the Spring/Autumn (770–403 BC) and Warring States periods (403–221 BC). In this study, the heartland (the middle and lower reaches of the Yellow River) is referred to as the “Central Plains,” while the contact zone is referred to as the “Great Wall region.”

The pathological approach to teeth and alveolar bone from human skeletal remains has been regarded as an effective method to assess diet and food-preparation techniques in past societies because these are strongly related to oral health (Turner, 1979; Powell, 1985; Walker and Erlandson, 1986; Lukacs, 1989; Walker and Hewlett, 1990; Larsen, 1997; Temple and Larsen, 2007). Lukacs (1989) proposed the dental pathology profile (DPP) as a standardization of recording and reporting dental pathological conditions for comparative research. The variables in DPP are caries, antemortem tooth loss (AMTL), periapical abscess, alveolar resorption, calculus, severe attrition, and enamel hypoplasia. The components of DPP generally shift from hunter-gatherer to agricultural societies: intensive agriculturalists typically have higher frequencies of caries, calculus, alveolar resorption, and enamel hypoplasia, and lower frequencies of severe attrition (unless abrasive materials were mixed with foods during preparation), compared to hunter-gatherers. Hunter-gatherers do not necessarily have lower frequencies of AMTL and periapical abscess because not only caries but also severe attrition can cause both pathological conditions. In recent years, there has been an increase in the number of studies examining the prevalence of oral disease in China from the Neolithic through Early Dynasties (Mao and Yan, 1959; Turner, 1979; Li and Huang, 1991; Inoue et al., 1997; Sakashita et al., 1997; Pechenkina et al., 2002, 2007, 2013ab; Todaka et al., 2003; Zhang, 2003; Gao et al., 2006; Eng, 2007; Zhang et al., 2009; Liu et al., 2010; Wei et al., 2013; Okazaki et al., 2013b). In particular, several paleopathological studies have focused on human skeletal remains from the Central Plains (Pechenkina et al., 2002, 2007, 2013ab) and the Great Wall region (Okazaki et al., 2013b), and they suggest a decrease in oral health and the degree of dental attrition over time. However, the difference in oral health between the two regions is not yet known. Historical and archaeological studies show that the pattern of subsistence change varied significantly between the two regions as described in detail below. Therefore, the correlation between oral health and subsistence patterns in both regions needs to be clarified in order to understand the variation of human adaptation to millet agriculture in China. This is the first comparative study of oral disease between the Central Plains and the Great Wall region during the Spring/Autumn and Warring States periods.

2. Historical/archaeological backgrounds and setting hypotheses

At the transition from the middle Spring/Autumn to the Warring States periods, the emphasis on chariots during warfare gradually decreased. Troops comprised more equitably of infantry, chariots and cavalry became more valued as the scale of interstate warfare gradually expanded and battlefields shifted from flatlands to mountainous regions (Liu and He, 2007). Until the middle Spring/Autumn period, troop membership was generally limited to noblemen, who could afford to equip themselves as charioteers or cavalrymen. Thereafter, the common people were also demanded to participate in warfare as infantrymen due to the expansion of interstate war. Accordingly, the social prestige of commoners was improved in exchange for their participation in wars, so that some of the educated commoners had an opportunity to serve as government officers (Liu and He, 2007). The feudal system inherited

from the western Zhou dynasty, which was ruled by *Zhou* (lords), *Qing* (upper noblemen), and *Dafu* (middle noblemen), gradually collapsed, while the centralization and bureaucracy supported by *Shi* (lower noblemen and educated commoners) were promoted in each state (Liu and He, 2007).

With the transition from feudalism to bureaucracy, urbanization accelerated, so that over 78 cities were recognized in the Central Plains (Chang, 1977). Archaeological evidence shows that these cities were generally rectangular or square and enclosed within walls constructed by the rammed earth technique. The cities of the Spring/Autumn period are mainly composed of a palace, residences for nobles, and religious ceremonial sites, while manufacturing and mercantile sections were located outside of the walls. In contrast, the cities of the Warring States period contain manufacturing and mercantile compartments inside city walls (Chang, 1977). Trade specialization and division of labor were further developed, as manufacturing and mercantile compartments were integrated under the guardianship of city. Farming instruments made of stone or wood had been commonly used until the Spring/Autumn period, although bronze was already utilized in ritual utensils and weapons (Chang, 1977). After the Warring States period, iron was utilized not only in weapons, but also in agricultural instruments, due to its mass production supported by the development of iron manufacturing technology. For instance, *lei* (a sort of spade), *si* (another sort of spade), *chu* (hoe for mowing), *lian* (sickle), *jue* (large-sized hoe), *cha* (shovel), *lihua* (plow), and several other iron farming instruments of varying shape and usage were invented. In particular, *cha* was useful in irrigation works, and *lihua* in ox plow tillage (Liu and He, 2007). The emergence of large-scale irrigation works and ox plow methods, which iron farming instruments made possible, increased the productivity of millet agriculture during the Warring States period in the Central Plains (Chang, 1977; Liu and He, 2007).

Some of the earliest evidence of millet agriculture is found at the Early Neolithic sites of the Great Wall region (e.g., Xinglongwa and Xinglonggou sites, Crawford, 2006). During the Spring/Autumn and Warring States periods, however, the ratio of agricultural foods to total diet consumed by the agriculturalists of the Great Wall region is thought to be a little lower than the case in the Central Plains. Historical documents (*Qimingyaoshu*) suggest that irrigation farming (*Daitianfa*) was not developed until the later Han dynasty period (206 BC–220 AD), which then enabled the local people to perform intensive millet agriculture (Liu, 2001; Luo, 2001). During the Spring/Autumn and Warring States periods, the pastoral economy was likely more suitable for colder and drier climate of the Great Wall region compared to millet agriculture. On the basis of previous research explained above, the following hypotheses were developed for the present study: 1) oral disease prevalence during the Spring/Autumn and Warring States periods should be relatively high compared to that of the former period (e.g., Yin dynasty) in the Central Plains due to the increase of agricultural yield, 2) the city dwellers of the Central Plains should show higher oral disease prevalence, compared to the soldiers and/or agriculturalists of the Great Wall region during the Spring/Autumn and Warring States periods, because of the difference of the degree of reliance on agricultural foods between the both regions.

3. Materials

3.1. Human bones and teeth

A total of 3844 teeth from 203 individuals from two sites dated the Spring/Autumn and Warring States periods were included in the study: Xinghong (Xinzheng, Henan Province) and Tuchengzi (Helingeer, Inner Mongolian Autonomous Region) (Table 1, Fig. 1).

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