THE EFFECTS OF THE LITTLE ICE AGE ON ORAL HEALTH AND DIET IN POPULATIONS FROM CONTINENTAL CROATIA

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Introduction

Little Ice Age (LIA) is a global climatic phenomenon characterized by the cooling of the Earth after the Medieval Warm Period (Ladurie 1971) that was especially pronounced between the 16th and the 19th century CE (Mann 2002). In Europe this period was characterized by the average temperature drop of about 0.6 °C resulting in extensive period of mountain glacier expansion (see references in Mann 2002). The global temperature decrease probably affected animal and plant life which had a significant impact on general health and diet. Therefore, the aim of this study is to investigate possible differences in oral health and dietary habits caused by climatic changes brought by the LIA in late medieval and early modern inhabitants of continental Croatia.

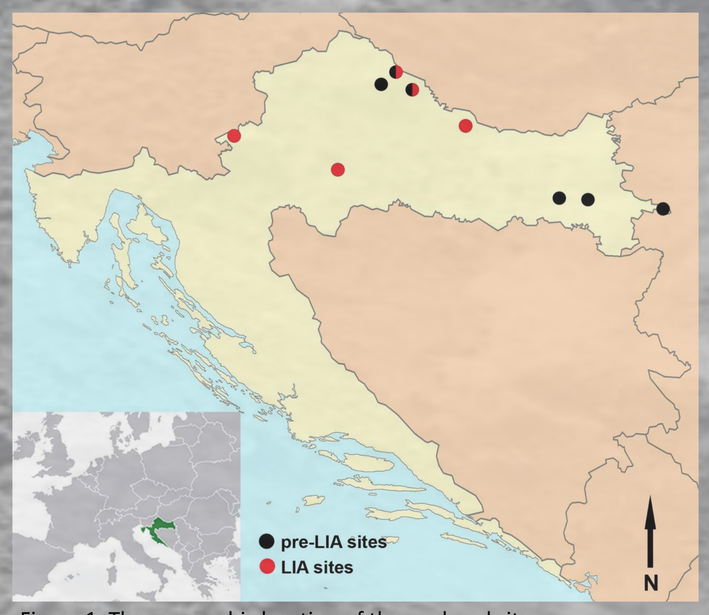

Figure 1. The geographic location of the analysed sites.

Figure 4. Caries and alveolar abscess on the left mandibular PM2, M1 and M2. Ilok-Krstbajer, burial 2.

Figure 5. Edentulous maxilla and mandible. Žumberak, burial 193.

Material and methods

The analysed skeletal/dental material consists of two composite samples: the pre-LIA series (end 13th – beginning 16th century CE) is comprised of six sites (Đakovo, Ilok, Ivankovo, Kamengrad, Torčec, and Virje), while the LIA sample (beginning 16th – beginning 19th century CE) is comprised of five sites (Sisak, Torčec, Virje, Zvonimirovo, and Žumberak; Fig. 1). In order to assess possible differences in oral health and dietary habits between these two temporally distinct series three dento-alveolar pathologies were analysed: caries, ante-mortem tooth loss (AMTL), and alveolar abscesses. The dietary profile was additionally assessed by analysing carbon and nitrogen stable isotope analysis from bulk collagen.

All conventional bioarchaeological analyses were carried out at the Institute for Anthropological Research in Zagreb and the Anthropological Centre of the Croatian Academy of Sciences and Arts in Zagreb. Carbon and nitrogen stable isotopes analyses were conducted at the Dorothy Garrod Laboratory for Isotopic Analysis, Cambridge University, and ^{14}Chrono Centre, Queen's University Belfast, UK. The samples from Sisak (24) and Žumberak (15) (LIA period burials) were processed in Cambridge, while the samples from Torčec (8) (pre-LIA burials) were processed in Belfast.

The frequencies (%) of the studied attributes were calculated by using the formula: [total number of teeth (or alveoli) affected by studied changes/total number of analysed teeth (or alveoli)] × 100. The observed differences between the sexes and the samples were evaluated with the chi-square test, and statistical significance was defined by probability levels of $P \leq 0.05$.

Results

The pre-LIA series consists of 170 adult individuals (76 females and 94 males), and the LIA series consists of 208 adults (84 females and 124 males) (Fig. 2). The age distributions between two composite series do not show any statistical differences. The first sample numbers a total of 2680 teeth and 3649 tooth sockets, and the second one consists of a total of 3322 teeth and 4696 alveoli.

The total frequency of caries in the pre-LIA sample is 11.4% (305/2680), while in the LIA series this prevalence is 13.8% (460/3322), and the difference is statistically significant (χ^2=8.114, df=1, P=0.004) (Figs. 3, 4). In the pre-LIA sample males exhibit significantly higher caries frequency in comparison to females (12.9% or 191/1480 vs. 9.5% or 114/1200; χ^2=7.62, df=1, P=0.006).

When AMTL frequencies between the two series are compared it is obvious that the LIA sample exhibits higher values when compared to the pre-LIA sample (21.3% or 996/4696 vs. 15.3% or 559/3649), and this difference is statistically significant (χ^2=46.989, df=1, P<0.001) (Fig. 5). In the LIA series females show significantly higher AMTL prevalence in comparison to males (23.5% or 432/1840 vs. 19.7% or 564/2856; χ^2=9.318, df=1, P=0.002).

The total frequency of alveolar abscesses is slightly higher in the LIA sample (4.7% or 222/4696 vs. 4.4% or 161/3649), but this difference is not significant. In the pre-LIA series males exhibit significantly higher frequency of this pathology when compared to females (5.1% or 108/2113 vs. 3.4% or 53/1536; χ^2=5.816, df=1, P=0.016).

The bulk collagen stable isotope data clearly shows that diets at two contemporaneous LIA sites (Žumberak and Sisak) were different, with individuals in Žumberak consuming less animal protein and less C4 plants (likely millet, possibly maize) than those in Sisak (Fig. 6). On the other hand, the pre-LIA samples from Torčec show almost identical values to those from the later Žumberak series suggesting a similar terrestrial diet for both sites that was mostly based on C3 plants with a relatively low intake of animal protein.

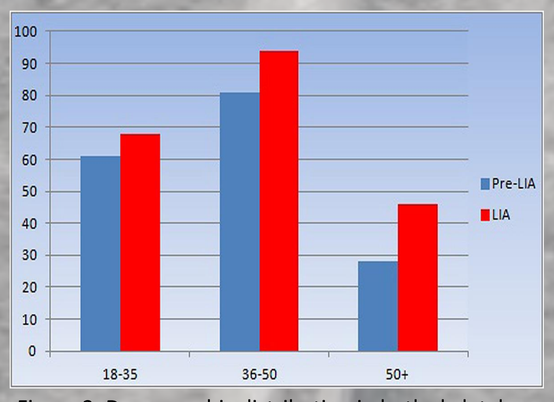

Figure 2. Demographic distribution in both skeletal samples.

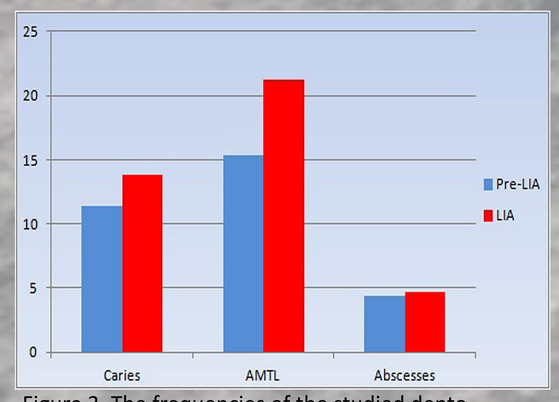

Figure 3. The frequencies of the studied dento-alveolar lesions in both skeletal samples.

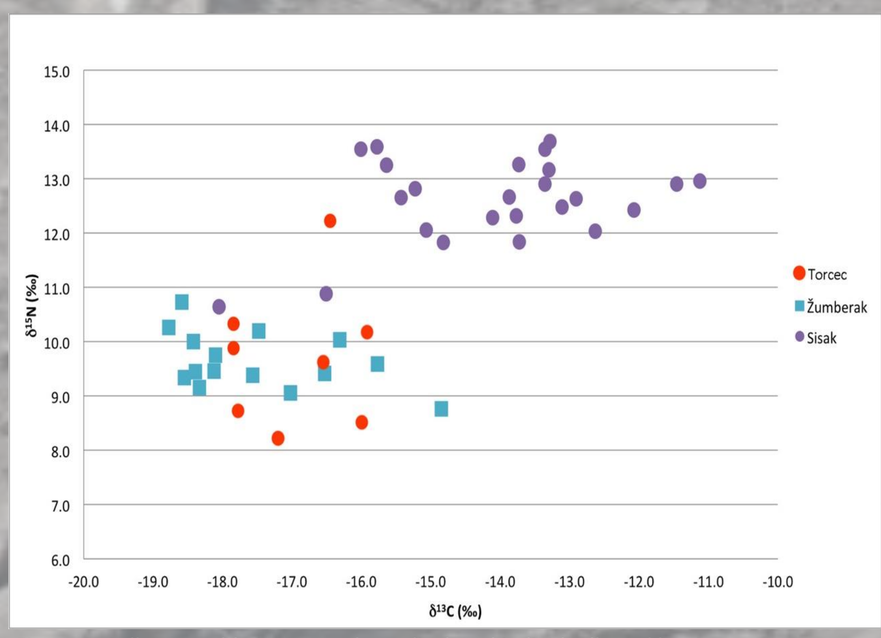

Figure 6. Collagen stable isotope values, displayed individually and by site.

Discussion and conclusion

The occurrence of the Little Ice Age had a dramatic impact on everyday life in Europe, and consequently on the territory of the present-day Croatia. There are numerous historic sources testifying about harsh and long winters during this period in this region. For example, written sources mention that in 1517 numerous serfs from the estates around Samobor (NW Croatia) were exempt from paying taxes due to famine caused by a long winter (Adamček & Kampuš 1976). Furthermore, Evliya Çelebi, Ottoman explorer, during his visit to Croatia in 1660 wrote that Međimurje (N Croatia) became a 'frozen wasteland' (Çelebi 1973). There are numerous other sources which give evidence of the effects that the LIA had on everyday life of the people inhabiting the region between the 16th and the 19th century CE, and all of them agree that the final result was general deterioration of living conditions caused by the lack of food and frequent outbreaks of infectious diseases. However, one has to bear in mind that this period was also a time of the Ottoman conquest of Europe and most of the military operations took place on the Croatian territory causing significant political, social and demographic changes. Some authors even suggest that the LIA helped the Ottomans as harsh winters caused frequent episodes of famine and plague (especially between 1523 and 1525) resulting in massive depopulation of the region thus allowing its easier conquest by the Ottomans (e.g. Kužić 1999, Jurković 2014).

Our study revealed a significant increase in caries and AMTL frequencies during the LIA on the territory of continental Croatia, but also a slight increase in alveolar abscesses prevalence. This might indicate a significant deterioration of oral health during this period that could be associated with changes in diet and subsistence due to the effects of the LIA, as already proposed by numerous historic sources. However, the available isotopic data do not confirm the hypothesis on dietary changes during the LIA as carbon and nitrogen values for Torčec (pre-LIA) and Žumberak (LIA) are almost identical strongly suggesting a very similar diet at these two sites. Furthermore, the isotopic data indicate significant differences in diet between two LIA sites (Žumberak and Sisak). It seems that additional isotopic research is necessary to resolve this issue.

In regard to the sex differences observed in both samples, it could be a result of different diet between the sexes but it might be also related to differential access to food resources for males and females. For example, Šlaus et al. (1997) suggested that the higher frequency of caries in younger males in the Nova Rača late medieval sample (continental Croatia) was probably caused by their importance in obtaining food through skill-intensive agricultural labour, i.e. young males were selectively buffered from the effects of malnutrition and had more access to limited food resources than young females. Of course, it is possible that some other cultural and/or biological factors contributed to the observed differences in caries, AMTL and alveolar abscesses frequencies between the sexes in the studied samples.

It has to be mentioned that the results presented in this study are preliminary as this is still an ongoing project and there are certain limitations in their interpretation. At the moment, the data on dento-alveolar pathologies strongly suggest that there are significant differences in oral health patterns in continental Croatia before and during the LIA. Nevertheless, it seems that the observed differences cannot be solely associated with the occurrence of the LIA, but were most probably caused by a combination of the negative effects of this climatic phenomenon and constant Ottoman intrusions in continental Croatia between the 16th and 18th century resulting in significant deterioration of general health.

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Acknowledgments

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