Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: http://www.elsevier.com/locate/aob

Dental caries and chemical analyses in reconstruction of diet, health and hygienic behaviour in the Middle Euphrates valley (Syria)

Jacek Tomczyk [a,*], *Krzysztof Szostek* [b], *Iulian Komarnitki* [c], *Hanna Mańkowska-Pliszka* [c], *Marta Zalewska* [d]

[a] *Department of Anthropology, Cardinal Stefan Wyszynski University, ul. Wóycickiego 1/3, 01-938 Warsaw, Poland*
[b] *Institute of Zoology, Department of Anthropology, Jagiellonian University, ul. Gronostajowa 9, 40-387 Cracow, Poland*
[c] *Department of Descriptive and Clinical Anatomy, Medical University of Warsaw, ul. Chałubińskiego 5, 02-004 Warsaw, Poland*
[d] *Department of Environmental Hazard Prevention and Allergology, Medical University of Warsaw, ul. Banacha 1a, 02-091 Warsaw, Poland*

ARTICLE INFO

Article history:
Accepted 31 December 2012

Keywords:
Caries
Chemical research
Diet
Oral hygiene
Syria

ABSTRACT

Objectives: The aim of this study was to use two methods, biological and chemical, to examine changes in diet and health in individuals from the Middle Euphrates valley (Syria). We determined the frequency distribution of dental caries. Chemical analyses were concerned with the presence of elements such as strontium, barium, calcium and stable carbon isotopes ($^{13}C/^{14}C$). We chose three consecutive periods: Late Roman (2nd–4th century AD), Islamic (600–1200 AD) and Modern Islamic (1850–1950 AD).
Materials and methods: We analysed the dental remains of 145 individuals, with a total of 2530 teeth. We used visual research (magnifying glass/sharp dental probe) and radiography. The frequencies of caries were calculated on the basis of the proportional correction factor of Erdal and Duyar. We chose 39 permanent second molars for chemical analyses.
Results: The frequency of carious lesions was similar in all three periods (6–8%). In the Modern Islamic and Islamic periods, occlusal surfaces were infected with caries most often, while the cemento–enamel junction (CEJ) and approximal surfaces were affected to a lesser degree. However, in the Late Roman period, the CEJ and approximal surfaces showed caries most frequently, in contrast to occlusal surfaces, which seldom showed signs of caries. Chemical analyses showed lower Sr/Ca ratios and Observed Ratio index values for the Modern Islamic and higher values for the Islamic and Late Roman periods. Mean stable isotope ($\delta^{13}C$) analyses demonstrated that the Modern Islamic period was strongly divergent from the other periods.
Discussion: These data suggest a similar socio-economic status during the Late Roman and Islamic periods. The diet of the population living in the Late Roman and Islamic periods contained a larger number of products containing strontium than calcium. In the modern population these proportions have been reversed.

1. Introduction

Dental caries, being a progressive process that causes demineralisation and, consequently, proteolytic decay of the hard tissues of a tooth, resulting in the formation of carious lesions, is one of the diseases of the masticatory organ most frequently observed in the historical material. Dental caries has a multifactorial aetiology. At least four factors are required to cause dental caries (dental plaque resulting from

* *Corresponding author*. Tel.: +48 22 5696801; fax: +48 22 5696814.
E-mail address: jaktom@post.pl (J. Tomczyk).
0003–9969/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.archoralbio.2012.12.014

the accumulation of bacterial deposits, a cariogenic diet which forms the basis for bacterial changes, the susceptibility of the dental tissues to decalcification, and the length of time that the pathogenic factor had an influence on the teeth), which reflect the person's state of health, hygiene and eating habits. Thus, a study of carious infection gives rise to the possibility of understanding the adaptations and health conditions of a population throughout time.[1,2]

In the last two decades, research aimed at studying the broadly defined biological state of our ancestors and their food preferences as determined by environmental and cultural factors has identified additional tools, such as chemical analyses of odontological material.[3–6] Theoretical models and experimental study results have shown that the most useful elements enabling a reconstruction of the diets of historic and prehistoric human populations are alkaline earth elements such as strontium, barium and calcium.[7–9] Also, many contemporary studies use stable carbon isotopes ($^{13}C/^{14}C$) in the wider contexts of diet reconstruction,[5,10,11] the weaning process ('weaning stress')[12,13] or environmental changes.[14]

Plants absorb strontium in large quantities directly from the environment, whilst mammals accumulate this element secondarily through plants and other animals.[8,15,16] Strontium substitutes for calcium, which is more easily assimilated in bones.[17] As the level of strontium accumulated in the mineral phase of a bone depends on the quantity of calcium contained in the food (high calcium products), it is not an unequivocal indicator of the relative proportion of consumed meat (a low calcium product) in comparison with plants.[8,16,18,19] Additionally, milk and dairy products contain low concentrations of strontium compared to calcium (high calcium products) and their consumption in large amounts manifests itself in low bone values of the Sr/Ca ratio.[9,20–22] Furthermore, low levels of the Sr/Ca ratio do not necessarily imply that the diet is enriched with animal protein, as they can be masked by complementation of the diet with components of high mineral content.[22,23] In summary, the analysis of bone/teeth levels of strontium and the Sr/Ca ratio allows determination of the proportions of plants and vegetable products, sea and freshwater organisms, and milk and dairy products in the human diet.

Barium and strontium do not participate in any well-known metabolic processes and are not subject to homeostatic control by the organism. The key difference between these elements lies in the fact that barium appears in the form of barite ($BaSO_4$) and, from the point of view of chemical analysis, is more stable and less at risk of dissolution than strontium.[24] Barium and strontium are synergistic elements that indicate an input of seafood.[23,25,26] In the diets of coastal human populations, the Ba/Sr ratio is close to zero, whilst a higher ratio is common among inland populations. Experimental research has shown that the coefficient of intestinal absorption for Ca, Sr and Ba is about 10:5:1, respectively.[7,27] The greater discrimination against barium in favour of calcium compared to strontium is consequently manifested by the fact that an analysis of the final concentration of barium allows for a more distinct division of groups of animal organisms, depending on their trophic position. In other words, high calcium products (milk, dairy products, vegetables) contribute to a decrease in the Sr/Ca ratio, whereas products rich in seafood cause a considerable decrease in the Ba/Sr ratio.Isotopic analyses are based on the observation that different environments are characterised by different isotopic compositions and that isotopic ratios in the tissues of living organisms inhabiting a given area reflect the isotopic composition of the shared environment. Stable carbon isotopes ($^{13}C/^{14}C$) contained in enamel bioapatite are the most useful tissues for isotopic analysis, since enamel bioapatite has been shown to be less susceptible to diagenetic alteration than bone or dentine.[6,28–30] Moreover, tooth enamel is not rebuilt once formed and its isotopic composition thus reflects dietary conditions at the time of its formation.[5,31,32]

Since dental caries and chemical analyses are considered as a source of information on health and diet, they are a variable worth analysing in the populations inhabiting the lower Middle Euphrates valley (Syria). The following three periods are of special interest: Modern Islamic which dates back to 1850–1950 AD, Islamic which is identified with the Early Middle Ages (600–1200 AD) (both periods are identified with Muslim culture), and Late Roman which is from the 2nd to the 4th century AD.

The aim of this study was to use two methods, biological (carious lesions) and chemical (elements and stable carbon isotopes), to examine changes in diet and health between individuals from the Late Roman to Modern Islamic periods in the Middle Euphrates valley. The study concerns two issues:

(i.) Archaeological data show that the Late Roman period was a time of political and economic instability.[38–41] Can this assumption be corroborated by odontological and chemical records? If so, then a completely different pattern of frequencies of caries and levels of elements and stable carbon isotopes should be expected from those originating in the Modern Islamic and Islamic periods, which are identified with better health in the local populations;
(ii.) Does the period when Islam first appeared and developed differ, in terms of dental caries and chemical analyses, from the Modern Islamic period?

2. Archaeological context

The dentition of the archaeological samples studied here was sourced from the lower Middle Euphrates valley, situated in the administrative areas of the province of Deir ez Zor (Syria). At present, excavations are being carried out in the area of the Middle Euphrates valley on the site of Tell Hariri (ancient Mari) and on several sites near the town of Tell Ashara, namely, in Terqa and Tell Masaikh. Terqa is situated on the right bank of the Euphrates, about 60 km north-west of Mari. Although the first mention of Terqa dates back to the end of the 19th century, when cuneiform plates with texts about Dagan's temple were found, it was not until 1974 that systematic research and works were undertaken by an American expedition. In 1996, works were extended outside the area of ancient Terqa 6 km north, in the direction of Tell Masaikh. Although these excavations were at first designed as a rescue operation, over time they were transformed into regular research works (Fig. 1).