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Periodontitis in 14th–17th century inhabitants of Brześć Kujawski in north-central Poland

Justyna Karkus

Department of Anthropology, Faculty of Biology and Environmental Protection,
University of Lodz, Poland

Abstract: Manifestations of periodontitis, the destructive form of periodontal disease affecting the alveolar bone, are often clearly recognizable in archaeological human remains. Analysis of this disease allows to obtain data not only about biological condition but also diet and nutrition of past populations. The objective of this paper was to asses periodontitis in the Polish urban population of Brześć Kujawski during Medieval – Modern transition (14th–17th centuries AD). An attempt was also made to explain the relationship between atrophy of alveolar bones and the type of diet. Lowering of alveolar crests was diagnosed based on measurements of the cementoenamel junction and the alveolar crest edge (CEJ–AC) distance and morphology of the alveolar edge. In studied population periodontitis affected 77.1% of individuals and 41.4% of all alveoli. Frequency, intensity and severity of the disease was higher in males and increased with the individual's age. Severity of alveolar destruction was associated with dental calculus accumulation. It seems that a high prevalence of the disease may be, among others, result of carbohydrate-rich diet and fragmented food. Sex differences could be related to differences in diet (especially in protein intake) and hormone levels or lack of oral hygiene in part of the population.

Key words: periodontal disease, oral health, teeth, diet

Introduction

Periodontitis is one of the most common disease and has accompanied humans at various stages of their development (Ripamonti 1988, Mitsis and Taramidis 1995, Petersen et al. 2005, Konig et al. 2010). It may therefore be observed not only in living patients, but also on archaeological human remains.

Clinical research have enabled the identification of many risk factors for bone loss associated with this disease, such as specific bacteria, advanced age, white race, sex, hormones, metabolism disorders, unhealthy habits (e.g. smoking), psychological stress (Kaczmarek et al. 1995, Genco et al. 1999, Aleksejūnienė et al. 2002, Adler et al. 2008, Rudziński 2010, Nociti et al. 2015). Its direct causes should be sought among genetic and environmental factors. In archaeological populations, the most important environmental factor was severe dental attrition. Dental wear beyond the contact points of neighboring crowns contributed to the formation of inter-

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dental sulcus. Fragmented food could then be easily retained and not only cause recession of gingival tissue between the teeth due to the pressure exerted by food during mastication but also promote the development of inflammation (Aufderheide and Rodríguez-Martín 1998). Other environmental factors include malnutrition or poor oral hygiene resulting in bacterial plaque and dental calculus (Anerud et al. 1991, Hillson 1996).

Compared with clinical ones, the research of archaeological samples poses some difficulties. The disease must be sufficiently advanced to be visible on the bone of alveolar processes. Due to the lack of unambiguous criteria, different authors accept various criteria to determine the occurrence of periodontitis symptoms. In some cases, the changes are qualified only as presence or absence of the disease (Pētersone-Gordina and Gerhards 2011). For this reason, methods based on measurement of distance between the cementoenamel junction and the alveolar crest edge (CEJ–AC) (e.g. Hamasaki and Takehara 2012) seem to be the most objective and comparable. However, there still exist discrepancies in the minimum magnitude of bone lowering regarded as a manifestation of the disease. The threshold value is accepted either at 2 mm (Clarke et al. 1986, DeWitte and Bekvalac 2010) or 3 mm (Delgado-Darias et al. 2006). Moreover, CEJ–AC measurement as the only survey could lead to misinterpretation as root exposure with advancing age is a natural phenomenon compensating for crown abrasion (Whittaker et al. 1990, Tomczyk et al. 2017). Therefore, in addition to metric analysis, some authors examine morphological changes, such as alveolar bone fenestration and dehiscence and root furcation (e.g. Vodanović et al. 2012, Tomczyk et al. 2018). In general, the absence of uniform methods hinders the comparison of data reported by different authors. Therefore, analysis of the frequency and severity of periodontitis allows to obtain indirect data on general health, living conditions, diet and nutrition or socio-economic status of past populations.

In contrast to another well-studied disease of the masticatory apparatus, dental caries, the documentation of periodontal lesions in past populations is much poorer. What is more, the published data on dental diseases in skeletal populations mainly concern prehistoric and early historic times, and in particular focus on the problem of the transition from the hunter-gatherer economy to agriculture, known as the Neolithic revolution (Mitsis and Taramidis 1995, Kerr 1998, Gómez Otero and Novellino 2011, Lorkiewicz 2012). Subsequent developments, e.g. the ones preceding the second epidemiological transition, are not documented so well.

One should note the importance of diet modifications, which began in 16th century Europe and affected large population groups as a result of an increased use of flour for bread production, the consumption of sugar, as well as the spread of numerous cariogenic foodstuffs from the New World. This is reflected in a marked rise in the prevalence of caries following a period of relative stability in the Middle Ages (Caselitz 1998, Lanfranco and Eggers 2012). Dietary changes of the type described above may have appeared earlier in urban environments. Considering the complex interactions between oral diseases and their causes (e.g. Lukacs 1989), they probably also affected the intensity and pattern of periodontal disease.

The objective of this paper was to give an analysis of periodontitis in the urban population of Brześć Kujawski dated to the final phase of the late Middle Ages and the beginning of the early modern period (14th–17th centuries AD). An attempt was also made to explain the relationship between atrophy of alveolar bones and the type of diet, which is manifested among others by the deposits of dental calculus.

Material and methods

The study material consists of a series of 48 skulls from an archaeological site Fara in Brześć Kujawski (Table 1). Brześć Kujawski is a historical town in north-central Poland (Figure 1). First settlement appeared in this area in the beginning of the Neolithic (4600-4000 BC). Late medieval/early modern population from Fara includes skeletons dated to 14th-17th century AD, which were excavated in 1970 and 1971. The cemetery was located around the parish church in Brześć Kujawski and probably was used by higher social class of the community. Therefore, it can be expected that skeletons from this site belonged to people in better biological condition than other members of the society. At the same time, compared with the earlier and later chronological periods, the biological status (indicated by higher prevalence of enamel hypoplasia and *cribra orbitalia*) of people from Fara was not better (own data). Significant deterioration of living conditions during war with Sweden, burning the town and epidemics of cholera had a negative impact on the health of all inhabitants of Brześć Kujawski (Głębowicz 1970).

Age at death was estimated by dental wear, ectocranial suture obliteration, changes in the symphyseal face of the pubis and the auricular surface of the ilium (Lovejoy et al. 1985, Szilvássy 1988, İşcan 1989, Brooks and Suchey 1990, Buckberry and Chamberlain 2002). Individuals were classified into four age groups: juveniles (14–20 years), young adults (20–35 years), middle adults (35–50 years), and older adults (50+ years). Sex was estimated using standard methods based on morphology of the skull and the pelvis (Workshop of European Anthropologists 1980).

Only fully erupted teeth with antagonists in opposite dental arch were included to analysis. Empty alveoli, teeth excessively worn or damaged were omitted. Occurrence of periodontitis manifestations was macroscopically assessed basing on changes in alveolar bone morphology: porous bone structure or a "shelf" form of the crest edge characteristic of horizontal bone loss (Clarke and Hirsch 1991) (Figure 2). The severity of alveolar bone loss was evaluated by measuring the CEJ–AC distance. The measurements

Table 1 Age and sex of the studied individuals

Age (years)	Male		Female		All	
	n	%	n	%	n	%
14–20	0	0.0	0	0.0	3	6.3
20–35	6	12.5	6	12.5	12	25.0
35–50	7	14.6	5	10.4	13	27.1
50+	14	29.2	6	12.5	20	41.7
Total	27	56.3	17	35.4	48	100.0

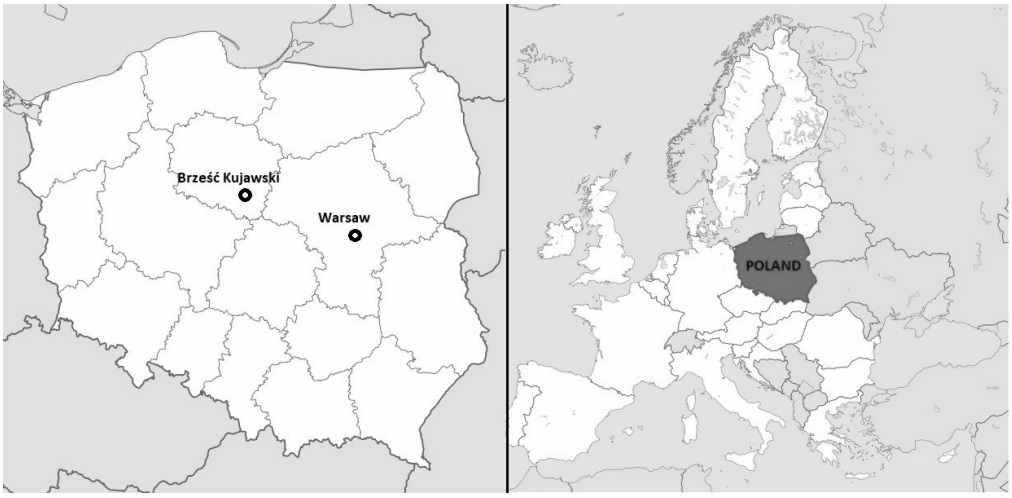

Figure 1. Map of the study area

Figure 2. Severe recession of the alveolar crest edge

were performed with an electronic caliper to the nearest 0.1 mm. Recession was measured on each tooth surface (labial/buccal, lingual, mesial, distal). Measurements of multi-rooted teeth were performed on the buccal and lingual surfaces of each root. A four-grade scale was adopted for classification of the observed lesions (Strohm and Alt 1998, modified): 1) no symptoms of crest atrophy; 2) initial stages of recession – the CEJ–AC distance not exceeding 2 mm; 3) moderate recession – the CEJ–AC distance ranging from 2 to 4 mm; 4) severe recession – the CEJ–AC distance exceeding 4 mm. Only cases with at least moderate bone atrophy and the presence of the morphological lesions described above were diagnosed as periodontal disease. The degree of dental calculus accumulation was evaluated macroscopically on all tooth surfaces using the scale proposed by Brothwell (1981): 0) no calculus, 1) poor accumulation, 2) moderate accumulation, 3) strong accumulation.

The alveolar crest edge dystrophy index and average degree of dental calculus accumulation were calculated for each tooth type as the sum of grades divided by the number of positions analyzed. The periodontitis intensity index (number of affected alveoli divided by the total number of alveoli analyzed) and the frequency index (number of individuals with the

disease divided by the total number of individuals analyzed) were also computed. All the indices were calculated for the four age groups, separately for males and females.

The results were tested for statistical significance using χ^2 or χ^2 with Yates's correction (for sex differences in the prevalence of the disease) and correlation coefficient (for correlation between the dental calculus accumulation and the degree of alveolar atrophy).

Results

The analyzed skulls revealed 77.1% frequency of periodontitis. Males were more often affected than females, although differences were not statistically significant (χ^2=0.018; p=0.893). The disease was found in 41.4% of the alveoli. Intensity in males was significantly higher than in females (χ^2=18.284; p<0.001) (Table 2).

Lesions qualified as initial stages were observed very rarely, which further confirms the usefulness of the performed measurements in diagnosing periodontitis in skeletal populations: at such slight alveolar bone dystrophy (grade 0 on the original Strohm and Alt scale (1988)), there were usually no bone lesions indicating the occurrence of this disease. The most common was second stage of destruction (2-4 mm). The presence of periodontitis as diagnosed by CEJ-AC measurement in the analyzed population also showed significant differences between the sexes (Figure 3). More than 60% of females alveoli (as compared to only 49% of males) did not reveal manifestations of destruction. At the same time, all grades indicating some degree of alveolar crest atrophy were found more often in males. These sex differences were statistically significant (χ^2=18.284, p<0.001 for alveoli without atrophy; χ^2=5.824, p<0.02 for 0–2 mm atrophy; χ^2=4.910, p<0.03 for 2–4 mm atrophy; and χ^2=5.774, p<0.02 for atrophy >4 mm).

The number of alveoli with horizontal loss increased with age (Table 3) and this tendency was observed at each stage of the disease (Figure 4). In both, males and females, differences between age classes were statistically significant (χ^2=78.739, p<0.001 in males and χ^2=29.234, p<0.001 in females). The most pronounced deterioration of the alveolar bone took place between 35-50 and above 50 years of age (27.9% for both sexes). In females also in this period progress of the disease was the biggest (by 25.8%), while in males this process had happened earlier – between 20-35 and 35-50 years of age (increase by 26.1%). In most age groups intensity of alveolar bone loss was higher in males than in females (Table 3).

Analyses of alveolar crest dystrophy and the degree of dental calculus accumulation were performed (Table 4). The

Table 2 Periodontitis frequency and intensity stratified by sex

Sex	Individuals			Alveoli		
	N	n	%	N	n	%
Male	27	24	88.9	511	260	50.9
Female	17	14	82.4	297	105	35.4
All	48	37	77.1	889	368	41.4

N – number of cases analyzed, n – number of cases with periodontitis

amount of dental calculus deposits varied depending on the type of tooth and was positively correlated with increasing destruction of the alveolar crest edge. In males the result was statistically significant ($r=0.936$ $\alpha=0.01$).

Discussion

The use of CEJ-AC distance as a proper periodontitis indicator is widely discussed by many authors. Non-pathological changes like compensation for tooth wear or continuing eruption can be potentially counted as cases of the disease (e.g. Costa 1982, Clarke et al. 1986, Whittaker et al. 1990, Clarke and Hirsch 1991, Hillson 1996). On the other hand some researches show that the tooth wear does not change CEJ-AC distance (e.g. Gonçalves et al. 2015) and mentioned processes do not change morphology of alveolar crests (e.g. DeWitte and Bekvalac 2010). The use of both, like

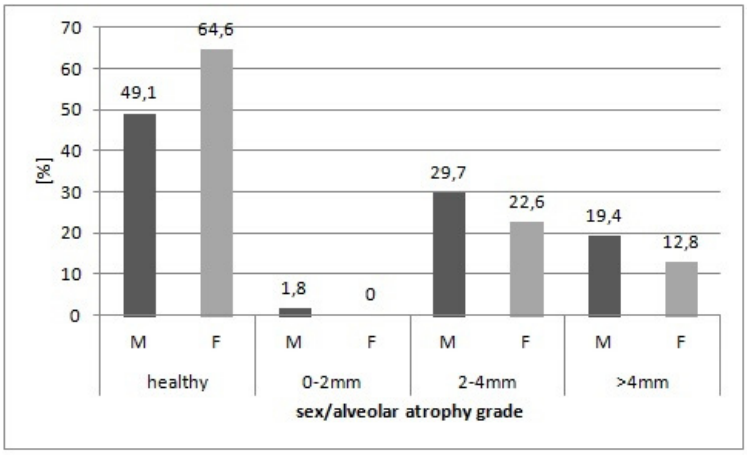

Figure 3. Sex differences in horizontal alveolar bone loss

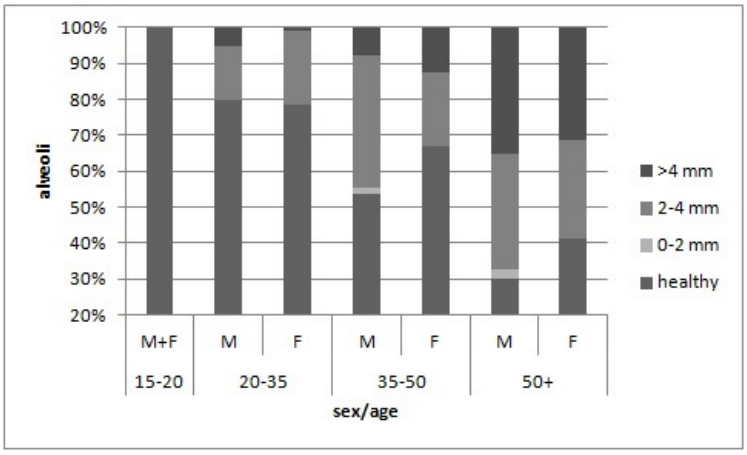

Figure 4. Sex and age differences in severity of periodontitis in alveoli

in this study, the metric method and the diagnosis of morphology, prevents incorrect classification of changes and overestimation of periodontitis prevalence.

Some researchers associate the occurrence of oral diseases with the type of food consumed (e.g. Lieverse 1999, Novak 2015). It is probable that diet could have been one of the factors influencing the wide spread of periodontitis among the inhabitants of Brześć Kujawski. According to Dembińska (1999) during the 15th to the 18th century the quality of food in Poland has radically improved. Food was well prepared and shredded with high carbohydrate content. People mainly consumed grains (millet, wheat and rye) and vegetables (onion, pease, cabbage). What is more, some new highly cariogenic foreign vegetables (e.g. potatoes) appeared in Polish cuisine at the turn of the 16th and the 17th centuries. Fruits were dessert foods of the rich but meat was consumed not only by members of the social elite. The main source of protein were pork, beef and poultry (especially guinea fowls and chickens). On fasting days meat was replaced by fish. The diet was supplemented with milk and dairy. Such high carbohydrate and crumbled food easily deposited on the teeth. This probably favored the development of bacterial plaque causing inflammation and destructive changes in the periodontium.

Historical data indicate that the end of the Middle Ages was a time of the socio-economic and demographic decline of Brześć Kujawski (Głębowicz 1970). The war with Sweden, epidemics and deteriorating living conditions contributed to the impoverishment of the diet and deterioration of the general health inhabitants of Brześć and consequently was manifested in poor oral health. What is more, analysis of environmental stress determinants showed that the population of Fara site had worse biological condition in com-

Table 3 Horizontal bone loss intensity depending on age and sex

Age (years)	Male			Female			All		
	N	n	%	N	n	%	N	n	%
14-20	-	-	-	-	-	-	58	0	0.0
20-35	118	24	20.3	120	26	21.7	238	50	21.0
35-50	166	77	46.4	97	32	33.0	286	112	39.2
50+	227	159	70.0	80	47	58.8	307	206	67.1
Total	511	260	50.9	297	105	35.4	889	368	41.4

Table 4 Alveolar bone loss (in mm) and the degree of dental calculus accumulation

Sex	Index	I1	I2	C	P1	P2	M1	M2	M3
M	average bone loss	2.8	3.0	2.8	2.5	2.5	3.5	3.3	2.6
	average dental calculus	0.7	0.6	0.6	0.6	0.6	0.7	0.7	0.5
F	average bone loss	2.6	2.9	2.4	2.5	3.3	2.9	2.5	2.8
	average dental calculus	0.4	0.5	0.5	0.5	0.5	0.7	0.6	0.7
All	average bone loss	2.7	2.9	2.6	2.4	2.7	3.1	2.9	2.6
	average dental calculus	0.6	0.6	0.5	0.5	0.6	0.7	0.7	0.6

parison with groups inhabiting this area in the early Middle Ages (11th-13th century) and in Modern times (16th-19th century) (Table 5). Frequency of enamel hypoplasia in Fara was higher than in early Middle Ages (χ^2=7.824, p=0.005), *cribra orbitalia* frequency higher than in Modern times (χ^2=6.787, p=0.009).

Also the psychosocial stress that accompanied the political destabilization at this time in Poland could have contributed to the intensification of the disease among the inhabitants of Brześć. Some authors (e.g. Genco et al. 1999, Aleksejūnienè et al. 2002) mention this as a factor related to lifestyle and thus the periodontal health.

In comparison with other urban groups from Poland from the late Middle Ages, frequency of periodontitis in studied population is higher but not statistically different (Table 6). These data may suggest that living conditions in those times were the same throughout Poland and therefore the prevalence of the disease was similar everywhere.

Many studies conducted so far indicate a higher prevalence of periodontitis in males (Kozłowski and Florkowski 1996, Garłowska 2001, Wasterlain et al. 2011, Bonsall 2014, Novak 2015, Tomczyk et al. 2018). Also in the studied population, both frequency and intensity were higher in this group. It seems that among others, this may be a result of sex differences in diet. Isotopic studies of the medieval Polish population showed that males consumption of meat was significantly higher than females (Reitsema et al. 2010). This may also be confirmed by the higher severity of dental calculus in males. A protein-rich diet has an alkaline effect and contributes to bacterial plaque mineralization, thus leading to an increased dental calculus accumulation (Hillson 1996, Lieverse 1999). It is generally accepted that mineral deposits on the teeth have a destructive effect on the bones of alveolar processes (e.g. Sewón et al. 1998). The relatively low general level of the calculus accumulation could be caused by a high-carbohydrate diet. At

Table 5 Environmental stress determinants in populations of Brześć Kujawski from early Middle Ages to Modern times (own data)

Period	enamel hypoplasia		*cribra orbitalia*	
	n/N	%	n/N	%
11th-13th century	13/32	40,6	13/38	34,2
14th-17th century (Fara)	28/38	73,7	12/30	40,0
16th-19th century	68/121	56,2	27/147	18,4

Table 6 Frequency in periodontitis in late medieval populations from Poland

Period	Site	Individuals		Source
		n/N	%	
13th-17th	Tum	37/56	66	Kozubkiewicz and Trachtenberg 1960
14th-17th	Radom	57/80	71	Tomczyk et al. 2018
14th-17th	Brześć Kujawski	37/48	77	the present study
15th-18th	Kraków	68/108	63	Gleń 1976

the same time, sex differences in dental deposits may indicate that the protein intake differed between males and females. It is also possible that the higher dental calculus accumulation in males could be caused by the lack of oral hygiene. Higher intensity and severity of periodontitis in this group seems to confirm this hypothesis.

Lower intensity of alveolar bone loss in females in most age groups additionally indicates that the sex differences described above are not attributable merely to the fact that the age at death of males was more advanced than females what is typical for prehistorical and historical populations.

Clinical studies shows the lack of protective effects of estrogens on the body in men (Mascarenhas et al. 2003). On the other hand, female sex and hormonal disorders during pregnancy and menopause which lead to mineral deficiencies are also indicated as a factor favoring periodontitis (Kaczmarek et al. 1995). These opinions correspond to the results obtained. The highest increase in the intensity of periodontitis in females was recorded between the oldest age classes (over 35 years). Hormonal disturbances associated with menopause occur during this period and this probably contributed to the increase in alveolar atrophy. In males the number of alveoli with symptoms of dystrophy increased the most at younger age (20-35 and 35-50 years old). Such an early worsening of the disease may result from the generally greater sensitivity of people of this sex to harmful environmental factors or greater exposure to them. It seems, therefore, that hormone deficiency affects the state of the periodontium of both sexes, but it manifests itself at different age. The biggest deterioration of the alveolar bone in younger age groups in men also indicate that it is not a result of tooth eruption resulting from older age but the progress of the disease.

Other factors such as loading of the masticatory apparatus and mechanical damage to alveoli or more advanced age at death of males typical of past populations cannot be excluded either. Therefore, periodontitis seems to be a disease with a very diverse etiology. However, its study is important as it allows to conclude not only on the biological condition of the past populations, but also on their living conditions.

Conclusions

The results of these analyses suggest that periodontitis in the 14th-17th century Poland was a common disease and one of its causes could have been diet. Obviously it is not the only or main cause of the disease, but in times when there was a change to more fragmented and cariogenic food this factor should be particularly considered. Also impact of hormones, dental calculus deposits or general living conditions (e.g. psychological stress) cannot be excluded. A high social status is not always associated with good health. In times of political and socio-economic crisis, the state of health of all, even the richest social class, is deteriorating. What is more, it seems that periodontitis can be considered as an indicator of general health of past human populations.

Corresponding author

Justyna Karkus, Department of Anthropology, Faculty of Biology and Environmental Protection, University of Lodz, Banacha 12/16, 90-237 Lodz, Poland
E-mail: justyna.karkus@biol.uni.lodz.pl

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