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Caries prevalence and periodontal status in 18th century population of Požega-Croatia

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ABSTRACT

Objective: The aim was to examine dental and periodontal status of adult Croatian 18th century population and compare the results with available literature data.
Materials and methods: 104 specimens from the crypt of Požega cathedral were grouped into three female and three male groups according to age. Caries was determined by visual inspection and dental probe. Ante and post mortem teeth losses were recorded. Periodontal status was determined according to the length of exposed tooth root from alveolar crest to cemento-enamel junction. The presence of dehiscences and fenestrations was recorded on facial and oral plate of alveolar bone.
Results: The whole sample exhibited ante- and post mortem teeth loss of 19.57% and 24.91%, respectively. The teeth most frequently lost postmortem were incisors. The canines were best preserved. The frequency of caries in both jaws was the highest in molars (26.63% in maxilla and 28.10% in mandible), whilst central incisors exhibited the least carious lesions (11.59 and 1.92%). The most frequently affected surfaces were occlusal, then proximal and facio-oral. The percentage of teeth with either moderate or considerable bone loss was higher in females. The frequency of considerable bone loss increased significantly with age. The frequency of dehiscences was 3.11%. It was higher in maxilla than in the mandible. The frequency of fenestrations was 5.65% and it was significantly higher in maxilla.
Conclusions: The results demonstrate poor oral health amongst 18th century population of continental Croatia, exhibiting high antemortem teeth loss, high periodontal disease frequency and occlusal and proximal caries frequency.
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1. Introduction

Teeth are best preserved components of bioarcheological material and the examination of dental remains forms an important part of the bioarcheological assessment. It gives the opportunity to investigate the patterns of dental caries that was not intercepted by dental treatments, except the extractions of teeth grossly destructed by caries.

Previous studies of dental caries in European populations from Iron Age times to modern times have shown that caries patterns in prevalence and site predilection started to change around 17th century – the increasing frequency and increasing incidence of contact point and occlusal caries.[1,2]

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A strong correlation between diet and dental caries has been established, and the increased prevalence of caries in more recent times was assigned primarily to the increased use of refined carbohydrates.[3–5] In earlier populations the site of caries was at the cemento-enamel junction or in the cementum.[1,2,6–8] The reasons for the changed pattern in site predilection could also be related to diet, but are not completely highlighted.

Fewer number of studies have been made with more recent populations compared to the ancient ones.[2,9] According to the available literature, only several papers deal with dental status in 18th century in Croatia and surrounding countries.[10,11] The present study reports on oral health amongst a group of 18th century population based on the analysis of osseal remains recovered from the crypt of Požega cathedral. The city of Požega is situated 150 km east of Zagreb in the continental part of Croatia (45.34°N i 17.68°E). It became a part of Habsburg Empire in the 18th century in which the cathedral of St Theresis of Avile was built. Požega was in that period the centre of agricultural surroundings, and in the city dominated mercantile and handicraft population.[12] The individuals buried in the cathedral belonged to the richer mercantile population and priests.

The aim of this study was to examine the prevalence and distribution of caries and periodontal status in a Croatian adult population of the 18th century, and to compare the results with findings in other European populations of the same period, and earlier populations in the same region.

2. Materials and methods

The osseal remains were recovered in 2005 from the crypt of Požega Cathedral (Croatia) after the floor deteriorated. Unfortunately, at the time the floor had collapsed considerable damage to the site was done, and therefore the material from the crypt could not be recovered as might have been expected. The sculls of 175 individuals were carefully placed in individually labelled containers and transported to the School of Dental Medicine at Zagreb University where the material was cleaned and examined. The osseal remains were afterwards returned to the original site.

Of the 175 sculls recovered, 71 were excluded from further analyses according to the following criteria: 14 were younger than 15 years, in 8 specimens either age or sex could not be determined and in 49 individuals age could be determined only according to palatal suture fusion.[13] In 104 specimens chosen for the investigation, the age determinations were based on abrasion patterns.[14,15] Sex determinations were made from the sculls alone, and were based on the shape of supraorbital ridges, nuchal crests, mastoid processes and muscular ridges. Most of the skeletons were incomplete and many of the long bones and pelvises were fragmented and it was not possible to use them in sex determination.

After age and sex had been determined the specimens were grouped into six groups: three female and three male groups of age: 15–29 years, 30–44 years and >45 years.

The Lovejoy[15] ageing method of assessing occlusal wear employed in this study is reproducible and does not imply destruction of archaeological material, but it is acknowledged that the ageing methods based on the analysis of dentition tend to underage the older individuals. This could explain way the oldest groups we analysed counted less individuals than the younger two groups.

The dentition was examined under good lighting conditions by visual inspection using dental probe. Carious lesions were recorded where a cavity in the enamel or cemetum was detected, and were classified by their location as occlusal, mesial, distal, buccal and lingual. Pigmentations of the enamel were not considered caries. The collected data were used to calculate caries frequencies, frequencies of caries on various surfaces and the average number of carious surfaces per carious tooth.

The extent of marginal destruction of alveolar bone and signs of the healing of bone were the main criteria in deciding whether a tooth was lost *ante* or *post* mortem. A third molar was considered lost *ante mortem* when distinct traces on the neighbouring tooth were recorded.

Periodontal status was determined according to the alveolar bone loss for each tooth. Length of exposed tooth root from alveolar crest to cemento-enamel junction was measured at 6 sites for each tooth (at distal, central and mesial aspect, both orally and facially) and the highest noted value subtracted by 2 mm was recorded as the bone loss.[16,17] If the bone loss for a particular tooth was between 3 and 6 mm, a tooth was recognized as moderately affected by periodontal disease, and where the bone loss was >6 mm, the tooth was classified as considerably affected by periodontal disease. The presence of dehiscences and fenestrations was recorded for all teeth on facial and oral plate of alveolar bone. In multirooted teeth dehiscences and fenestrations were recorded for each root, and if they were present on both buccal roots in upper molars, or both roots in lower molars it was noted as two dehiscences or fenestrations.

Estimation of skeletal age at death was carried out by one examiner (MV). Sex determination, caries, dehiscence and fenestration diagnosis and periodontal status was carried out by two examiners independently (AIM, SJK). The discrepancies in recording were resolved in discussion during simultaneous investigation, and the interval between the readings was 1 month.

The data were analysed using SPSS programme (except 'program' in computers) package version 16.0 (SPSS Inc., Chicago, IL). The data were analysed using descriptive statistics, one way ANOVA, Student's *t*-test for paired and independent samples, Friedman and Kruskal Wallis test at the level of significance $p < 0.05$.

3. Results

The analysed material consisted of sculls of 104 adult individuals which comprised a total of 1610 permanent teeth. The percentage of ante- and postmortem missing teeth in different age groups is shown in Table 1. The total number of antemortem missing teeth was 567, and the difference between groups (three female and three male) in antemortem teeth loss was significant (ANOVA, $F = 3.86$, df = 5, $p = 0.001$). In females, antemortem teeth loss was lower in the youngest age group compared to the older two, but the difference was not

Table 1 – Teeth present, teeth lost antemortem (AM) and postmortem (PM).

	Number of individuals	Teeth present	AM teeth loss	PM teeth loss	Teeth present + AM + PM loss	Antemortem loss (%)	Postmortem loss (%)	% total tooth loss
Females 15–29	14	155	91	111	357	25.49	31.09	56.58
Females 30–44	21	238	176	114	528	33.33	21.59	54.9
Females 45+	4	49	41	33	123	33.33	26.80	60.16
All females	39	442	308	258	1008	30.55	25.59	56.15
Males 15–29	28	570	73	174	817	8.93	21.29	30.23
Males 30–44	27	449	127	214	790	16.08	27.08	43.16
Males 45+	10	149	59	76	284	20.77	26.76	47.53
All males	65	1168	259	464	1891	13.70	24.55	38.25
All adults	104	1610	567	722	2899	19.57	24.91	44.48

significant (ANOVA, $F = 0.578$, df = 2, $p = 0.565$). In males, on the other hand, the increase in antemortem teeth loss with increasing age was statistically significant (ANOVA, $F = 3.468$, df = 2, $p = 0.037$). Teeth lost postmortem counted 722, and varied insignificantly amongst groups (ANOVA, $F = 1.093$, df = 5, $p = 0.379$). The teeth most frequently lost postmortem were incisors, whilst the canines were preserved at the highest rate.

Table 2 shows that more than 74% of the examined individuals had at least one carious lesion, and groups did not significantly differ in total caries experience (ANOVA, $F = 0.904$, df = 5, $p = 0.482$).

Table 3 shows the frequencies of carious lesions amongst different groups considering tooth type. Carious lesions were observed in all examined groups, and the difference amongst them was not significant (ANOVA, $F = 0.904$, df = 5, $p = 0.482$). The frequency of carious lesions did not increase with age as might have been expected. It was the highest in the middle age group in both genders, but in interpreting the results antemortem teeth loss should be taken into consideration. The total frequency of carious lesions was 18.39%, and it was higher in females, but not significantly (t-test, $t = 1.047$, df = 102, $p = 0.297$). Considering tooth type, the lowest frequency was noticed in mandibular central incisor (1.92%), and it was the highest in mandibular third molar (31.82%). The youngest male group did not exhibit carious lesions in maxillary central incisors and canines. In the oldest female group carious lesions were not noted in maxillary incisors and canines, but it should be emphasized that the group consisted of only 4 individuals where overall (antemortem + postmortem) teeth loss was more than 60%. Furthermore, analysis by tooth type in maxilla showed that incisors exhibited carious lesions in 13.92%, canines in 12.60%, premolars in 17.41% and molars in 26.63%. The difference in the frequency in molars was significantly higher compared to premolars and anterior teeth (Friedman test, $X^2 = 26.668$, df = 2, $p = 0.0001$). Different tooth types in mandible exhibited the following caries frequencies: incisors 4.62%, canines 12.50%, premolars 11.96% and molars 28.10%, and the difference was significant (Friedman test, $X^2 = 25.224$, df = 2, $p = 0.0001$). In general, the frequency of carious lesions was the highest in molars (26.63% in upper jaw and 28.10% in lower jaw), whilst central incisors exhibited the least carious lesions (11.59% in upper and 1.92% in lower jaw). Overall caries frequency differed significantly between jaws, and was higher in maxilla (Friedman test, $X^2 = 10.903$, df = 1, $p = 0.001$).

Table 4 shows the frequencies of carious lesions with respect to the location of the caries. The frequencies of carious lesions observed in maxilla were: 10.86% at the occlusal surface, 4.01% mesio-distally and 1.03% bucco-lingually. In the mandible the frequencies on specific surfaces were: 9.94% at the occlusal surface, 2.55% at proximal surfaces and 2.14% at bucco-lingual surfaces. In the case of proximal carious lesions in males in maxilla, the percentage of affected surfaces increased with age.

Table 5 shows the average number of carious surfaces per carious tooth. The teeth where the specific surfaces affected with caries could not be clearly determined, as was the case with profound caries, were excluded from this particular analysis. In these cases practically only radices remained in the alveolus, and counting five surfaces as being affected with caries would render the number of caries surfaces per caries tooth unrealistically high. The average number of carious surfaces per carious tooth was lower in anterior than in posterior teeth and was higher in the upper jaw. For all teeth the average number was 2.15.

Table 2 – Individulas with caries experience.

	Number of individuals	Number of individuals with caries	Percentage of individuals with caries (%)
Females 15–29	14	13	92.86
Females 30–44	21	15	71.43
Females 45+	4	2	50.00
All females	39	30	76.92
Males 15–29	28	15	53.57
Males 30–44	27	24	88.89
Males 45+	10	8	80.00
All males	65	47	72.31
All adults	104	77	74.04

Table 3 – Cries prevalence in upper (a), lower (b) jaw and total (c) caries prevalence.

	I1		I2		I1 + I2		C		P1		P2		P1 + P2		M1		M2		M3		M1 + M2 + M3		Total upper jaw	
	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%
(a) Upper jaw																								
Females 15–29	3/1	33.33	8/2	25.00	11/3	27.27	13/4	30.77	13/3	23.08	19/4	21.05	32/7	21.88	13/5	38.46	13/4	30.77	8/4	50.00	34/13	38.24	90/27	30.00
Females 30–44	12/4	33.33	13/7	53.85	25/11	44.00	19/6	31.58	15/7	46.67	20/5	25.00	35/12	34.29	23/6	26.09	20/5	25.00	12/5	41.67	55/16	29.09	134/45	33.58
Females 45+	1/0	0.00	3/0	0.00	4/0	0.00	3/0	0.00	3/1	33.33	5/0	0.00	8/1	12.50	3/0	0.00	3/0	0.00	2/0	0.00	8/0	0.00	23/1	4.35
All females	16/5	31.25	24/9	37.50	40/14	35.00	35/10	28.57	31/11	35.48	44/9	20.45	75/20	26.67	39/11	28.21	36/9	25.00	22/9	40.90	97/29	29.90	247/73	29.55
Males 15–29	27/0	0.00	34/1	2.94	61/1	1.64	41/0	0.00	51/3	5.88	47/5	10.64	98/8	8.16	45/8	17.78	45/10	22.22	33/7	21.21	123/25	20.33	323/34	10.53
Males 30–44	22/2	9.09	23/4	17.39	45/6	13.33	31/4	12.90	34/4	11.76	37/8	21.62	71/12	16.90	27/7	25.93	36/12	36.11	27/11	40.74	90/30	33.33	237/52	21.94
Males 45+	4/1	25.00	8/0	0.00	12/1	8.33	12/1	8.33	15/2	13.33	11/5	45.45	26/7	26.92	8/2	25.00	12/3	25.00	8/1	12.50	28/6	21.43	78/15	19.23
All males	53/3	5.66	65/5	7.69	118/8	6.78	84/5	5.05	100/9	9.00	95/18	18.95	195/27	13.85	80/17	21.25	93/25	26.88	68/19	27.94	241/51	21.16	638/101	15.83
All adults	69/8	11.59	89/14	15.73	158/22	13.92	119/15	12.60	131/20	15.27	139/27	19.42	270/47	17.41	119/28	23.53	129/34	26.36	90/28	31.11	338/90	26.63	885/174	19.66

	I1		I2		I1 + I2		C		P1		P2		P1 + P2		M1		M2		M3		M1 + M2 + M3		Total lower jaw	
	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%
(b) Lower jaw																								
Females 15–29	2/0	0.00	5/1	20.00	7/1	14.29	12/5	41.67	13/3	23.08	9/2	2.22	22/5	22.72	7/3	42.86	8/2	25.00	9/4	44.44	24/9	37.50	65/20	30.76
Females 30–44	6/1	16.67	14/3	21.43	20/4	20.00	15/3	20.00	17/2	11.76	16/4	25.00	33/6	18.18	10/5	50.00	12/5	41.67	14/6	42.86	36/16	44.44	104/29	27.88
Females 45 +	2/0	0.00	4/0	0.00	6/0	0.00	5/1	20.00	4/1	25.00	4/2	50.00	8/3	37.50	2/0	0.00	3/0	0.00	2/0	0.00	7/0	0.00	26/4	15.38
All females	10/1	10.00	23/4	17.39	33/5	15.15	32/9	28.13	34/6	17.65	29/8	27.59	63/14	22.22	19/8	42.11	23/7	30.43	25/10	40.00	67/25	37.31	195/53	27.18
Males 15–29	21/0	0.00	25/0	0.00	46/0	0.00	37/0	0.00	32/1	3.13	32/1	3.13	64/2	3.13	33/7	21.21	37/9	24.32	30/7	23.33	100/23	23.00	247/25	10.12
Males 30–44	16/0	0.00	20/1	5.00	36/1	2.78	33/5	15.15	32/4	12.50	31/4	12.90	63/8	12.70	23/3	13.04	30/11	36.67	27/11	40.74	80/25	31.25	212/39	18.40
Males 45+	5/0	0.00	10/0	0.00	15/0	0.00	10/0	0.00	8/0	0.00	11/1	9.10	19/1	5.26	9/2	22.22	12/2	16.67	6/0	0.00	27/4	14.81	71/5	7.04
All males	42/0	0.00	55/1	1.82	97/1	1.03	80/5	6.25	72/5	6.94	74/6	8.11	146/11	7.53	65/12	18.46	79/22	27.85	63/18	28.57	207/52	25.12	530/69	13.02
All adults	52/1	1.92	78/5	6.41	130/6	4.62	112/14	12.50	106/11	10.38	103/14	13.59	209/25	11.96	84/20	23.81	102/29	28.43	88/28	31.82	274/77	28.10	725/122	16.83

	Total upper + lower jaw O/A	%
(c) Total caries experience		
Females 15–29	155/47	30.32
Females 30–44	238/74	31.09
Females 45+	49/5	10.20
All females	442/126	28.51
Males 15–29	570/59	10.35
Males 30–44	449/91	20.27
Males 45+	149/20	13.42
All males	1168/170	14.55
All adults	1610/296	18.39

I1 – central incisor, I2 – lateral incisor, C – canine, P1 – first premolar, P2 - second premolar, M1 – first molar, M2 – second molar, M3 – third molar, O – number of teeth present, A – number of teeth with caries.

Table 4 – Location of caries.

	Occlusal		Mesial		Distal		Mesial + distal		Buccal		Lingual		Buccal + ingual	
	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%
(a) Upper jaw														
Females 15–29	66/7	1.52	90/3	3.33	90/3	3.33	180/6	3.33	90/5	5.56	90/1	1.11	180/6	3.33
Females 30–44	90/11	12.22	134/8	5.97	134/10	7.46	168/18	10.71	134/0	0.00	134/3	2.24	168/3	1.79
Females 45+	16/0	0.00	23/0	0.00	23/0	0.00	46/0	0.00	23/0	0.00	23/1	4.35	46/1	2.17
All females	172/18	10.47	247/11	4.45	247/13	5.26	494/24	4.86	247/5	2.02	247/5	2.02	494/10	2.04
Males 15–29	221/25	11.31	323/4	1.24	323/5	1.55	646/9	1.39	323/1	0.31	323/0	0.00	626/1	0.16
Males 30–44	161/19	11.80	237/14	5.91	237/10	4.22	474/24	5.06	237/3	1.27	237/1	0.42	474/4	0.84
Males 45+	54/4	7.41	78/5	6.41	78/5	6.41	156/10	6.41	78/2	2.56	78/0	0.00	156/2	1.28
All males	436/48	11.00	638/23	4.20	638/20	3.13	1276/43	3.37	638/6	0.94	638/1	0.16	1276/7	0.55
All adults	608/66	10.86	885/34	3.84	885/33	3.73	1670/67	4.01	885/11	1.24	885/6	0.68	1650/17	1.03

	Occlusal		Mesial		Distal		Mesial + distal		Buccal		Lingual		Buccal + ingual	
	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%
(b) Lower jaw														
Females 15–29	46/3	6.52	65/5	7.69	65/4	6.15	130/9	6.92	65/6	9.23	65/0	0.00	130/6	4.62
Females 30–44	69/7	10.14	104/5	4.81	104/8	7.69	208/13	6.25	104/1	0.96	104/6	5.77	208/7	3.37
Females 45+	15/0	0.00	26/0	0.00	26/0	0.00	52/0	0.00	26/0	0.00	26/1	3.85	52/1	1.92
All females	130/10	7.69	195/10	5.13	195/12	6.15	390/22	5.64	195/7	3.59	195/7	3.59	390/14	3.59
Males 15–29	164/18	10.98	247/3	1.21	247/1	0.40	494/4	0.81	247/3	1.21	247/0	0.00	494/3	0.61
Males 30–44	143/17	11.89	212/5	2.36	212/5	2.36	424/10	2.36	212/5	2.36	212/8	3.77	424/13	3.07
Males 45+	46/3	6.52	71/0	0.00	71/1	1.41	142/1	0.70	71/1	1.41	71/0	0.00	142/1	0.70
All males	353/38	10.76	530/8	1.51	530/7	1.32	1060/15	1.42	530/9	1.70	530/8	1.51	1060/17	1.60
All adults	483/48	9.94	725/18	2.48	725/19	2.62	1450/37	2.55	725/16	2.62	725/15	2.07	1450/31	2.14

O – number of observed surfaces; A – number of surfaces with caries.

Table 5 – Number of carious surfaces per carious tooth.

	Anterior teeth - maxillary			Posterior teeth - maxillary			All maxillary teeth		
	N of carious teeth	N of carious surfaces	N of carious surfaces/teeth	N of carious teeth	N of carious surfaces	N of carious surfaces/teeth	N of carious teeth	N of carious surfaces	N of carious surfaces/teeth
Females 15–29	4	4	1.00	13	15	1.15	17	19	1.12
Females 30–44	6	7	1.17	18	22	1.22	24	29	1.21
Females 45+	0	0	0.00	1	1	1.00	1	1	1.00
All females	10	11	1.10	32	38	1.19	42	49	1.17
Males 15–29	1	1	1.00	26	35	1.35	27	36	1.33
Males 30–44	9	12	1.33	29	35	1.21	38	47	1.24
Males 45+	2	2	1.00	12	14	1.17	14	16	1.14
All males	12	15	1.25	67	84	1.25	79	99	1.25
All adults	22	26	1.18	99	122	1.23	121	148	1.22

	Anterior teeth - mandibular			Posterior teeth - mandibular			All mandibular teeth		
	N of carious teeth	N of carious surfaces	N of carious surfaces/teeth	N of carious teeth	N of carious surfaces	N of carious surfaces/teeth	N of carious teeth	N of carious surfaces	N of carious surfaces/teeth
Females 15–29	6	7	1.17	11	11	1.00	17	18	1.06
Females 30–44	5	5	1.00	17	20	1.18	22	25	1.14
Females 45+	1	1	1.00	2	3	1.50	3	4	1.33
All females	12	13	1.08	30	34	1.13	42	47	1.12
Males 15–29	0	0	0.00	19	24	1.26	19	24	1.26
Males 30–44	5	5	1.00	32	37	1.16	37	42	1.14
Males 45+	0	0	0.00	5	5	1.00	5	5	1.00
All males	5	5	1.00	56	66	1.18	61	71	1.16
All adults	17	18	1.06	86	100	1.16	103	118	1.15

	All teeth		
	N of carious teeth	N of carious surfaces	N of carious surfaces/teeth
Females 15–29	34	37	1.09
Females 30–44	46	54	1.17
Females 45+	4	5	1.25
All females	84	96	1.14
Males 15–29	46	60	1.30
Males 30–44	75	89	1.19
Males 45+	19	21	1.11
All males	140	170	1.21
All adults	224	266	2.15

Table 6 – Alveolar bone loss.

	Number of individuals	Teeth present	Number of teeth with moderate bone loss (3–6 mm)	%	Number of teeth with considerable bone loss (>6 mm)	%
Females 15–29	14	155	61	39.35	36	23.23
Females 30–44	21	238	148	62.18	65	27.31
Females 45+	4	49	17	34.69	26	53.06
All females	39	442	226	51.13	127	28.73
Males 15–29	28	570	70	12.28	40	7.02
Males 30–44	27	449	151	33.63	128	28.51
Males 45+	10	149	33	22.15	91	61.07
All males	65	1167	254	21.77	259	22.19
All adults	104	1609	480	29.83	386	23.99

Table 6 shows alveolar bone loss amongst different groups. As far as considerable bone loss is concerned, the difference between sex and age groups was significant (Kruskal–Wallis, $X^2 = 20.585$, df = 5, $p = 0.001$), whilst moderate bone loss did not significantly differ between groups (Kruskal–Wallis, $X^2 = 3.375$, df = 5. $p = 0{,}642$). The percentage of teeth with considerable bone loss was higher in females, but not significantly (Kruskal–Wallis, $X^2 = 1.193$, df = 1, $p = 0.275$). Also, the percentage of teeth with moderate bone loss did not differ significantly between genders (Kruskal–Wallis, $X^2 = 0.003$, df = 1, $p = 0.953$). However, percentage of teeth with considerable bone loss increased with age in both genders and the difference between age groups was significant for both, females (Kruskal Wallis test, $X^2 = 6.906$, df = 2, $p = 0.032$) and males (Kruskal Wallis test, $X^2 = 12.635$, df = 2, $p = 0.002$).

Table 7 shows the frequency of dehiscences considering tooth type. The overall observed frequency was 3.11%. When comparing the frequency of dehiscences amongst groups, the difference was not statistically significant (Kruskal Wallis test, $X^2 = 2.831$, df = 5, $p = 0.794$). It was noted that the middle age group in both genders exhibited more dehiscences in both jaws than the other two age groups, except for mandibular dehiscences in men where dehiscences frequency decreased with age. When comparing jaws, higher frequency was noted in maxilla (3.95%) than in the mandible (2.07%) and the difference was significant (t-test, $t = 2.220$, df = 103, $p = 0.029$).

Considering tooth type, the highest observed frequencies in maxilla were: 8.70% in central incisors and 7.56% in canines and first molars. In the mandible the highest observed frequencies of dehiscences were in first molars (5.95%) and canines (4.46%).

Table 8 shows the frequency of fenestrations considering tooth type. The total observed frequency for all teeth examined was 5.65%, and the difference between groups was insignificant (Kruskal Wallis test, $X^2 = 4.504$, df = 5, $p = 0.443$). The overall frequency of fenestrations was significantly higher in maxilla (8.81%) than in the mandible (1.79%) (t-test, $t = 4.014$, df = 103, $p = 0.0001$), and this pattern was observed in both genders (t-test, $t = 3.04$, df = 37, $p = 0.004$ – females; t-test $t = 2.666$, df = 65, $p = 0.01$ – males). When comparing genders, it was observed that females (7.24%) exhibited more fenestrations than males (5.05%), but not significantly (t-test, $t = 0.746$, df = 102, $p = 0.457$). Considering tooth type, the highest observed frequencies in maxilla were observed in central incisors (14.49%), first molars (12.61%), canines (10.22%) and second molars (10.08%). In the mandible the highest observed frequencies were observed in canines (3.57%) and first molars (3.57%).

4. Discussion

During the first part of the 18th century in continental Croatia – especially the region of Slavonia – organized health care did not exist and most of the ‘‘medical’’ procedures were performed by priests and barbers. Jesuit pharmacy in Požega was well known and appreciated. During this period hygiene was pretty low, which together with humid surroundings due to numerous swamps, favoured big plague epidemic in 1739. During Maria Theresia era, health care and infrastructure were much improved, and by 1770s, medical procedures were almost entirely performed by educated physicians. Despite the improvements in health care and hygiene standards, epidemics including chicken pocks, diphtheria, malaria and typhus were out breaking during entire 18th century.[12]

The particularities concerning the site of Požega cathedral were mentioned in Section 2. Of the 175 sculls recovered, 104 specimens (where age according to Lovejoy[15] and sex were determined) were chosen for the investigation, irrespective of the degree of preservation to avoid reduction in caries prevalence, since the bones weakened by diseases ante mortem are more prone to mechanical damage and erosion post mortem.[18,19]

24.91% of the specimens suffered postmortem loss of teeth which might have lessened the quality of the whole sample compared to the previous studies.[14,20] On the other hand, postmortem teeth loss as a measure of the quality of the sample has been questioned, since it does not influence the results, if caries prevalence is calculated as a percentage of the total number of teeth present without referring to the number of specimens.[18] The overall tooth loss in our study (44.48%) was more frequent in older age groups which could be explained by probable presence of some chronic periodontal diseases.[21] The increased postmortem teeth loss in older age groups was observed in other studies.[9,14] In some studies of 18th century populations postmortem teeth loss was 10%[14] which is less than in our study, but in other referential studies of historic populations postmortem teeth loss was 16.3%.[18,22]

Total antemortem teeth loss was 19.57%. It was increasing with age, and was higher in females (30.55%) than in males (13.70%). The criterion for recognizing antemortem tooth loss

Table 7 – Prevalence of dehiscences in upper (a), lower jaw (b) and total prevalence in both jaws (c).

	I1		I2		C		P1		P2		M1		M2		M3		Total upper jaw	
	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%
(a) Upper jaw																		
Females 15–29	3/0	0.00	8/0	0.00	13/0	0.00	13/1	7.69	19/5	26.32	13/5	38.46	13/2	15.38	8/1	12.50	90/14	15.55
Females 30–44	12/2	16.67	13/0	0.00	19/3	15.79	15/1	6.67	20/1	5.00	23/0	0.00	20/0	0.00	12/0	0.00	134/7	5.22
Females 45+	1/1	100.00	3/0	0.00	3/0	0.00	3/0	0.00	5/1	20.00	3/0	0.00	3/0	0.00	2/0	0.00	23/2	8.69
All females	16/3	18.75	24/0	0.00	35/3	8.57	31/2	6.45	44/7	15.90	39/5	12.82	36/2	5.56	22/1	4.55	247/13	5.26
Males 15–29	27/3	11.11	34/1	2.94	41/5	12.19	51/3	5.89	47/0	0.00	45/3	6.67	45/1	2.22	33/1	3.03	323/17	5.26
Males 30–44	22/0	0.00	23/1	4.35	31/1	3.23	34/1	2.94	37/1	2.70	27/0	0.00	36/0	0.00	27/0	0.00	237/4	1.69
Males 45+	4/0	0.00	8/0	0.00	12/0	0.00	15/0	0.00	11/0	0.00	8/1	12.50	12/0	0.00	8/0	0.00	78/1	1.28
All males	53/3	5.66	65/2	3.08	84/6	7.14	100/4	4.00	95/1	1.05	80/4	5.00	93/1	1.08	68/1	1.47	638/22	3.45
All adults	69/6	8.70	89/2	2.25	119/9	7.56	131/6	4.58	139/8	5.76	119/9	7.56	129/1	0.78	90/1	1.11	885/35	3.95

	I1		I2		C		P1		P2		M1		M2		M3		Total lower jaw	
	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%
(b) Lower jaw																		
Females 15–29	2/0	0.00	5/0	0.00	12/1	8.33	13/1	7.69	9/0	0.00	7/0	0.00	8/0	0.00	9/0	0.00	65/2	3.08
Females 30–44	6/0	0.00	14/0	0.00	15/0	0.00	17/0	0.00	16/0	0.00	10/0	0.00	12/0	0.00	14/0	0.00	104/0	0.00
Females 45+	2/0	0.00	4/0	0.00	5/0	0.00	4/0	0.00	4/0	0.00	2/0	0.00	3/0	0.00	2/0	0.00	26/0	0.00
All females	10/0	0.00	23/0	0.00	32/1	3.13	34/1	2.94	29/0	0.00	19/0	0.00	23/0	0.00	25/0	0.00	195/2	1.03
Males 15–29	21/0	0.00	25/0	0.00	37/3	8.11	32/2	6.25	32/0	0.00	33/3	9.09	37/0	0.00	30/1	3.33	247/9	3.64
Males 30–44	16/0	0.00	20/0	0.00	33/1	3.03	32/0	0.00	31/1	3.23	23/2	8.70	30/0	0.00	27/0	0.00	212/4	1.89
Males 45+	5/0	0.00	10/0	0.00	10/0	0.00	8/0	0.00	11/0	0.00	9/0	0.00	12/0	0.00	6/0	0.00	71/0	0.00
All males	42/0	0.00	55/0	0.00	80/4	5.00	72/2	2.78	74/1	1.35	65/5	7.69	79/0	0.00	63/1	1.59	530/13	2.45
All adults	52/0	0.00	78/0	0.00	112/5	4.46	106/3	2.83	103/1	0.97	84/5	5.95	102/0	0.00	88/1	1.14	725/15	2.07

	Total upper + lower jaw	
	O/A	%
(c) Total prevalence of dehiscences		
Females 15–29	155/16	10.32
Females 30–44	138/7	5.07
Females 45+	49/2	4.08
All females	442/15	3.39
Males 15–29	570/26	4.56
Males 30–44	449/8	1.78
Males 45+	149/1	0.67
All males	1168/35	3.00
All adults	1610/50	3.11

O – number of teeth; A – number of teeth with dehiscence; I – incisive; C - canine; P – premolar; M – molar.

Table 8 – Prevalence of fenestrations in upper (8a) and lower jaw (8b) and total prevalence in both jaws (8c).

	I1		I2		C		P1		P2		M1		M2		M3		Total upper jaw	
	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%
(a) Upper jaw																		
Females 15–29	3/1	33.33	8/1	12.50	13/1	7.69	13/3	23.08	19/1	5.26	13/4	30.77	13/5	38.46	8/2	25.00	90/18	20.00
Females 30–44	12/0	0.00	13/0	0.00	19/2	10.53	15/1	6.67	20/0	0.00	23/2	8.70	20/2	10.00	12/1	8.33	134/8	5.97
Females 45+	1/1	1	3/0	0.00	3/1	33.33	3/0	0.00	5/1	20.00	3/0	0.00	3/0	0.00	2/0	0.00	23/3	13.04
All females	16/2	12.5	24/1	4.17	53/4	7.55	31/4	12.9	44/2	4.55	39/6	15.38	36/7	19.44	22/3	13.64	247/29	11.74
Males 15–29	27/4	14.81	34/4	11.76	41/5	12.20	51/0	0.00	47/4	8.51	45/5	11.11	45/2	4.44	33/0	0.00	323/24	7.43
Males 30–44	22/2	9.09	23/0	0.00	31/2	6.45	34/2	5.88	37/1	2.70	27/2	7.41	36/1	2.78	27/1	3.70	237/11	4.64
Males 45+	4/2	50.00	8/0	0.00	12/3	25.00	15/1	6.67	11/3	27.27	8/2	25.00	12/3	25.00	8/0	0.00	78/14	17.95
All males	53/8	15.09	65/4	6.15	84/10	11.9	100/3	3.00	95/8	8.42	80/9	11.25	93/6	6.45	58/1	1.72	638/49	7.68
All adults	69/10	14.49	89/5	5.61	137/14	10.22	131/7	5.34	139/10	7.19	119/15	12.61	129/13	10.08	80/4	5	885/78	8.81

	I1		I2		C		P1		P2		M1		M2		M3		Total lower jaw	
	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%	O/A	%
(b) Lower jaw																		
Females 15–29	2/0	0.00	5/0	0.00	12/1	8.33	13/0	0.00	9/0	0.00	7/0	0.00	8/0	0.00	9/0	0.00	65/1	1.54
Females 30–44	6/0	0.00	14/0	0.00	15/1	6.67	17/1	5.89	16/0	0.00	10/0	0.00	12/0	0.00	14/0	0.00	104/2	1.92
Females 45+	2/0	0.00	4/0	0.00	5/0	0.00	4/0	0.00	4/0	0.00	2/0	0.00	3/0	0.00	2/0	0.00	26/0	0.00
All females	10/0	0.00	23/0	0.00	32/2	6.25	34/1	2.94	29/0	0.00	19/0	0.00	23/0	0.00	25/0	0.00	195/3	1.54
Males 15–29	21/1	4.76	25/2	8.00	37/2	5.41	32/0	0.00	32/0	0.00	33/2	6.06	34/1	2.94	30/0	0.00	247/8	3.24
Males 30–44	16/0	0.00	20/0	0.00	33/0	0.00	32/1	3.13	31/0	0.00	23/0	0.00	30/0	0.00	27/0	0.00	212/1	0.47
Males 45+	5/0	0.00	10/0	0.00	10/0	0.00	8/0	0.00	11/0	0.00	9/1	11.11	12/0	0.00	6/0	0.00	71/1	1.41
All males	42/1	2.38	55/2	3.64	80/2	2.5	72/1	1.39	74/0	0.00	65/3	4.62	79/1	1.27	63/0	0.00	530/10	1.89
All adults	52/1	1.92	78/2	2.56	112/4	3.57	106/2	1.89	103/0	0.00	84/3	3.57	102/1	0.99	88/0	0.00	725/13	1.79

	Total upper + lower jaw	
	O/A	%
8 c. Total prevalence of fenestrations		
Females 15–29	155/19	12.26
Females 30–44	138/10	7.25
Females 45+	49/3	6.12
All females	442/32	7.24
Males 15–29	570/32	5.61
Males 30–44	449/12	2.67
Males 45+	149/15	10.07
All males	1168/59	5.05
All adults	1610/91	5.65

was the absence of any part of the tooth socket. It was much discussed about too low an estimate of caries prevalence when excluding teeth lost antemortem in calculating caries prevalence. However, it is impossible to determine whether the caries was the cause of a particular tooth loss. Therefore, it is currently accepted that corrective factors, dependent of the age group and derived from the total antemortem tooth loss, should not be considered when calculating caries prevalence.[14,18,20] It was noted that antemortem teeth loss in the older age groups was higher than in the mediaeval populations, and this could be explained by the diet containing more refined carbohydrates than in the older historic populations. This pattern was noticed by Whittaker and Molleson,[14] in 18th century London population.

Gradual increase in caries prevalence from neolitic to medialeval to 18th century in historic populations in continental Croatia can be noticed as shown in Table 9.[22,23] The caries prevalence 19.60% is significantly higher than in mediaeval populations of the same area. Furthermore, in our study all individuals in the older age groups, that were not completely edentulous, had some carious teeth, which was not noted in mediaeval populations.[23]

Similar gradual increase in caries frequencies from mediaeval to 18th century populations was observed in British historic populations, where Romano British population and mediaeval Scots exhibited significantly lower caries frequencies (7% and 5.1%, respectively) than the 18th century London population (18%).[1,24] When directly comparing the caries frequencies in different historic populations in Croatia, the fact that different investigators performed the recordings should be considered. Relatively high caries frequency in 18th century Požega population could be explained by carbohydrate rich diet, and since the individuals investigated belonged to richer classes it is fair to assume they consumed more sugar.

Lesions were mostly found on occlusal surfaces: 10.86% of occlusal surfaces in upper and 9.94% in lower jaw were affected. The frequencies were lower on proximal and buccolingual surfaces. Whittaker and Molleson[14] also reported that the majority of lesions occurred occlusaly in the 18th century London population, but the frequency was considerably higher (20%) than in our population. Such distribution of caries is typical of refined carbohydrate diet, and is in contrast with reports concerning mediaeval material where proximal caries were most frequently recorded.[22,23] It could be explained by the fact that the food was in that time much coarser leaving proximal surfaces more prone to caries than pit and fissures of the occlusal surface. Besides, the consumption of refined carbohydrates and sugars increased only in the 18th century.

Significant differences in caries of the proximal, lingual and buccal surfaces were noted between females and males, females having higher caries frequency on each surface. Perhaps the expalanation could lie in hormonal differences.

The study also showed that the frequency of caries teeth varied, but it can be noted that molars showed more susceptibility to carious decay. Caries was less recorded in anterior teeth. This pattern can be explained by the morphology of molars with more sites prone to caries development. These findings are similar to those of numerous paleological studies.It could be noticed that considerable alveolar bone loss increased with age.

Some anthropologists are of the opinion that periodontal disease has increased since the Palaeolithic period, with relative frequency in the Neolithic period and further increases up to the present time.[25] On the contrary, Kerr[26] study showed that the prevalence of periodontitis remained constant during the past 3000 years in Britain. Kerr[26] questioned the method of simple root exposure measurement in assessing periodontal disease. In dentitions with severe occlusal attritions, compensatory coronal movement or further eruption occurs without periodontal apparatus being affected.[21] Therefore, the bone loss could not unequivocally be regarded as the consequence of periodontal disease, but as an indicator of both, periodontal disease and compensatory tooth eruption in cases of more pronounced attrition. Besides the obvious lack of standardization in the recording of results, other difficulties exist in determining periodontal disease in osteological material such as postmortal damage of alveolar bone and impossibility of relating bone and soft tissue.

The advantages of using skeletal material in assessing periodontal pathology include direct visibility, accurate measurement and the ability to study fenestrations and dehiscences.[27]

In studying antique and mediaeval population, Vodanović[28] found correlation between calculus deposits, periodontal disease prevalence and bony defects (dehiscences and fenestrations) prevalence, which were all significantly higher in medialeval than antique populations in Croatia. This is inconsistent with the results obtained by Whittaker et al. which suggest that the amount of calculus may reflect the

Table 9 – Antemortem loss, caries prevalence and location of caries in different historic populations of continental Croatia.

Archaeological site	Vinkovci-Gepid	Privlaka	Bijelo Brdo	Đakovo	Vinkovci	Nova Rača	POŽEGA
Century	6–7	8–9	10–11	11–13	11–14	14–17	18
AM loos	2.3	14	6.7	8	5.3	10.9	19.57
Caries prevalence	3.2	11	9.5	6.2	10.5	9.4	19.60
Location of caries							
Proximal	62.5	67.1	63.4	41.7	45.5	68.0	39.10
Occlusal	25.0	23.1	15.8	41.7	36.4	18.5	42.86
Buccal	0	9.1	18.3	16.6	18.1	12.0	10.15
Lingual	12.5	0.7	2.5	0	0.0	1.5	7.89
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

dietary habits, but it does not influence the degree of alveolar bone loss.[17]

In Rupprecht[29] study of modern American sculls collected between 1920–1950, 4.1% teeth had dehiscences and 9.0% had fenestrations which is higher than in our study, but in our sample the average number of teeth per scull was 15.47 compared to 22.7 in the mentioned study. The authors positively correlated dehiscences and fenestrations with thin alveolar bone, but no association between wear or attrition of the teeth and the loss of buccal bone around the roots of the teeth was found.[29] Dehiscences were more common in the mandible and fenestrations in the maxilla, whilst in our study, both fenestrations and dehiscences, were more common in the maxilla. This could be due to thinner alveolar plate. The study of 20th century population of northwestern Croatia showed dehiscences and fenestrations to be most prevalent in canines of both jaws and significantly higher than in the 18th century population studied.[30] This could partly be assigned to significantly more teeth per scull available for inspection (25 teeth/scull). Our population exhibited more bony defects on central incisors and first molars followed by canines. This could be explained by less pronounced intreproximal attrition of more recent population often leaving less space for the permanent canine, especially in the maxilla, leading to its buccal movement.

In addition, the lifespan of antient populations influences the frequency and distribution of caries, periodontal status and antemortem tooth loss. The average lifespan is itself determined by numerous socio-economic factors.[31] Recent researches showed strong associations between prevalence of dental caries and destructive periodontitis with socio-economic status in contemporary populations.[32] This clearly suggests that in populations, such as the antient ones, lacking appropriate dental care, caries and periodontal disease prevalence, together with antemortem teeth loss are increased with increased average lifespan.

Our study demonstrates poor oral health amongst 18th century population of continental Croatia, exhibiting high antemortem teeth loss, high periodontal disease frequency and occlusal and proximal caries frequency.

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Competing interests

The authors declare that there are no conflicts of interest and they are not aware of any inappropriate relationship of my Institution with other people or organizations.

Ethical approval

The research was performed on an archaeological sample. After the recordings had been done, the osseal remains were returned to the original sample.

REFERENCES

1. Moore WJ, Corbett E. The distribution of dental caries in ancient British populations. II. Iron Age, Romano-British and Mediaeval periods. *Caries Res* 1973;**7**(2):139–53.
2. Moore WJ, Corbett ME. Distribution of dental caries in ancient British populations. III. The 17th century. *Caries Res* 1975;**9**(2):163–75.
3. Corbett ME, Moore WJ. Distribution of dental caries in ancient British populations. IV. The 19th century. *Caries Res* 1976;**10**(6):401–14.
4. Davies GN. Social customs and habits and their effect on oral disease. *J Dent Res* 1963;**2**:209–32.
5. Quensel CE, Gustafsson BE, Grahnen H. The Vipeholm dental caries study: reliability of the method in the determination of caries activity. *Acta Odontol Scand* 1954;**11**(3–4):365–88.
6. Moore WJ, Corbett ME. The distribution of dental caries in ancient British populations. 1. Anglo-saxon period. *Caries Res* 1971;**5**(2):151–68.
7. Lunt DA. The prevalence of dental caries in the permanent dentition of Scottish prehistoric and mediaeval populations. *Arch Oral Biol* 1974;**19**(6):431–7.
8. Varrela TM. Prevalence and distribution of dental caries in a late medieval population in Finland. *Arch Oral Biol* 1991;**36**(8):553–9.
9. Whittaker DK, Molleson T, Bennett RB, Edwards I, Jenkins PR, Llewelyn JH. The prevalence and distribution of dental caries in a Romano-British population. *Arch Oral Biol* 1981;**26**(3):237–45.
10. Slaus M. Biocultural analysis of sex differences in mortality profiles and stress levels in the late medieval population from Nova Raca, Croatia. *Am J Phys Anthropol* 2000;**111**(2):193–209.
11. Mucić D. Caries research on anthropologic material from the last two millennia in Yugoslavia. *Stomatološki glasnik Srbije* 1991;**1**(1):24–31.
12. Belicza B. Health care and health conditions in Slavonia in 18th century. *Zbornik petog znanstvenog sabora Slavonije i Baranje*. 1991:297–300.
13. Mann RW, Symes SA, Bass WM. Maxillary suture obliteration: aging the human skeleton based on intact or fragmentary maxilla. *J Forensic Sci* 1987;**32**(1):148–57.
14. Whittaker DK, Molleson T. Caries prevalence in the dentition of a late eighteenth century population. *Arch Oral Biol* 1996;**41**(1):55–61.
15. Lovejoy CO. Dental wear in the Libben population: its functional pattern and role in the determination of adult skeletal age at death. *Am J Phys Anthropol* 1985;**68**(1):47–56.
16. Lennon MA, Davies RM. Prevalence and distribution of alveolar bone loss in a population of 15-year-old schoolchildren. *J Clin Periodontol* 1974;**1**(3):175–82.
17. Whittaker DK, Molleson T, Nuttall T. Calculus deposits and bone loss on the teeth of Romano-British and eighteenth-century Londoners. *Arch Oral Biol* 1998;**43**(12):941–8.
18. Watt ME, Lunt DA, Gilmour WH. Caries prevalence in the permanent dentition of a mediaeval population from the south-west of Scotland. *Arch Oral Biol* 1997;**42**(9):601–20.
19. Beeley JGLD. The nature of biochemical changes in softened dentine from archeological sites. *J Archeol Sci* 1980;**7**:371–7.
20. Kerr NW, Bruce MF, Cross JF. Caries experience in Mediaeval Scots. *Am J Phys Anthropol* 1990;**83**(1):69–76.
21. Whittaker DK, Molleson T, Daniel AT, Williams JT, Rose P, Resteghini R. Quantitative assessment of tooth wear, alveolar-crest height and continuing eruption in a Romano-British population. *Arch Oral Biol* 1985;**30**(6):493–501.

22. Slaus M. Osteological and dental markers of health in the transition from the late antique to the early medieval period in Croatia. *Am J Phys Anthropol* 2008;**136**(4):455–69.
23. Vodanovic M, Brkic H, Slaus M, Demo Z. The frequency and distribution of caries in the mediaeval population of Bijelo Brdo in Croatia (10th-11th century). *Arch Oral Biol* 2005;**50**(7):669–80.
24. Kerr NW, Bruce MF, Cross JF. Caries experience in the permanent dentition of late mediaeval Scots (1300-1600 a.d.). *Arch Oral Biol* 1988;**33**(3):143–8.
25. Alt KW, Rosing FW, Teschler-Nicola M. *Dental anthropology: fundamentals, limits, and prospects*. Wien, New York: Springer; 1998.
26. Kerr NW. The prevalence and natural history of periodontal disease in Britain from prehistoric to modern times. *Br Dent J* 1998;**185**(10):527–35.
27. Kerr NW. Prevalence and natural history of periodontal disease in a London, Spitalfields, population (1645-1852 AD). *Arch Oral Biol* 1994;**39**(7):581–8.
28. Vodanović M, Šlaus M, Savić I, Njemirovskij V, Brkić H. Periodontal health of an antique and medieval population from Croatia. *Book of abstracts: PEF IADR 2008 Conference*. 2008:161.
29. Rupprecht RD, Horning GM, Nicoll BK, Cohen ME. Prevalence of dehiscences and fenestrations in modern American skulls. *J Periodontol* 2001;**72**(6):722–9.
30. Jorgic-Srdjak K, Plancak D, Bosnjak A, Azinovic Z. Incidence and distribution of dehiscences and fenestrations on human skulls. *Coll Antropol* 1998:111–6. 22 Suppl:.
31. Manzi G, Salvadei L, Vienna A, Pssarello P. Discontinuity of life conditions at the transition from the Roman Imperial Age to the early Middle Ages: example from central Italy evaluated by pathological dento-alveolar lesions. *American Journal of Human Biology* 1999;**11**(3): 327–41.
32. Hobdell MH, Oliveira ER, Bautista R, Myburgh NG, Lalloo R, Narendran S, et al. Oral diseases and socio-economic status (SES). *Br Dent J* 2003;**194**(2):91–6. discussion 88.