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ORAL PALEOPATHOLOGICAL INVESTIGATION OF THE AVAR PERIOD (6–7TH C. CE) POPULATION FROM NAGYKŐRÖS

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Quiroz-Cabascango, X., Berta, N., Szeniczey, T.: *The main goal of the research is to widen our knowledge about oral health during the Early Avar Period (6–7th c. CE). We used the individual and tooth count method to record abrasion, caries, antemortem tooth loss, periapical lesions, linear enamel hypoplasia, calculus and dental trauma of 26 individuals from the Nagykőrös-Kovács tanya site (9 males, 6 females, 11 subadults). The examination of the remains showed the noteworthy presence of dental abrasion and calculus among subadults, which increased with age. Only the tooth count analysis revealed a significant difference between the adults, as females had more teeth with caries and hypoplasia, while for calculus males had increased intensity in their dentition. The comparison with Late Avar Period skeletal assemblages from other geographic regions indicated possible spatial or temporal trends of oral health.*
Keywords: *Avar Period; Oral health; Dental paleopathology; Dental trauma.*

Introduction

During the first millennia of the common era, the Carpathian Basin or Pannonian Basin was inhabited by several waves of nomadic groups coming mainly from Asia. One of the main groups was the Avars, who represented one of the most significant political and military forces in the early medieval Central Europe for more than two centuries (Vida 2008, Pohl 2018). During this period, the Avar Khaganate exerted its dominion over a vast expanse of territory, encompassing modern-day Hungary, Slovakia, Austria, and other surrounding regions. The Avars, a nomadic group of Eurasian origin, established a complex and hierarchical political structure and established their rule over a diverse populace.

The chronology of the Avar Period can be divided into 3 phases: Early (568–650/670), Middle (middle 7th – early 8th c.) and Late period (700/710–811/822). The early Avar Period was marked by significant cultural exchanges and interactions between the Avars and the “autochthonous” populations of the Carpathian Basin. The Avars integrated with the local populations to a certain extent, fostering a multicultural society, which was a rather peaceful coexistence over hostile actions between these communities (Vida 2008). The distinctive multicultural character of the Early Avar Period rapidly faded away throughout the 7th century, when the nomadic state underwent repeated crises of authority. As a result of consolidation, a more consistent material culture was formed in the Carpathian Basin, marking the beginning of the Late Avar Period in the 8th century (Vida 2008, Garam 2019).

Given the importance of this Period, extensive bioarchaeological research has been conducted; yet, in terms of dental paleopathology, relatively little detailed data about the Avar Period population in Hungary is known (as exception see Molnár 2000, Évinger 2003). The scarcity of data is especially noticeable in the case of the oral health of subadults and dental trauma. Dental paleopathology is a subfield of bioarchaeology that investigates ancient human skeletal remains, with a primary focus on the examination of dental health and related conditions. By examining dental remains and associated pathologies, one can gain valuable insights into the overall well-being of ancient societies, their dietary choices, oral hygiene practices and the prevalence of specific diseases or conditions. The aim of this study was to present a detailed analysis of the oral health status of the Early Avar Period population excavated at Nagykőrös-Kovács tanya.

Materials and Methods

Prior to road building, a trial excavation was done in the vicinity of Nagykőrös (Hungary, Pest County) in the spring of 2021, with two study trenches opened and 14 archaeological features documented. The majority of these are related to an unknown, likely modern-era farmstead, and an Avar-period cemetery was also discovered. The site is located approximately 3.5 km southeast of the town, on the east side of the Csongrádi road, near the county border.

Except for a smaller section at the western edge, a total of 145 stratigraphic units were observed on an area of 5125 m^2 after the removal of the humus layer, of those, there are 31 graves from the Migration Period, including a trench encircling a tomb as one of the stratigraphic units. Additionally, 113 are settlement features without datable artifacts, which can be associated with the known settlement. The early Avar-period graves, with few exceptions, proved to be undisturbed compared to the general grave robbery of the period. The graves were loosely arranged, oriented in a roughly northeast to southwest direction, and spaced approximately 8–10 meters apart. They were excavated more densely as they grouped towards the western end of the area. The cemetery segment can be considered closed to the north (and likely east), with the possibility of additional burials to the west and a clear continuation of the rows of graves to the south. Among the excavated graves, the wealth of male graves is noticeable. The remains belonging to the Avar Period were excavated by the archaeologist Norbert Berta.

The Avar Period skeletal sample consisted of 26 skeletons: 9 male, 6 female and 11 subadults (Table 1) with 582 teeth: 257 from males, 143 from females and 182 from subadults (Annex, Table A1). The age at death of adults was categorized into 3 groups: young adults (20–35 years old), middle adults (35–50 years old) and old adults (>50 years old). In the same way, the subadults were divided into 3 groups: Infans I (0–6 years old), Infans II (6–14 years old) and Juveniles (14–20 years old).

The age at death of the subadults was estimated based on dentition, including tooth formation and eruption (AlQahtani et al. 2010). In juveniles, the fusion of primary and secondary ossification centres was considered (Schaefer et al. 2008). In adults, macromorphological analysis of the sternal end of the rib (Iscan et al. 1984, 1985), obliteration of the ectocranial suture of the skull (Meindl and Lovejoy 1985), and the age-related changes of the symphysial surface of the pubic bone (Brooks and Suchey 1990) were considered. Additionally, the epiphyseal union of the sternal end of the clavicle (Buikstra and Ubelaker 1994) and dental abrasion (Lovejoy 1985) were also employed in conjunction with previously mentioned methods for comprehensive age estimation.

Table 1. Number of individuals by age group and sex.

Individuals	Number of individuals	Sex	Age
Adults	4	Male	Young adult
	4	Female	Young adult
	3	Male	Middle adult
	2	Female	Middle adult
	2	Male	Old adult
	0	Female	Old adult
Subadults	3	–	Infans I
	5	–	Infans II
	3	–	Juveniles

Regarding the sex estimation in adults, macromorphological analysis on the bones of the skull, pelvis, sacrum and femora was carried out (Buikstra and Ubelaker 1994, Éry et al. 1963).

The study involved an analysis of teeth, maxilla and mandible to identify oral pathologies such as abrasion, caries, hypoplasia, calculus and periapical lesions. Abrasion was assessed using the Huszár and Schranz (1976) method, where teeth were scored on a scale from 0 to 5 representing different levels of abrasion. – 0: sine abrasione (SA), 1: abrasio superficialis I (AS I), 2: abrasio superficialis II (AS II), 3: abrasio media (AM), 4: abrasio profunda compensata (APC), 5: abrasio profunda incompensata (API).

Similarly, the diagnosis of caries was based on the Huszár and Schranz method, with each tooth assigned a score from 0 to 6, indicating the severity of caries – 0: no caries, 1: caries type 1 (affecting only the enamel), 2: caries type 2 (affecting both enamel and dentin), 3: caries type 3 (affecting dentin with an open pulp chamber), 4: caries type 4 (most of the crown missing), 5: caries type 5 (only the root remains), 6: caries type 6 (some of the roots are missing).

Linear enamel hypoplasia was evaluated based on Lovejoy's methodology (Lovejoy 1985). Additionally, the formation of enamel defects was estimated using the standards proposed by Smith and Littleton (2019). The periapical lesions were evaluated based on the diagnostics criterion summarized in Nikita (2016). The evaluation focused solely on the presence or absence of periapical cavities, without consideration for the disease progression. A binary scoring system was employed, where a score of 1 denoted the presence of periapical cavities, while a score of 0 indicated their absence. Antemortem tooth loss (AMTL) was identified by assessing the maxillary and mandibular sockets. If any degree of remodelling or resorption was observed in these sockets, it was categorized as AMTL.

Two methods were used in the oral palaeopathological analysis. The individual count method calculates the disease's prevalence based on the number of people affected. To be classified as having a dental pathology, an individual must have at least one tooth with a specific pathology. The tooth count method uses tooth type and class to determine the frequency of lesions. The second method is useful when specific tooth classes or jaws are of concern, or when sample subdivision results in a small dataset.

Since our sample consisted of a few individuals, the statistical analysis was carried out by one selected aspect. In the case of children, age was considered as a grouping variable, while in the case of adults, sex was taken into account. In the latter case, the decision was made because the distribution of age groups was almost similar between the two sexes. In any case, in the results of the adults, we also discussed the differences between ages in tabular and textual form.

Finally, for the statistical analysis, the association between the frequency of dental/oral lesions and the demographic attributes (age, sex) was analysed with a chi-square test. If the contingency table did not match the chi-square test's requirements, the Fisher exact test was used. Statistics were computed using the InfoStat desktop software (version 2020) and RStudio (version 1.4.1717). For the analysis, the alpha-value was set to 0.05.

Results

Subadult analysis

Individual count method. The frequencies of analysed lesions observed at the individual level are shown in Table 2.

Table 2. Counts and frequencies of oral pathological conditions by individual count and age group in subadults.

Pathology	Age	Present	Absent	Fisher test (p)
Abrasio	Infans 1	3 (100.0%)	0 (0.0%)	–
	Infans 2	5 (100.0%)	0 (0.0%)	
	Juveniles	3 (100.0%)	0 (0.0%)	
	Total	11 (100.0%)	0 (0.0%)	
Caries	Infans 1	0 (0.0%)	3 (100.0%)	–
	Infans 2	0 (0.0%)	5 (100.0%)	
	Juveniles	0 (0.0%)	3 (100.0%)	
	Total	0 (0.0%)	11 (100.0%)	
Periapical lesion	Infans 1	0 (0.0%)	3 (100.0%)	–
	Infans 2	0 (0.0%)	5 (100.0%)	
	Juveniles	0 (0.0%)	3 (100.0%)	
	Total	0 (0.0%)	11 (100.0%)	
Hypoplasia	Infans 1	1 (33.3%)	2 (66.7%)	0.999
	Infans 2	2 (40%)	3 (60%)	
	Juveniles	1 (33.3%)	2 (66.7%)	
	Total	4 (36.3%)	7 (63.7%)	
Calculus	Infans 1	1 (33.3%)	2 (66.7%)	0.363
	Infans 2	4 (80.0%)	1 (20.0%)	
	Juveniles	3 (100.0%)	0 (0.0%)	
	Total	8 (72.7%)	3 (27.3%)	
Chipping	Infans 1	0 (0.0%)	3 (100.0%)	–
	Infans 2	0 (0.0%)	5 (100.0%)	
	Juveniles	0 (0.0%)	3 (100.0%)	
	Total	0 (0.0%)	11 (100.0%)	
Notching	Infans 1	1 (33.3%)	2 (66.7%)	0.121
	Infans 2	0 (0.0%)	5 (100.0%)	
	Juveniles	2 (66.7%)	1 (33.3%)	
	Total	3 (27.3%)	8 (72.7%)	

All the individual presented abrasion, however no caries and periapical lesions were observed on their teeth. The degree of abrasion increased with age, however tooth wear may have started at an early age as the youngest individual in our analysis (4–5-year-old) already exhibited abrasio media on the deciduous maxillary first incisors. Hypoplasia was found in 36.3% of the analysed subadult individuals, typically with more hypoplastic lines indicating more stress periods. The age at which hypoplasia lines appeared is shown in Table A2 (Annex). Most of the first enamel defects appeared at the age of 2.2–2.8 and 2.8–4.0 years, the second and third lines of hypoplasia usually appeared at 2.8–4.0 years old. It suggests a first stress period at 2.2–2.8 years and a second period at 2.8–4.0 years. Most of the subadults were affected by calculus as it was present in 72.7% of cases. Finally, no subadults presented chipping, whereas 27.3% presented notching. Statistical analysis did not show significant associations between age group and the presence of hypoplasia (p=0.999), calculus (p=0.363) or notching (p=0.121). For abrasion, caries, periapical lesions and chipping was not possible to carry out the Fisher test.

Tooth count method. Table 3 depicts pathological changes in deciduous and permanent teeth based on tooth count.

Table 3. Frequencies of oral pathological conditions by tooth count and age in subadults.

Pathology	Teeth	Age	Present	Absent	Chi^2 test (p)
Abrasion	Deciduous	Infans I	24 (96.0%)	1 (4.0%)	–
		Infans II	28 (100.0%)	0 (0.0%)	
		Juveniles	–	–	
		Total	52 (98.1%)	1 (1.9%)	
	Permanent	Infans I	0 (0.0%)	2 (100.0%)	<0.001
		Infans II	28 (41.8%)	39 (58.2%)	
		Juveniles	50 (83.3%)	10 (16.7%)	
		Total	78 (60.5%)	51 (39.5%)	
Hypoplasia	Deciduous	Infans I	0 (0.0%)	25 (100.0%)	–
		Infans II	0 (0.0%)	28 (100.0%)	
		Juveniles	–	–	
		Total	0 (0.0%)	53 (100%)	
	Permanent	Infans I	1 (50.0%)	1 (50.0%)	0.007
		Infans II	8 (11.9%)	59 (88.1%)	
		Juveniles	1 (1.7%)	59 (98.3%)	
		Total	10 (7.8%)	119 (92.2%)	
Calculus	Deciduous	Infans I	2 (8.0%)	23 (92.0%)	<0.001
		Infans II	15 (53.6%)	13 (46.4%)	
		Juveniles	–	–	
		Total	17 (32.1%)	36 (67.9%)	
	Permanent	Infans I	0 (0.0%)	2 (100%)	0.602
		Infans II	19 (28.4%)	48 (71.6%)	
		Juveniles	19 (31.7%)	41 (68.3%)	
		Total	38 (29.4%)	91 (70.6%)	
Notching	Deciduous	Infans 1	1 (4.0%)	24 (96.0.0%)	–
		Infans 2	0 (0.0%)	28 (100.0%)	
		Juveniles	–	–	
		Total	1 (1.9%)	52 (98.1%)	
	Permanent	Infans 1	0 (0.0%)	2 (100.0%)	0.311
		Infans 2	0 (0.0%)	67 (100.0%)	
		Juveniles	2 (3.3%)	58 (96.7%)	
		Total	2 (1.6%)	127 (98.4%)	

The total frequency of abrasion in deciduous teeth was 98.1%, while it was 60.5% in permanent teeth. The majority of deciduous teeth exhibited mild abrasion, predominantly characterized by abrasion media and abrasio superficialis II. There was an evident age-related increase in abrasion levels, as the mean abrasion score was lower in the Infans I age group (mean = 1.96) compared to the Infans II age group (mean = 2.42). Permanent tooth abrasion followed a similar pattern, increasing with age. In particular, the Infans II age group had a lower mean abrasion score (mean = 0.44) than the Juveniles (mean = 1.28), whereas the two permanent teeth from the Infans I age group had no discernible abrasion. Only permanent teeth (7.8%) showed hypoplasia. Calculus was found in 32.1% of deciduous teeth and 29.4% of permanent teeth. Notching was on 1.9% of deciduous teeth and 1.6% of permanent teeth. These permanent teeth with notching belonged to 2 distinct Juvenile individuals.

The chi-square test of independence between the age group and the presence of pathological alterations was significant for abrasion of permanent teeth ($p<0.001$), as the teeth of Juvenile age group show remarkably more abrasion. In the same way, the analysis is significant for hypoplasia ($p=0.007$). Although the Infans I age group showed the highest frequency, it is important to note that the sample size in this age group was limited to only two teeth. The analysis did not reveal a significant association between the age group and the presence of calculus on permanent teeth ($p=0.602$), however on deciduous dentition the frequency of calculus increased with age ($p<0.001$).

Adult analysis

Individual count method. The frequencies of abrasion, caries, periapical lesions, hypoplasia, and calculus based on the individual count method are shown in Table 4.

Table 4. Frequencies of oral pathological conditions by individual count and sex in adults.

Pathology	Sex	Present	Absent	Fisher test (p)
Abrasion	Males	9 (100.0%)	0 (0.0%)	–
	Females	6 (100.0%)	0 (0.0%)	
	Total	15 (100.0%)	0 (0.0%)	
Caries	Males	5 (55.6%)	4 (44.4%)	0.999
	Females	3 (50.0%)	3 (50.0%)	
	Total	8 (53.3%)	7 (46.7%)	
Periapical lesion	Males	1 (11.1%)	8 (88.9%)	0.999
	Females	1 (16.7%)	5 (83.3%)	
	Total	2 (13.3%)	13 (86.7%)	
Hypoplasia	Males	3 (33.3%)	6 (66.7%)	0.999
	Females	2 (33.3%)	4 (66.7%)	
	Total	5 (33.3%)	10 (66.7%)	
Calculus	Males	9 (100.0%)	0 (0.0%)	–
	Females	6 (100.0%)	0 (0.0%)	
	Total	15 (100.0%)	0 (0.0%)	
AMTL	Males	2 (22.2%)	7 (77.8%)	0.999
	Females	1 (16.7%)	5 (83.3%)	
	Total	3 (20.0%)	12 (80.0%)	
Chipping	Males	8 (88.9%)	1 (11.1%)	0.131
	Females	4 (66.7%)	5 (33.3%)	
	Total	12 (80.0%)	6 (20.0%)	
Notching	Males	1 (11.1%)	8 (88.9%)	0.999
	Females	0 (0.0%)	6 (100.0%)	
	Total	1 (6.7%)	14 (93.3%)	

All the individuals in the studied age groups presented abrasion and calculus (Fig. 1a, b). Caries was present in 53.3% of the individuals. Out of the 5 males who presented caries, 3 were categorized into the young adult age group, while the remaining 2 were categorized as middle and old adults. In the case of females, out of the 3 individuals with caries, one was a young adult and 2 were categorized into the middle adult age group (Fig. 1c). Interestingly, the young female had a high intensity of caries (13 teeth). Periapical lesions were present in 13% of the adults and all of them were categorized into the middle adult age group (Fig. 1d). Hypoplasia had a prevalence of 33.3% of the adults. Out of 3 males with hypoplasia, 2 were in the young adult age group and one in the middle age group, whereas the females were in the young age group (Fig. 1e).

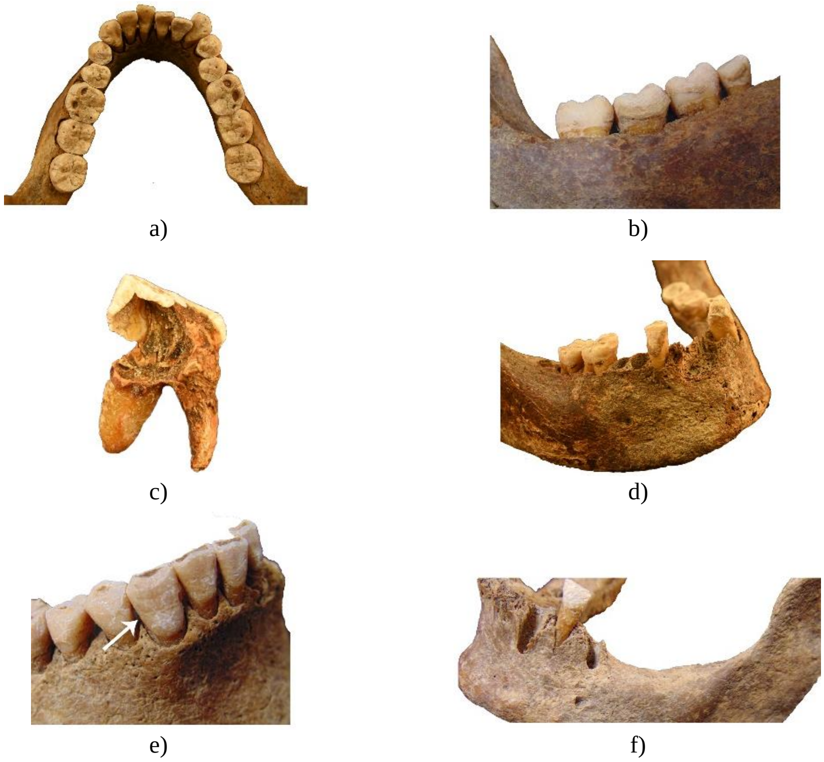

Fig. 1: Examples of the identified dental paleopathological alterations. a) Abrasio media on the permanent mandibular first molars (Obj: 150/150; 20–25-year-old male). b) Calculus on the permanent left mandibular molars and second premolar (Obj: 52/52; 20–25-year-old female). c) Caries type 4 on the permanent right maxillary first molar (Obj: 133/133; 50+ -year old female). d) Periapical lesion on the alveoli of permanent first mandibular incisors (Obj: 53/53; 40–50-year-old male). e) Linear enamel hypoplasia on the permanent right mandibular canine (Obj: 34/34; 20–24-year-old male). f) Antemortem tooth loss on the left side of the mandible (Obj: 133/133; 50+ -year old female).

The ages at which hypoplasia lines appeared are shown in Table A3 (Annex). Most of the first lines appeared at the age of 2.8–4.0 years and the second lines usually appeared at 4.0–5.2 years old. The total frequency of antemortem tooth loss is 20%, which is higher in males however, the absolute number of AMTL was low in both sexes (Fig. 1f). Chipping was present in 80% of adults and its frequency was higher in males. Notching was present in one male belonging to the old adult age group (6.7%). The Fisher test did not show a significant association between sex and caries, periapical lesions, hypoplasia, AMTL, notching (p=0.999) and chipping (p=0.131). For abrasion and calculus, it was not possible to carry out the Fisher test as these conditions were identified in every individual.

Tooth count method. Table 5 exhibits the frequencies of the examined pathological alterations based on tooth counts. Most teeth presented slight to moderate abrasion, with the most common grade of abrasio media. The abrasion on the mandibular teeth (mean = 2.38) was slightly less marked than the maxillary teeth (mean = 2.46). As expected, the degree of abrasion increased with age in the sample. Abrasion was less marked in young adult's teeth (mean = 2.09), followed by middle adult's teeth (mean = 2.76), and was most pronounced in old adult's teeth (mean = 3.18). Considering every tooth of the adults, the mean abrasion was 2.42.

Table 5. Frequencies of oral pathological conditions by tooth count and sex in adults.

Pathology	Sex	Present	Absent	Chi^2 test (p)
Abrasion	Males	257 (100.0%)	0 (0.0%)	–
	Females	143 (100.0%)	0 (0.0%)	
	Total	400 (100.0%)	0 (0.0%)	
Caries	Males	9 (3.5%)	248 (96.5%)	0.002
	Females	17 (11.9%)	126 (88.1%)	
	Total	26 (6.5%)	374 (93.5%)	
Periapical lesion	Males	4 (1.6%)	240 (98.4%)	0.970
	Females	2 (1.6%)	124 (98.4%)	
	Total	6 (1.5%)	364 (98.5%)	
Hypoplasia	Males	10 (3.9%)	247 (96.1%)	0.030
	Females	14 (9.8%)	129 (90.2%)	
	Total	24 (6%)	376 (94.0%)	
Calculus	Males	168 (65.4%)	89 (34.6%)	<0.001
	Females	59 (41.3%)	84 (58.7%)	
	Total	227 (56.8%)	173(43.2%)	
Chipping	Males	21 (8.2%)	236 (91.8%)	0.820
	Females	10 (7%)	133 (93.0%)	
	Total	31 (7.8%)	369 (92.2%)	
Notching	Males	2 (0.8%)	255 (99.2%)	0.750
	Females	0 (0.0%)	143 (100.0%)	
	Total	2 (0.5%)	398 (99.5%)	

The overall frequency of caries on teeth was 6.5%, with a higher prevalence in females (11.9%) compared to males (3.5%). Apart from a young adult female who exhibited a high intensity and severity of cavities, more severe cavities were observed in middle-aged and older adults (Table A4, Annex). To account for AMTL, the correlated caries rate was also calculated (Table A5, Annex). The corrected caries rate was also higher on female teeth (12.7%) in comparison with male teeth (7.3%). Conversely, in the analysis by bone, the mandibular teeth exhibited a higher observed and corrected caries rate (8.2% and 9.8%, respectively) compared to the maxillary teeth (4.7% and 8.7%, respectively).

The overall prevalence of hypoplasia was 6%, with females showing higher frequency (9.8%) than males (3.9%). Calculus had a total frequency of 56.8%, and it was more common in male dentition (65.4%). The overall frequency of periapical lesions was 1.5%, and it was the same for males and females (1.6%). The most common trauma on male teeth is chipping, found in 21 teeth (8.2%), followed by 2 teeth with notching (0.8%). The majority of chipping on male teeth occurred on the posterior teeth (maxillary and mandibular molars and premolars), notably on the mesiobuccal surface (Fig. 2a). Those chipped teeth belonged to 8 males. Notching was observed in two males, specifically on the mandibular second incisors and the right maxillary first incisor (Fig. 2b). In contrast to the males, the most prevalent trauma on female teeth was chipping (7%), which was found in 10 teeth, predominantly on anterior teeth (maxillary incisors, mandibular incisors and maxillary canine) rather than posterior teeth. These chipped teeth were attributed to 4 female individuals. There was no notching present in the female dentition.

The chi-square test of independence found a significant association between sex and the presence of caries (p=0.002), hypoplasia (p=0.030) and calculus (p<0.001), indicating that sex may influence the likelihood of these dental conditions. The statistical analysis revealed no significant association between the sex and periapical lesions of the mandibular and maxillary teeth (p=0.970), as well as chipping and notching (p=0.820 and p=0.750, respectively). These findings suggested that the occurrence of periapical lesions, chipping or notching was not influenced by sex within the examined sample.

a) b)

Fig. 2: Examples of the identified dental traumas. a) Chipping on the permanent right maxillary first molar (mesiobuccal and mesiolingual surface) and the buccal surface of the permanent right second premolar (Obj: 30/30, 50+ -year-old male). b) Notches on the permanent right maxillary first incisor (Obj: 30/30, 50+ -year-old male).

Discussion

In the subadult group, the absence of caries and periapical lesions suggested a relatively low prevalence of oral infections. The presence of medium abrasion at young ages, however, highlighted the wear and tear on their teeth, which might be linked to dietary choices, such as the consumption of abrasive foods or cultural practices. The presence of hypoplasia suggested periods of physiological stress during early childhood. The hypoplastic lines indicated the diverse occurrence of stress episodes, however, the timing of the first lines reflected the vulnerabilities of young individuals during 1.5–2.8 years of age. Calculus was found in a majority of subadult cases, which may be related to dietary factors, suggesting that a substantial portion of their diet consisted of foods conducive to calculus formation. The lack of a significant association between age group and calculus may imply a consistent dietary pattern across different subadult age groups.

Moving to the adult analysis, caries was notably present in a considerable percentage of adults, and its distribution between age groups showed a noteworthy prevalence among middle-aged individuals. Periapical lesions appearing in 13.3% of the adults were primarily associated with middle and old adult age groups. This finding may suggest that dental infections became more common as individuals aged, possibly related to a combination of factors, including dental wear and tear, which similarly exhibits an increasing trend with age.

Furthermore, besides dental wear and tear, dietary changes and overall health can also serve as triggering factors for the more intense formation of cavities. In the adult group, hypoplasia was observed in 33.3% of individuals, indicating that a substantial portion of the population experienced episodes of physiological stress during their childhood.

The examination of dental pathologies through the tooth count method added an extra layer of detail to the analysis, allowing for a more nuanced understanding of dental health. The observed sex differences in caries and calculus highlighted the potential role of sex-specific factors influencing oral health in the studied population. These factors might be related to dietary differences, as caries formation and calculus deposition may rely on the carbohydrate, protein and fat content of the diet (Forshaw 2004).

The majority of male teeth chipping was found on permanent maxillary and mandibular molars and premolars, notably on the mesiobuccal surface. Because the posterior teeth are more commonly employed for food processing than the anterior teeth it is feasible to conclude that tooth chipping in these cases is primarily caused by food processing. In the case of females, chipping was found predominantly on the maxillary and mandibular incisors and canines. As a result, it is possible to conclude that chipping on female teeth is caused by extramasticatory activities. Notching in adults is limited to three teeth, all of which were incisors, and they belonged to two male individuals in the old adult age group. In children, notches were present in 3 teeth (incisors) belonging to 3 different individuals (two of the Juvenile age group and one Infant of 5–6 years old). Both masticatory and extramasticatory activities can produce tooth chipping however, notches are primarily induced by extramasticatory activity (Bonfiglioli et al. 2004). It is possible that these individuals carried out activities relating to a specific work process.

For evaluating the results of the Avar Period sample, there were more sources from the literature that can be used as a comparative material. From the Transtisza region, Molnár (2000) analysed the oral health of the Late Avar Period population from Pitvaros-Víztározó archaeological site. Besides, some data was also available from another Late Avar Period site from the Transztisza region (Horváth et al. 1995). Évinger (2003) published his results about the palaeostomatological results of two Late Avar Period cemeteries (Toponár and Fészerlak – the name of the sites in the archaeological literature are Kaposvár-Toponár 40-es őrház and Kaposvár-Toponár-Fészerlak-puszta, respectively.) from Transdanubia. In addition, data on caries were also available from the Late Avar Period site in Austria (Meinl et al. 2010). Due to variations in methods and scoring of alterations, not all identified alterations in our study were published in the referenced papers. Consequently, we collected data suitable for comparison and presented it in Tables 6–7.

At the Nagykőrös site, over half of the individuals displayed at least one carious tooth. However, there were no significant differences between males (55.6%) and females (50.0%). This trend aligns with findings from Molnár's research at the Pitvaros-Víztározó site, where males exhibited 53.4% and females 50.0% prevalence of caries (Molnár 2000).

In the Transdanubian Avar Period population of Fészerlak, there was an elevated prevalence of caries among adults, with 76.1% of males and 71.7% of females displaying carious teeth. In contrast, Toponár, another Transdanubian Avar Period archaeological site, demonstrated a more skewed ratio of caries at the individual level. Specifically, 76.6% of females and 95.8% of males exhibited at least one tooth with a cavity (Évinger 2003).

Table 6. Summary of oral pathological conditions of different samples from the Avar Period.

Pathology	Site of skeletal remains Nagykőrös[1]	Toponár[2]	Fészerlak[2]	Pitvaros[3]
Analysed individuals	15	54	88	169
Caries	53.3%	85.1%	66.3%	54.7%
Antemortem tooth loss	20.0%	71.6%	51.1%	44.7%
Periapical lesion	13.3%	46.2%	45.9%	17.7%
Linear enamel hypoplasia	33.3%	58.6%	62.5%	11.5%
Analysed teeth	400	876	1465	3573
Caries	6.5%	24.7%	17.6%	6.7%
Linear enamel hypoplasia	6.0%	39.6%	49.7%	–

[1]: present study, [2]: Évinger (2003), [3]: Molnár (2000)

Table 7. Summary of oral pathological conditions by sex of different samples from the Avar Period (M: males, F: females).

	Site of skeletal remains							
	Nagykőrös[1]		Toponár[2]		Fészerlak[2]		Pitvaros[3]	
Pathology	M	F	M	F	M	F	M	F
Analysed individuals	9	6	24	30	42	46	81	82
Caries	55.6%	50.0%	95.8%	76.6%	76.1%	71.7%	54.3%	50.0%
Antemortem tooth loss	22.2%	16.7%	69.6%	73.5%	52.3%	50.0%	–	–
Periapical lesion	11.1%	16.7%	45.4%	47.0%	50.0%	23.9%	–	–
Linear enamel hypoplasia	33.3%	33.3%	64.5%	51.8%	76.1%	50.0%	–	–
Analysed teeth	257	143	424	452	769	696	1672	1640
Caries	3.5%	11.9%	22.6%	26.7%	18.2%	17.1%	7.4%	8.6%
Linear enamel hypoplasia	3.9%	9.8%	44.5%	32.9%	53.7%	43.9%	–	–

[1]: present study, [2]: Évinger (2003), [3]: Molnár (2000)

In the Toponár sample, the frequency of caries was considerably larger however, the ratio of the males (22.6%) and females (26.7%) teeth with caries was nearly equal. A similar trend was observed in the Fészerlak sample, but the intensity of the cavities on the teeth was not as elevated as in the Toponár sample. This discrepancy in our sample can be attributed to a female who presented a larger number of teeth with caries. Furthermore, it is important to note that the sample from Nagykőrös was the most limited in size among the compared samples. Consequently, even minor fluctuations in its dimensions can lead to significant variations in the proportions. The analysis by age indicated an increase in caries intensity, consistent with other available references.

The total frequency of caries in the Nagykőrös sample was 6.5%. This value is quite similar to those found in the Pitvaros sample (6.7%), however, a different percentage was found in a cemetery from the Avar Period in Austria (14.9%; Meinl et al. 2010) and Fészerlak cemetery (17.6%) and considerably different from the Toponár cemetery (24.7%). It is evident that the three sites display elevated rates of dental caries in comparison to the Nagykőrös and Pitvaros samples. These values may be attributed to carbohydrate consumption as well as to poor dental hygiene habits. Moreover, their place on the social hierarchy may also have an impact on their oral health status.

Based on the individual count method, the total frequency of periapical lesions was 13.3%. This value is relatively lower when considering the percentage of periapical lesions found in the Fészerlak (45.9%) and Toponár cemeteries (46.2%). These high values, particularly in the Toponár Cemetery, exhibit a notable association with dental caries, which are also elevated when considering the caries found at the Fészerlak cemetery. Furthermore, it was not possible to compare the severity of caries between cemeteries.

The total frequency of hypoplasia based on the individual count method was 33.3%, whereas in Toponár cemetery was 58.6% and in Fészerlak was 62.5%. It showed a big discrepancy in comparison with our sample and implies that Toponár and Fészerlak may have been exposed to a greater degree of stress or, they had a greater chance of surviving stress. The analysis of Pitvaros cemetery provided a considerably smaller occurrence of linear enamel hypoplasia with 11.54%. Moreover, there was comparative data from the Trans-Tisza region, where at the Szarvas site, enamel hypoplasia had been identified in 27% of the individuals (Horváth et al. 1995).

These findings provide valuable insights into the oral health, dietary habits and lifestyle of the population from Nagykőrös of the Avar Period. However, it is important to consider the relatively small sample size significantly can influence the prevalence of dental conditions. Finally, comparisons with other cemeteries and populations of the Avar Period, have highlighted interesting variations in dental health of our sample.

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ANNEX

Table A1. Tooth count for maxilla and mandible in subadults and adults (d: deciduous teeth).

	Subadults			Adults				
				Males		Females		
Tooth	Maxilla	Mandible	Total	Maxilla	Mandible	Maxilla	Mandible	Total
dI1	1	2	3	–	–	–	–	–
dI2	3	2	5	–	–	–	–	–
dC1	6	4	10	–	–	–	–	–
dM1	5	8	13	–	–	–	–	–
dM2	9	13	22	–	–	–	–	–
I1	14	11	25	16	16	9	7	48
I2	9	14	23	15	16	7	8	46
C1	6	9	15	18	17	9	11	55
PM1	5	7	12	14	16	10	12	52
PM2	5	6	11	16	18	9	11	54
M1	15	16	31	17	18	12	10	57
M2	5	7	12	16	17	8	10	51
M3	–	–	–	12	15	4	6	37
Total	83	99	182	124	133	68	75	400

Table A2. Estimated times of the formation of linear enamel hypoplasia in subadults.

Individual	Tooth	Lines	Age line (years)
40/40 (6–7-year-old)	RI^1	1st	2.2–2.8
		2nd	2.8–4.0
	LC_1	1st	2.2–2.8
		2nd	2.8–4.0
		3rd	4.0–5.2
	LI^1	1st	2.2–2.8
		2nd	2.8–4.0
60/60 (9–11-year-old)	RM_2	1st	1.5–2.2
		2nd	2.2–2.8
	LPM_2	1st	4.0–5.2
		2nd	5.2–9.0
	RI^1	1st	1.5–2.2
		2nd	2.2–2.8
		3rd	2.8–4.0
	LI^1	1st	1.5–2.2
		2nd	2.2–2.8
		3rd	2.8–4.0
	LM^2	1st	5.2–9.0
110/110 (13–14-year-old)	LI^2	1st	2.2–2.8
		2nd	2.8–4.0
129/129 (4–5-year-old)	LC_1	1st	4.0–5.2

Table A3. Hypoplasia lines formed in adults.

Individual	Tooth	Lines	Age line (years)
34/34 (male, 25–35-year-old)	RI_2	1st	2.8–4.0
	RC_1	1st	2.8–4.0
		2nd	4.0–5.2
	RPM^1	1st	4.0–5.2
	LC^1	1st	4.0–5.2
	LPM^1	1st	9.0–14
	LPM^2	1st	9.0–14
51/51 (female, 20–25-year-old)	LI^1	1st	1.5–2.2
		2nd	2.8–4.0
	LI^2	1st	2.8–4.0
	LC^1	1st	2.8–4.0
		2nd	4.0–5.2
	LPM^1	1st	5.2–9.0
	LM^1	1st	2.2–2.8
52/52 (female, 20–25-year-old)	RC_1	1st	2.8–4.0
		2nd	4.0–5.2
	RC^1	1st	4.0–5.2
	RPM^1	1st	5.2–9.0
	RPM^2	1st	5.2–9.0
	RM^1	1st	2.2–2.8
	RM^2	1st	4.0–5.2
		2nd	5.2–9.0
	LPM^1	1st	4.0–5.2
	LPM^2	1st	4.0–5.2
	LM^2	1st	5.2–9.0
141/141 (male, 25–30-year-old)	LPM_1	1st	4.0–5.2
	RC^1	1st	1.5–2.2
		2nd	2.2–2.8
	RI^2	1st	2.8–4.0
145/145 (male, 35–45-year-old)	LC_1	1st	2.2–2.8
		2nd	2.8–4.0

Table A4. Degree of caries by age, sex and tooth in adults.

	Degree of caries				
	1	2	3	4	Total
Males					
20–35 years old	2	1	0	0	3
35–50 years old	0	0	1	0	1
50+ years old	0	1	2	2	5
Females					
20–35 years old	6	2	5	0	13
35–50 years old	1	1	1	1	4
50+ years old	–	–	–	–	–

Table A5. Tooth count of pre-mortem (PE) and post-mortem (PO) teeth loss and prevalence rates for caries in adults.

Group	Teeth present	PE	PO	Observed caries rate	Corrected caries rate
Sex – Male	257	4	13	3.5%	7.3%
– Female	143	7	20	11.9%	12.7%
Bone – Mandible	208	7	14	8.2%	9.8%
– Maxilla	192	4	18	4.7%	8.7%
Total	800	22	65	6.5%	9.0%