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Dental health evaluation of ancient Philadelphia society (Karaman, Turkey)*

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Abstract

A total of 53 human skeleton dated to 3rd Century CE were found in the Philadelphia rock tomb excavations and 422 permanent teeth from these findings were used in this study. This study on dental health comprises evaluations of dental wear, caries, abscess, dental calculus and antemortem tooth loss. Caries is found to be 6.9 % in 422 teeth, wear is calculated to be 2.82 on average, the frequency of abscess is 1.67 %, calculus frequency is 18.72% and graded to be 1.96 based on Buikstra and Ubelaker's scale. The rate for antemortem tooth loss is 16.6 %. Based on these results, the caries, abscess, calculus and antemortem tooth loss are compared with some other populations from the Roman Era. According to this comparison, dental caries, abscess and dental calculus frequencies are lower than other Roman sites, just antemortem tooth loss is a higher degree of prevalence. The results show that the Philadelphia skeletons are found to be healthier regarding oral and dental health except among the Roman sites. Furthermore, the results point out a diet which is based on protein intake rather than a carbohydrate rich diet. This is a preliminary study on Philadelphia society and ongoing excavations will reveal more details about the society in the near future.

Keywords: Ermenek; Philadelphia ancient city; dental health; dental pathology

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Introduction

Dental analyses are one of the most important parts of bioarcheological studies. Beside the revealing the oral health of the individuals and societies, important data on the diet of the societies can be reached as the result of dental studies.

Anatolia, as being an important corridor among three continents, hosts numerous civilizations both in prehistoric and historic times. Ancient humans spread the whole Anatolia and adapted different environments and lifestyles. Thus, an important variation in their lifestyles emerged and it also affected skeletal systems, especially teeth. Numerous studies were conducted on skeletal remains from ancient Anatolia in order to assess the oral health of these ancient societies (1).

In this study, it is aimed to reveal dental pathological lesions from a Roman site, Philadelphia, from Central Anatolia. This is the

The city was a part of Cetis region in Isauria-Cilicia Tracheia (2). Ramsay pointed out that that Philadelphia should be located between ancient cities of Germenikopolis and Laranda (3). The city was dated back to the 3rd century AD according to archaeological finds.

The necropolis area of Philadelphia is rocky and partly plains just above Çamlıca and Gökçeseki Villages, which is reached after the 20th km of the modern road between Ermenek and Mut. The necropolis of the city was covered by mostly rock tombs and also some sarcophagi (4).

The excavation was conducted in 2015 under the presidency of Karaman Museum and scientific consultancy of Ass. Prof. Dr. Ercan Aşkın. Th fieldwork mainly focused on sarcophagi area and a rock tomb (5), Figure 2.

The skeletons were transported to Anthropology Laboratories of Burdur Mehmet Akif Ersoy University for scientific analysis. After cleaning
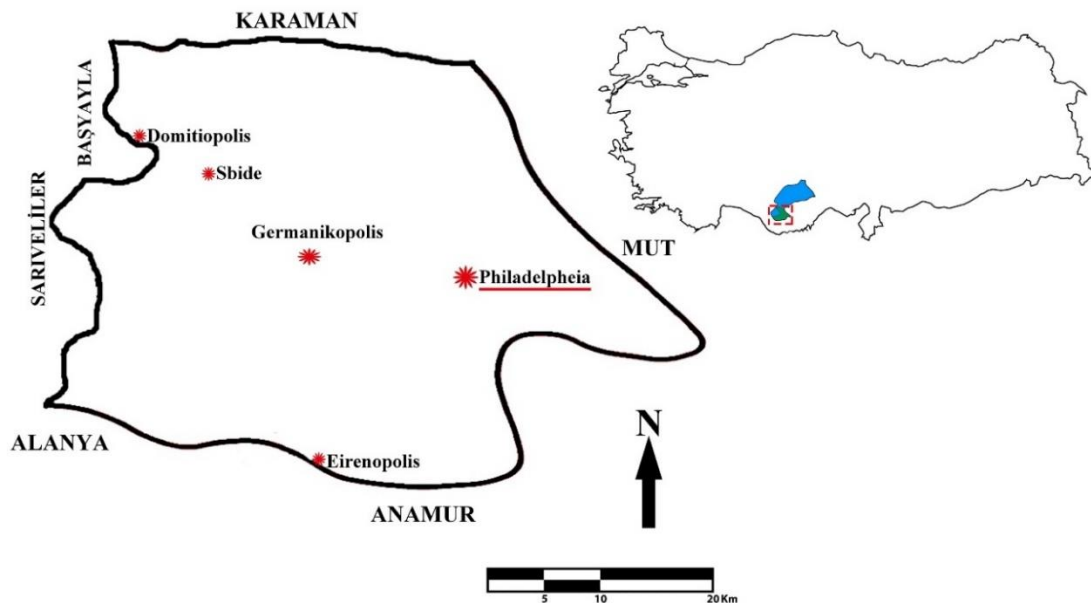
Figure 1 The location of Philadelphia Ancient City.

first bioarcheological study from the site and focuses on the caries, dental calculus, dental wear and antemortem tooth loss of the Philadelphia society.

Materials and Methods

The skeleton material was obtained from the ancient city of Philadelphia in Ermenek district of Karaman province in modern Anatolia (Figure 1).

and reconstruction, the demographic analyses were conducted. Sex determination and age of death estimation were done through morphological analysis of cranium (glabella, processus mastoideus, processus zygomaticus, tuber frontalia and parietalia, inclination of frontal, orbital form, supra orbital margin, sutural obliteration, craniofacial morphology), mandible (total aspect, mandibular angel, margo inferior,

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dental wear), os coxae (auricular surface, incisura ischiadica major, angulus pubis, arc compose, foramen obturatum, corpus ossis ischii, crista iliaca, fossa iliaca, pelvis major, pelvis minor and subpubic angle), clavicle (medial epiphysis and cortical index) and femur (proximal end) (6-14).

A total of 53 individuals were examined. The distribution of the individuals was determined as; 24 adults (17 male, 7 female), 1 adolescent, 11 children and 4 infants. Sex and age of 14 individuals could not be determined due to insufficient data.
The age distribution of male adults is; 6 young adults, 6 middle adults and 5 old adults. For the female adults, the distribution is; 6 middle adults and 1 old adult.
Permanent teeth were analyzed for antemortem tooth loss, wear levels, calculus, caries and abscess.

Results
A total of 422 permanent teeth were examined in order to reveal the oral health of the individuals. The distribution of examined teeth is given in Table 1.

Table 1. Distribution of examined teeth.

Type	Number of teeth
I1	32
I2	32
C	58
P3	58
P4	53
M1	76
M2	72
M3	41

Dental Caries
The frequency of dental caries is observed as 4.97 % in 422 teeth. After Lucas (15) correction (considering antemortem tooth loss), corrected rate was determined as 6.9%. Most common caries frequency is seen in molar (totally 36 teeth with caries) and the least common is seen in incisive (totally 7 teeth with caries). When the caries was evaluated by tooth type, the rates were; 8.46 % for molars, 2.7 % for premolars, 1.72 % for canines and 1.56 % for incisive. Each caries lesion was counted as '1' for related tooth.

Dental Wear

Figure 2 Philadelphia rock tomb (5).

Dental wear was observed in all of the examined teeth and most of them can be classified as moderate (2.82 on average) (Table 2). Most common degree is 3 for incisive, 2 for canine, 2 for premolar and 3 for molar. The least common degree is 1 for incisive, 4 for canine, 4 for premolar and 5 for molar. Advanced wear was not observed. Wear degrees were evaluated by the criteria of Buisktra & Ubelaker (9).

Table 2. Dental wear degrees for each tooth.

Type	Number of examined teeth	Wear Degree
I1	32	3,12
I2	32	2,75
C	58	2,51
P3	58	2,62
P4	53	2,83
M1	76	3,51
M2	72	2,79
M3	41	2,43

Abscess
Totally 540 alveolar sockets were evaluated for abscess formation (Figure 3) and frequency for abscess formation was found as 1.67 %. Most common abscess frequency is seen in second molar (totally 18 teeth with abscess) and the least common is seen in central incisive (totally 7 teeth with abscess). When the abscess was evaluated by tooth type, the rates were; 1.36 % for central incisive, 2.74 % for lateral incisive, 2.67 % for canines, 1.42 % for third premolars, 1.45 % for first molars, 3.34 % for second molars. No

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abscess was found in the fourth premolars and the third molars.

Dental Calculus
Dental calculus degree was evaluated by the criteria of Buisktra & Ubelaker (9). 79 of 422 teeth possess dental calculus (18.72 %) (Figure 4). Each tooth was evaluated separately (Table 3) and total degree for the whole material was found 1.96.

Table 3. Number and calculus degrees for each tooth.

Type	Number of observed calculus	Calculus Degree
I1	5	1,8
I2	8	2,12
C	6	2,33
P3	5	2
P4	8	2
M1	16	1,81
M2	18	2
M3	13	1,84

Antemortem tooth loss
24 of 53 individuals have maxilla and mandibula fragments and a total of 90 antemortem tooth loss was observed in 540 alveolar sockets (16.6 %) (Figure 5). The highest frequency was observed in molar whereas the lowest was in incisive (Table 4).

Evaluating all of the dental pathologies in Philadelphia society; it can be seen that most common pathology is antemortem tooth loss when the least common pathology is abscess. There are no other documented dental pathologies in Philadelphia society.

Table 4. Observed antemortem tooth loss number for each tooth type.

Type	Number of ATL
I1	7
I2	7
C	7
P3	8
P4	13
M1	19
M2	16
M3	13

Discussion
Dental health status of Philadelphia society was evaluated in this study. Anthropological analyses revealed the frequencies and rates of dental caries, dental wear, abscess, dental calculus and antemortem tooth loss. Then the results were compared with other sites in the different regions in Anatolia.

Dental caries is one of the most common pathologies in bioarcheological material. It is characterized by multifactorial demineralization of the tooth and generally associated with a carbohydrate rich diet. In general, a low frequency of caries can be seen as a result of low carbohydrate and high protein intake. The frequency of dental caries is observed as 4.97 % in 422 teeth (corrected rate is 6.9 %).

The highest frequency among all tooth types is observed in molars (8.46 %) which is a general trend because of the morphological characters of the molars (large surface, early eruption etc.). A low frequency of caries indicates a protein rich diet rather than a carbohydrate-based diet in Philadelphia, or at least a balanced diet. Caries frequencies were determined as 3.6 % in Parion (16), 4.7 % in Amasya (17), 6.19 % in Midyat (18), 9.12 % in Akgüney (19), 9.5 % in Aslantepe (20), 11.11 % in Panaztepe (21), 12 % in Dara (22), 12.7 % in Kerti Höyük (23) and 12.9 % in Spradon (24). As having a 6.9 %, it can be concluded that caries frequency is lower than most of the Roman sites and thus much lower than the Roman average. Since the number of studied individuals is relatively low, a clear distinction cannot be done about the dental caries frequency among the age groups and between sexes. Nevertheless, it can be said that the highest frequency is seen in middle adults for both sexes. But more detailed study is planned when more skeletal is exhumed in future.

After caries, dental calculus is the most common dental disease in general, and the frequency is 18.72 in Philadelphia. It is mineralized dental plaque and can be a reason of periodontal diseases. Again, as same as in caries, the most affected teeth are the molars. Calculus frequencies were determined as 2.9 % in Amasya (17), 14.75 % in Panaztepe (21), 17.95 % in Parion (16), 28.98 % in Akgüney (19), 42.95 % in Midyat (18), 54.9 % in Kerti Höyük (23) and 68.98 % in Dara (22). Dental calculus frequency of Philadelphia (18.72 %) is lower than most of the Roman sites same as in caries. Although there is a relationship between calculus and diet, the

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exact reason is not clear since both carbohydrate and protein rich diets can cause calculus formation (25-27). The rate of calculus is not as high as in most of Anatolian Roman sites, nevertheless, it can be an indicator of relatively high protein intake especially when we consider the low frequency of caries in Philadelphia population.
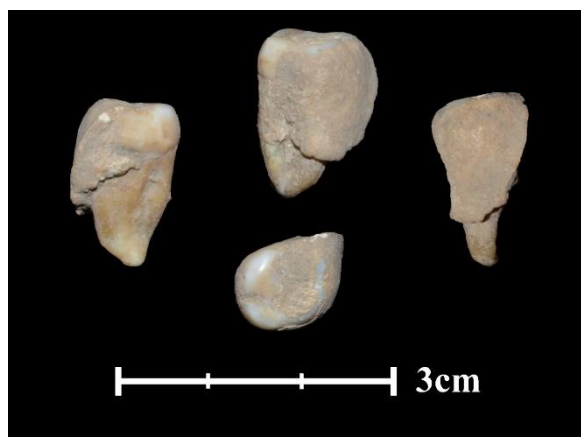

Figure 3. An abscess formation.

Figure 4. Calculus deposition on a molar.

Figure 5. Antemortem tooth loss in mandible.

In 540 teeth sockets, frequency for abscess formation was found as 1.67 %. Abscess frequencies were determined as 1.16 % in Akgüney (19), 1.7 % in Amasya (17), 3.71 % in Dara (22) and 9.29 % in Midyat (18). In this case, again, the frequency is lower than other Roman sites, except Akgüney. Abcess is one of the most common periodontal diseases and generally associated with caries and high level of dental wear. When we consider relatively low frequency of these factors in Philadelphia, a low abscess rate is plausible.

Oral pathological lesions in Philadelphia have a lower rate when we compare with contemporary Roman sites. The exceptional case is seen in antemortem tooth loss.

Antemortem tooth loss frequencies were determined as 6.04 % in Parion (16), 7.15 % in Dara (22) and 7.82 % in Akgüney (19), when the frequency is 16.6 % in Philadelphia. Among examined individuals, it is seen that almost all of the antemortem tooth loss cases belong to old adults. Thus, the high frequency of the antemortem tooth loss can be interpreted as a result of aging, rather than poor level of oral health. The real frequency of antemortem tooth loss will be put forth when the new skeletal series from the site are examined.

Dental wear is classified as moderate in general and heavy dental wear is not recorded in Philadelphia society. Most affected teeth are first molars and central incisors, while the least affected teeth are third molars and canines. Both dietary and non-dietary factors play roles in dental wear. It is also known that there is a positive correlation between wear and aging. However, even old adult individuals don't possess any advanced dental wear and it is also an indicator of a relatively soft diet for Philadelphia society.

After comparing the results of this study with the contemporary sites in Anatolia, it is seen that dental pathologies have lower frequencies than other sites. Thus, it indicates that oral health of Philadelphia society was in a better condition. It can be also pointed out that the diet of the Philadelphia society was not based on very hard nutritional elements. Since the excavations are relatively new and archaeological record is not intense yet, it is impossible to find out the archaeological data about the nutrition economy of the Philadelphia society.

Furthermore, in the light of the results, it can be also said that protein intake was also notable comparing carbohydrate values.

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Conclusion

Philadelphia skeletons is found to be healthier regarding oral and dental health except for the frequency of antemortem tooth loss. Furthermore, the results point out a diet which based on protein intake rather than carbohydrate rich diet. Ongoing excavations in the site are revealing new archaeological and skeletal material. After examining the new material, much more information about the economic structure and dental health of the ancient Philadelphia society will be put forth in future. It is also planned to see the differences between males and females when a large number of individuals are analyzed.

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Declaration of Interest

The authors state that there is not declaration of interest.

Author contributions

AYY and SY did osteological analyses on the skeleton. All of three authors examined the results. AİA and AYY wrote the manuscript.

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