Dental Caries and Tooth Wear in a Byzantine Paediatric Population (7th to 10th Centuries AD) from Yenikapı-Constantinople, Istanbul

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Key Words
Byzantine era · Children · Dental caries · Dental wear · Paediatric population

Abstract
Dental caries and wear are important conditions to record in archaeological collections. The aim of the present paper is to determine the frequency and distribution of dental caries and dental wear in a mediaeval Byzantine paediatric population in Yenikapi, Constantinople, Istanbul. The present research was carried out on the skeletal remains of 1 infant and 28 children with a total of 180 teeth (113 primary and 67 permanent teeth). The frequency of ante-mortem tooth loss in the sample was 1%. The total frequency of carious lesions in the sample was 2.2%. The frequency of dental wear was rather low (3.3%) exhibiting presence of dentin clusters mostly. The present study evaluated an archaeological collection with low dental wear and low dental caries prevalence indicating a fishing community.

Dental findings of ancient populations give us important data regarding health care within a community. While dental caries is caused by the demineralization of dental tissues by organic acids released during the breakdown of carbohydrates by bacteria under genetic control, caries frequency is more affected by cultural factors such as dietary habits, nutrients and food production techniques. Ollson and Sagne [1976] and Hillson [2001] recently stated that ‘the frequency and distribution of dental caries in ancient populations enable us to follow their economic, social, and cultural progress through different historic eras’. At this point diagnosis and evaluation of archaeological dental tissue and past lifestyles would indicate what they consumed and how they lived [Lukacs, 1989].

In the literature, there are limited data regarding dental health of the ancient Byzantine population [Caglar et al., 2007]. Yenikapi is a Byzantine architectural-archaeological complex that was found during the Istanbul Marmaray metro project which began in 2004. Yenikapi is located on the southern shores of the Marmara Sea, inside the Historical Peninsula, and corresponds to the largest harbour of the Byzantine capital of Constantinople. Many skeletal remains, Byzantine buildings including Theodosis Harbour, a church complex, over 30 shipwrecks and thousands of archaeological artefacts were excavated in Yenikapi [Asal, 2010]. The skeletal remains also include an important paediatric population dating from the 7th to 10th centuries AD. To our knowledge, regarding den-
tistry, there are no recent studies referring only to an ancient paediatric population. Therefore the aim of the present paper is to determine the frequency and distribution of dental caries and dental wear in a mediaeval Byzantine paediatric population in Yenikapi, Constantino-
ple, Istanbul.

**Materials and Methods**

The present research was carried out on the skeletal remains of 1 infant and 27 children excavated in 2004 from the archaeological site in Yenikapi, Istanbul downtown. The samples were stored and preserved in ISTYAM, Yıldız University, Istanbul. All available skulls were analysed, regardless of the level of damage. The state of preservation varied from completely preserved skulls with complete mandibles to cases where only small fragments of the mandible were preserved.

Age classification was carried out according to the criteria of Watt et al. [1997]. Samples were classified into the following groups: 0–6 months (infant edentulous), 0.5–5 years (primary dentition), 6–12 years (mixed dentition). Tooth loss was classified as ante- or post-mortem. Teeth were considered lost post-mortem if there was clear evidence of alveolar sockets. Teeth were diagnosed macro-scopically under a bright light, with the help of a dental probe.

**Evaluation of Dental Caries**

Evaluation of dental caries was detected according to the method of Caglar et al. [2007]. A carious lesion was considered present if there was a clear defect in tooth tissue. Colour changes of the enamel were not considered as caries unless there was cavitation underneath. The number of caries lesions, as well as their location (fissure, occlusal, mesial, distal, buccal, and lingual) was recorded. Caries frequencies, i.e. frequencies of carious lesions on the various tooth surfaces, were calculated. The skeletal root index was not calculated.

**Evaluation of Dental Wear**

Dental wear was graded according to the Brabant [1962] index. The following levels of wear were employed:
0 = no wear, no loss of surface features; 1 = wear limited to enamel; 2 = presence of dentin exposure; 3 = most dentin still covered; and 4 = involvement of pulpal horns or pulpal exposure.

This index is easy to use, appropriate and was used in a recent Byzantine archaeological study [Caglar et al., 2007].

**Results**

The analysed sample consisted of the skeletal remains of 28 children (table 1) that had a total of 180 teeth (113 primary and 67 permanent teeth). The number of teeth analysed as well as the frequencies of ante-mortem and post-mortem tooth loss were recorded. There was 1 infant (aged 0–6 months) with edentulous ridges. There were 5 individuals (aged from 0.6 months to 5 years) with a total of 23 teeth with no ante-mortem loss. Twenty-two individuals (aged 6–12 years) exhibited a total of 157 teeth where there were only 2 teeth lost ante-mortem (loss rate 1.2%). The total frequency of ante-mortem tooth loss for the sample was 1%.

The group aged 0.6 months to 5 years exhibited a total of 54 teeth lost post-mortem (loss rate 75%). The group aged 6–12 years exhibited a total of 61 teeth lost post-mortem (loss rate 27.23%). The total frequency of post-mortem tooth loss for the sample was 38.85%. Incisors were the teeth most frequently lost post-mortem while primary and permanent molars had the highest rate of preservation. Nearly 10% of the analysed children have 1 carious lesion. All from the 5 children in the group aged 0.6 months to 5 years were found to be caries free. In the 6- to 12-year age group, 2 individuals (9%) were observed to have 4 carious teeth (2 primary and 2 permanent molars).

Table 2a and b shows the frequencies of carious lesions regarding tooth type in primary and permanent dentitions. Regarding primary dentition, primary incisors and canines were caries free (0%) while 7.1% of first primary molars and 6.2% of second primary molars were carious (table 2a). Analysis by permanent tooth type showed that central incisors, lateral incisors, canines, 1st premolars, and 2nd premolars had caries in 0%, 1st molars in 4.3%, and 2nd molars in 50% (table 2b). The total frequency of carious lesions in the sample was 2.2%.

There were only 2 mesial and 2 distal caries lesions in adjacent teeth. No fissure, lingual, and buccal lesions were noticed.

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**Table 1. Preservation of the skeletal remains**

<table>
<thead>
<tr>
<th>Level of preservation</th>
<th>Individuals, n</th>
<th>Maxillas, n</th>
<th>Mandibles, n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Preservation of both maxilla and mandible and preservation of more than 50% of alveolar bone</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>2 Preservation of both maxilla and mandible but with preservation of less than 50% of alveolar bone</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3 Preservation of only the maxilla or the mandible and preservation of more than 50% of alveolar bone</td>
<td>18</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>4 Preservation of only the maxilla or the mandible and preservation of less than 50% of alveolar bone</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>17</td>
<td>16</td>
</tr>
</tbody>
</table>
Regarding the children exhibiting dental wear, while none of the permanent teeth had dental wear (0%), only 6.6% of primary teeth exhibited dental wear in the 5 children of the 6- to 12-year age group (22.7% of the present group, 18.5% of all individuals). Only a few maxillary and mandibular primary molars exhibited presence of dentin clusters as most of the dentin had the appearance of being covered by enamel.

Table 3a and b shows the frequency and distribution of dental wear regarding each tooth in primary and permanent dentition. Analysis by tooth type showed that central incisors, lateral incisors, canines, 1st premolars, 2nd premolars, 1st molars and 2nd molars had 0% of dental wear.

Regarding dental wear, 168 teeth (63 maxillary, 105 mandibular; 93.3%) had no loss of surface features. Only 1 mandibular tooth was coded as 1 and 3 (0.5% each). The most frequent level of dental wear examined was code 2 with 6 maxillary and 4 mandibular teeth (5.5%) showing presence of dentin exposure. No teeth exhibited involvement of pulpal horns or pulpal exposure.

**Discussion**

The Yenikapı precinct, the former largest harbour of the Byzantine capital known as the harbour of Eleutherius or Theodosius, was planned to be a metro station of the intercontinental subway. Excavations were made under the authority of Istanbul Archaeological Museums. The skeletal remains were recently brought to Istanbul University Forensic Medicine Institute to establish the anatomical reconstruction while age, sex, and stature assessments were carried out [Görgülü, 2009].

Established by Theodosius I. (379–395 BC), Yenikapi had been a desirable precinct for the Byzantine aristocracy from the 5th to 11th centuries [Magdalino, 2000]. It consisted of a major forum, the harbour, 11 streets, 363 houses, 3 great porticoes, 5 baths, 5 bakeries, small shops, mitata (special lodging houses for merchants), warehouses and fora [Görgülü, 2009].

The literature confirms that the study of pathological changes in the dental systems of mediaeval populations serves as important resource for evaluating life conditions of archaeological populations [Varrela, 1992; Barthélémy et al., 1999; Djuric Srejic, 2001]. The paediat-
ric population in Yenikapı was excavated from a church graveyard indicating that they were offspring of the aristocracy. However, it is evident that paediatric science in Byzantine was not well organized. Byzantine physicians recognized the main otolaryngological problems of childhood, including asthma, and prescribed medical treatments [Ramoutsaki et al., 2002]. Yet scientific evidence attests to the high rate of infant and child mortality in Byzantium, which may have approached 50% by the age of 5 [Talbot, 1984]. Although the almost universal practice of breast-feeding must have provided children with a relatively safe supply of milk and built up their antibodies, they were still prone to malnutrition and anaemia, and no doubt many died from diarrhoeal diseases and infections [Lunt, 1974].

Regarding dental health, there is limited information from Byzantine times [Mylonas et al., 2014] where tooth brushing was probably not practiced. The present condition highlights the importance of diet. The solidify of food in a diet affected the localization of caries. In populations whose nutrition is based on solid food, which extensively abrades teeth, higher frequencies of interproximal caries are recorded. Due to abrasion, the occlusal surface is worn out and smoothed and is no longer a predilection spot for caries development. Vodanovic et al. [2005] considered that there is a reduced contribution of interproximal caries in the total frequency of caries in modern populations. The increase in the number of caries is related to an increase in carbohydrate consumption where this tradition has not been changed from recent centuries to our days of refined sugar [Caglar and Kuscu, 2016]. Also, caries frequencies depend on the economy of the society [Hobdell et al., 2003]. Low caries frequencies are found in fishing and hunting communities (0.0–5.3%), while high caries frequencies are recorded in agricultural communities (2.3–26.5%). The present finding of a caries frequency of 2.2% in this paediatric population supports the hypothesis of the fishing society. This marine society never consumed hot food at home, often found it cheaper to eat it in taverns where hot meals were served. The recent literature [Koder, 1993, 2002; Caglar et al., 2007] noted that – not to be compared with a modern western diet – the coasts of the Marmara Sea possibly enabled Yenikapı residents to consume a variety of food types including wine and fresh fish [Balaska and Selenti, 1998] in comparison to many other societies in mediaeval times. Additionally in Yenikapı, malt drink and wine in amphoras, and cherries in baskets were found in a shipwreck coded ‘YK12’ from the 9th century AD [Pulak, 2007]. Fruit juice and wine were vital for Byzantine children.

### Table 3. Prevalence of dental wear

<table>
<thead>
<tr>
<th>Age group</th>
<th>Maxilla</th>
<th>Mandible</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>i1</td>
<td>i2</td>
<td>i1 + i2</td>
</tr>
<tr>
<td>0.5–5 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teeth present, n</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Worn teeth, n</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Worn teeth, %</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6–12 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teeth present, n</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Worn teeth, n</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Worn teeth, %</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Maxilla</th>
<th>Mandible</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I1</td>
<td>I2</td>
<td>I1 + I2</td>
</tr>
<tr>
<td>Teeth present, n</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Carious teeth, n</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Carious teeth, %</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Primary dentition: i = incisor; c = canine; m = molar. Permanent dentition: I = incisor; C = canine; P = premolar; M = molar.
dren as the fresh water source was limited. The lack of sugar cane, sugar types, sweeteners, biscuits and carbonated beverages should be underlined in the mediaeval Byzantine diet [Caglar et al., 2007].

There are recently analysed ancient European populations from the late Middle Ages, such as Bijelo Brdo [Vodanovic et al., 2005], Stenjevec, Dakavo, Deklevec, Stitarjevo, and Vinkovci from Croatia [Ramoutsaki et al., 2002], Clopton [Tattersall, 1968] from England, La-Selvicciola [Manzi et al., 1999] from Italy, Aberdeen [Telmont, 1984], Linlithgow [Kerr et al., 1990], Kirkhill [Lunt, 1974], and Whithorn [Watt et al., 1997] from Scotland, Eski Cezaevi [Duyar and Erdal, 2003] and Iznik [Erdal, 1996; Caglar et al., 2007] from Turkey. However, these populations generally consisted of adult skeletons, and it seems hard to compare the present data with the latter.

Tooth wear was not prominent in our samples. Low wear in the present archaeological population can be linked to age effects of attrition and non-abrasive diet of a fishing society of which some signs are found in the Byzantine diet. According to Caglar et al. [2007], it would be suitable to use the term ‘dental wear’ instead of erosion or attrition. It was noted that to evaluate erosion and attrition, live biological information and clinical examination of the teeth were necessary. In an archaeological population, a key element, evaluation of the proper diet, is missed of the teeth were necessary. In an archaeological population, a key element, evaluation of the proper diet, is missed whereas in the present study – as the sample is a paediatric one – it is more complex. Generally, erosion can be distinguished from wedge-shaped defects which are located at or apical to the enamel-cementum junction. Further progression of occlusal erosion leads to a rounding of the cusps, grooves on the cusps and incisal edges, and restorations rising above the level of the adjacent tooth surfaces. The distinction between occlusal erosion and abrasion/demastication is much more difficult, which sometimes are of similar shape. Significant occlusal tooth wear from mastication can occur either in the presence of high amounts of abrasives in the food bolus or in the case of acid softening of enamel and dentine. In a recent study [Caglar et al., 2007] 4 children of 6–12 years of age had a dental wear of 100%, whereas the present paediatric population of the same age era did not show any dental wear. This might be due to the nature of the society, i.e. its use of a soft diet. To our knowledge, the present study is the first to evaluate dental caries and dental wear together in a mediaeval paediatric population. In conclusion, the present study evaluated an archaeological collection with low dental wear and low dental caries prevalence.

**Author Contributions**

Caglar E.: writer-investigator. Görgülü M.: writer-commenter. Kuscu O.O.: writer-commenter. We would like to thank Dr. Roland Blankenstein (UK) for his English revision.

**Disclosure Statement**

No potential conflicts of interest exist in this study for any author.

### References


