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1 **Supernumerary cheek tooth in a Byzantine horse from Theodosius Harbour, Istanbul,**  
2 **Turkey**

3

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12 **Keywords:** Byzantium; cheek teeth; equine dentistry; horse; Istanbul; polyodontia

13

14 **Summary**

15 The subject was a mandible belonging to a morphologically mature horse of the late  
16 Byzantium period, discovered during excavations at Theodosius Harbor in Istanbul, Turkey  
17 that had a developmental molar tooth abnormality, i.e. a supernumerary molar tooth. This is  
18 an interesting case due to the rarity of supernumerary molars in archeozoological materials,  
19 and also because it is the only such case of equid polyodontia from the late Byzantium period  
20 from that archaeological site.

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## 26 **Introduction**

27 Animal remains are among the materials most often acquired during exporation of  
28 archeological sites (Baker and Brothwell 1980; O'Connor 2000; Davis 2002; Bartosiewicz  
29 2008; Lasota-Moskalewska 2008; Reitz and Wing 2008; Waldron 2009). Animal bone or  
30 dental remains from excavations are, mainly because of their stability over time, a source of  
31 invaluable information on the anatomy and morphology of the detected species (Bökönyi  
32 1974; Baker and Brothwell 1980; O'Connor 2000; Davis 2002; Bartosiewicz 2008). Because  
33 of the presence of multiple skeletons in some sites, they are suitable for comparative,  
34 quantitative and qualitative analyses (von den Driesch 1976). These archeozoological findings  
35 also indicate the role which domesticated animals had in cultural development of  
36 communities at that time (Lasota-Moskalewska 2005), and how domestication affected the  
37 biological characteristics of those animals (Bökönyi 1974; Lasota-Moskalewska 2008). They  
38 are also a source of information on diseases of animals closely associated with humans  
39 (Bartosiewicz 2008; Waldron 2009). However, due to the fact that human consumption  
40 remnants prevail in archeozoological materials, animal remains with possible pathological  
41 abnormalities, including skull fragments with anomalies, are very rare (Hillson 2005; Lasota-  
42 Moskalewska 2008; Reitz and Wing 2008; Waldron 2009; Pasicka *et al* 2012, 2014).

43

## 44 **Materials and methods**

45 The analysed material consisted of a right-sided mandible (catalog no. MRY3467), belonging  
46 to a morphologically mature horse aged approximately 9-11years old at the time of death  
47 This age was estimated by examination of the very well preserved incisors, including  
48 assessment of the oval shape of their occlusal surface, and the presence of some of residual  
49 infundibula in all incisors (Fig 1). In this paper the Triadan system of equine dental

50 nomenclature (Fig 3) is used to identify individual teeth (Dixon and du Toit 2011). The well  
51 preserved undamaged right mandibular bone had loss of  
52 Triadan 406 and the presence of a caudally situated supernumerary molar tooth (Triadan  
53 412). The attached rostral aspect of the left mandibular bone contained an incisor tooth and  
54 a portion of the left physiological diastema (Fig 2a-c). The presence of fully developed and  
55 erupted canine teeth confirms it was an adult male horse (Fig 1).

56

57 This specimen is a part of a collection owned by Osteoarchaeology Practice and Research  
58 Centre, Department of Anatomy, Faculty of Veterinary Medicine, İstanbul University. The  
59 mandible was mined during excavation at the site of Theodosius harbour at Yenikapi in  
60 İstanbul, Turkey. The age of this specimen was estimated by radiocarbon dating ( $^{14}\text{C}$ ) as  
61 being from the period of Late Byzantium (15th century AD) (Onar *et al.* 2013). This jaw  
62 presents an anomaly in molar dentition uncommon for osteo-archaeological materials, as  
63 manifested by the presence of an additional cheek tooth (Lasota-Moskalewska 2008). It is  
64 also the only recorded occurrence of polyodontia in Equidae from the Byzantium period at  
65 the location in question (Onar *et al.* 2015).

66

67

## 68 **Results and Discussion**

69 Estimating the age, at which animals died on the basis of skeletal or dental remains, is hardly  
70 ever precise. Animals in prehistory were characterized by a slower ontogeny rate, compared  
71 to current species where there is a faster morphological puberty, manifested by more rapid  
72 dental development and closure of growth plates of long bones. Because of the geographical  
73 site of recovery of this skull, this horse was possibly an Arabian horse-type breed, whose  
74 incisor wear differs from other breeds (Muyllé 2011) Additionally, when determining the

75 age of an individual based on dental examinations one should consider that the age norms  
76 adopted in archaeozoological research have been established in modern species (Lasota-  
77 Moskalewska 2008). Visual examination of the incisor occlusal surfaces indicated the animal  
78 was 9-11 years old, but applying another method of ageing, namely radiographic  
79 examination of the reserve crowns and roots using the guidelines for modern horses of Dixon  
80 and Copeland (1993), this specimen could be aged as between 12 - 15 years of age when it  
81 died.

82

83 Anomalies in dentition occur in both man and animals (Hillson 2005; Reitz and Wing 2008;  
84 France 2009; Waldron 2009) and they can be divided into genetic, developmental, and  
85 acquired in origin (Baker and Brothwell 1980; Hillson 2005). Malocclusion is the most  
86 common equine dental disorder and is caused by uneven attrition of the cheek teeth occlusal  
87 surface, possibly due to dietary reasons (Lasota-Moskalewska 2008).

88 Among the common equine developmental dental abnormalities, one should list the atavistic  
89 polydontia (typical), associated with the occurrence of a rudimentary 105/205 tooth at the  
90 beginning of the row (*wolf tooth*, *dens lupinus*) (König and Liebich 2006).

91 Developmental dental abnormalities include anomalies of shape and position of teeth,  
92 reduced numbers (hypodontia) or even total absence of teeth (anodontia). Hypodontia must  
93 be differentiated from where a tooth has been lost due to disease or extracted during the  
94 animal's life (acquired anomaly), and the alveoli of such teeth shows signs of healing (Chaix  
95 *et al.* 1997).

96

97 Apparent supernumerary teeth may actually be due to retention of deciduous teeth. True  
98 polyodontia may be due to random divisions of dental primordia. Horses can also have

99 displaced polyodontia, exemplified by a dentigerous cyst, found on the dorsal aspect of the  
100 skull in horses (Jubb and Kennedy 1963).

101

102 The true prevalence of equid supernumerary teeth is unknown, but clinical surveys have  
103 shown it to occur more commonly in incisors than in cheek teeth (Bökönyi 1974; Dixon *et al.*  
104 1999a, 1999b; Hillson 2005), and more commonly in younger than in adult horses (Bökönyi  
105 1974; Dixon *et al.* 2005; Hillson 2005). However in donkeys, polyodontia was identified in  
106 4-5% of cases aged 6 years and older (Rodrigues *et al.* 2013).

107

108 Examination of photographs and radiographs of this specimen showed loss of the Triadan  
109 406 (– but no radiographic or gross anatomic evidence of alveolar disease was evident and so  
110 this loss is likely an artefactual post-mortem loss. On gross examination, there is a slight  
111 ventral swelling of the mandible, circa 3-4 cm in length beneath the Triadan 407 and 408,  
112 with a more focal 1-2 cm wide periosteal reaction beneath the buccal root of 407.  
113 Radiography does not show any abnormalities in the overlying 407 or 408 teeth, but  
114 confirmed the presence of a localised periostitis of the ventral mandible. In an equid of this  
115 age, this swelling is very likely to be due to a local mandibular trauma that occurred many  
116 months earlier. Younger (3-5 year old) equids commonly have mandibular swellings due to  
117 eruption cysts at this site (Dixon and du Toit 2011).

118

119 There exists an apparently artefactual, superficial, vertical fracture of the lateral aspect of the  
120 mandible between 407 and 408 – that is not apparent on radiography and so this fracture is  
121 also likely to be a post-mortem artefactual fracture (Fig 3).

122

123 The 411 that is normally the most caudal cheek tooth, has a normal occlusal surface, i.e. and  
124 contains the usual 6 pulp horns and the normal triangular occlusal shape of a mandibular  
125 Triadan 411 (Dixon and du Toit 2011). Lateral radiographs (Fig 3). of this tooth shows a  
126 wide reserve crown, and a poorly defined cadual root, as compared to all other cheek teeth  
127 roots in this specimen – but this wide reserve crown and delayed cadual root development is  
128 a common feature of the equid Triadan 411 mandibular tooth (Dixon and Copeland 1993).

129

130 As noted there is a supernumerary cheek tooth (412) present. Because of the absence of an  
131 antagonist tooth, this tooth has overgrown considerably (> 1cm) in height, particualry on its  
132 caudal aspect (Fig 3). If the animal had survived, this 412 overgrowth would have increased  
133 greatly and eventually caused a severe clinical problem by initially lacerating the tongue and  
134 soft tissues of the hard palate region during mastication and even later, possibly penetrating  
135 the hard palate (Dixon 2010). Food invariably becomes impacted into diastemata that  
136 commonly develop between the supernumeray and adjacent teeth leading to painful  
137 periodontal disease (Dixon *et al.* 1999b; 2005; Dixon 2010).

138

139 Radiographic examaintion of the apex of this supernumerary tooth indicates this to be a  
140 relatively recently (estimated to be less than 2- 3 years old) erupted tooth because there is no  
141 root (enamel free apical area) developed yet, even allowing that root development in a  
142 supernumerary teeth may not follow the usual pattern, and that this Byzantine period horse  
143 may not have grown and developed as quickly as modern horses. There is also a lucent area  
144 beneath the apex of the supernumerary tooth resembling an eruption cyst, with sclerosis of  
145 the adjacent alveolar lining. However, the height of the overgrowth on this tooth may indicate  
146 that the tooth has been erupted for possibly 4-6 years (Fig 3). This supernumerary tooth is  
147 also possibly dysplastic because does not taper (rostro-caudally) in an apical direction like a

148 normal cheek tooth (Dixon *et al.* 2012), but instead appears to be slightly wider more  
149 apically, even allowing that it is a young tooth. However, its structure is not that of a  
150 connated (more than one tooth joined together) supernumerary tooth (Dixon *et al.* 2010).  
151 Otherwise this tooth seems of normal morphology.

152

153 Based on the information gathered during analyses, we can conclude that the described  
154 mandible belonged to a morphologically adult horse, which survived with the described  
155 developmental polyodontia up to about 9 -11 years of age. There is no gross or radiographic  
156 evidence that the presence of this additional tooth was causing a clinical problem to this horse  
157 and it was very unlikely to have caused its death.

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159

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#### 161 **Authors declaration of interests**

162 No conflicts of interests have been declared.

163

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250 Fig 1: Incisor teeth of a Byzantine period horse recovered from Theodosius Harbour. Infundibular  
251 remnants are still present in all incisors; including a well-defined, small "cup" in 302 and irregular  
252 shaped enamel "rings" ("marks") in 303 and 403 (black arrows).

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Fig 2a: Right mandible of a Byzantine period horse recovered from Theodosius Harbour: lateral view.

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278 Fig 2b: Close up view of a right mandible of a Byzantine horse recovered from Theodosius Harbour:  
279 lateral view.

280 The 406 tooth – is missing (site indicated by star, 407, 408 , 409 , 410 , 411 (M<sub>3</sub>),and an overgrown  
281 supernumerary tooth (412 -arrow) are present

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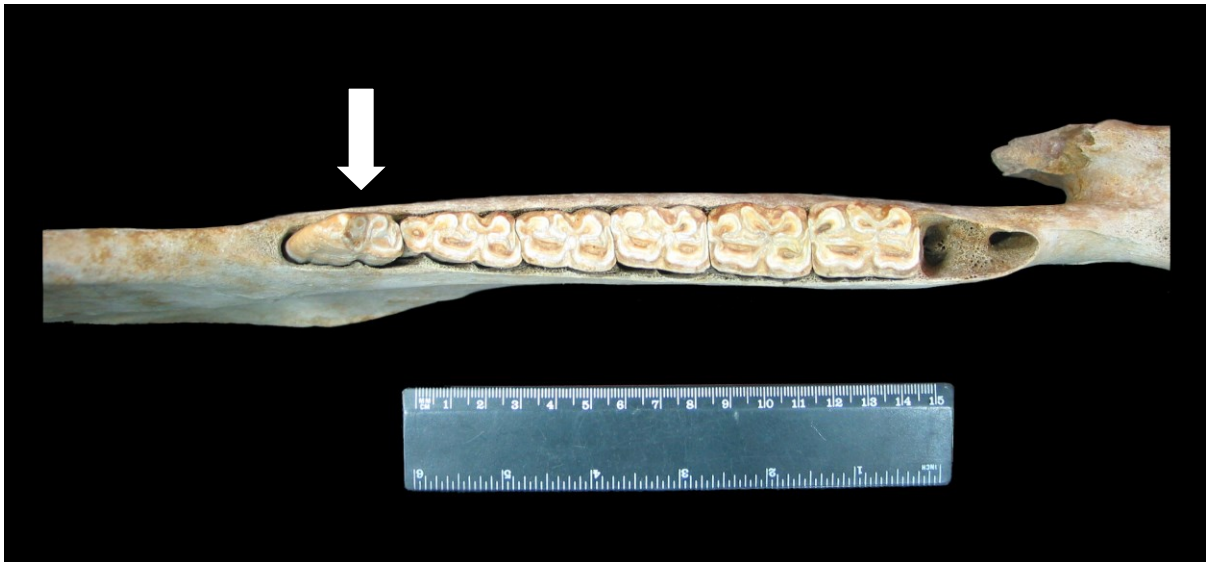
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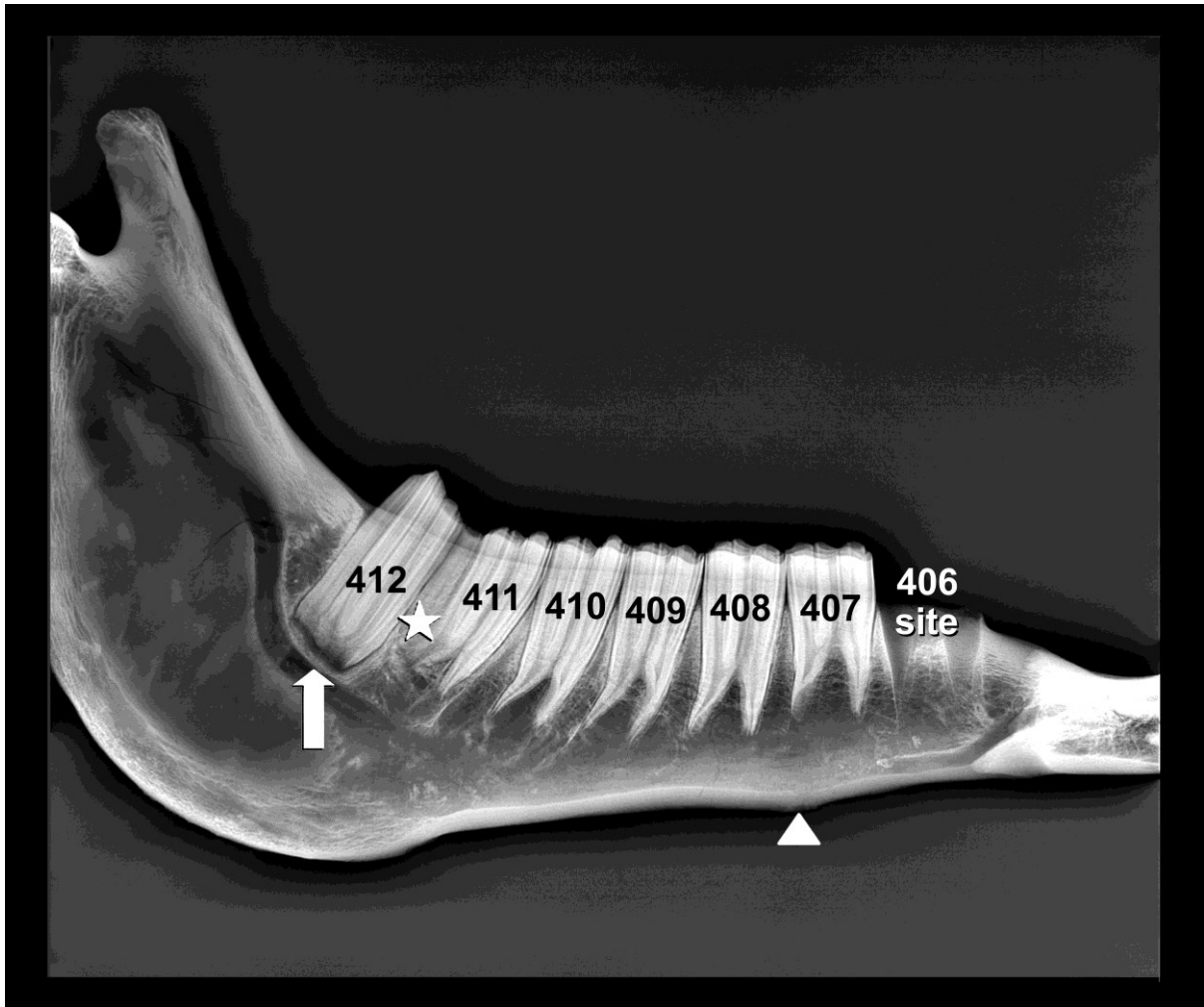
289 Fig 2c: Right mandible of a Byzantine perido horse recovered from Theodosius Harbour: dorsal view.

290 The 406 tooth is missing; and a supernumerary 412 (arrow) is present.

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295 Fig 3: Lateral Radiograph of a mandible of a Byzantine period horse recovered from Theodosius  
 296 Harbour with teeth labelled using the Triadan system:.

297 ▲-indicates a swelling, circa 3-4 cm in length beneath the Triadan 407 and 408, with a more focal 1-2  
 298 cm wide periosteal reaction over the cadual root of 407; ↑- poorly defined, wide caudal root of 412.

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