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Periapical lesions in hominids: Abscesses on the maxilla of a 2 million-year-old early *Homo* specimen

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Abstract

Periapical lesions can develop after exposure of a tooth's pulp chamber and are commonly associated with heavy crown wear, trauma, or caries. In this study, maxilla and mandible fragments from the South African fossil hominin collections were studied, including specimens assigned to *Homo naledi*, *Paranthropus robustus*, *Australopithecus africanus*, and early *Homo*. *Gorilla gorilla gorilla*, *Pan troglodytes*, and *Homo sapiens* were also studied for comparative purposes. Only one fossil hominin specimen displayed voids consistent with periapical lesions. The specimen, SK 847, is described as early *Homo* and has been dated to 2.3–1.65 Ma. There is one definite periapical lesion and likely more with post-mortem damage, all on the anterior aspect of the maxilla and associated with the incisors. The lesions originate from the apices of the incisor roots and are therefore unlikely to represent a systemic disease such as multiple myeloma. The one well-preserved lesion was likely an abscess rather than a cyst or granuloma, with a rounded thickened rim around the lesion. These lesions in an early *Homo* specimen highlight that this individual used their anterior dentition extensively, to the point that the pulp chambers were exposed on multiple teeth. This is one of the earliest hominin examples of periapical lesions and shows that this individual was able to cope with potentially several concurrent abscesses, clearly surviving for an extended period. Periapical lesions are relatively common in the great ape (*P. troglodytes*: 1.99%; *G. gorilla gorilla*: 1.86%) and human samples (2.50%) but absent in large samples of *P. robustus* and *A. africanus* (*n* = 0/373 teeth). Therefore, this finding adds additional information to the history of dental pathology in our genus and also suggests that other hominin genera may have been less susceptible to dental abscesses, potentially relating to dietary or behavioural differences.

Introduction

Abscesses and other periapical voids are commonly found in the mandible and maxilla of humans and other animals (e.g., Eshed, Gopher, & Hershkovitz, 2006; Jurmain, 1990; Miles & Grigson, 2003; Sauther, Sussman, & Cuozzo, 2002; Schultz, 1956). These voids can develop after exposure of a tooth's pulp chamber, often through heavy wear (i.e., attrition or abrasion), trauma, and caries (Dias, Prasad, & Santos, 2007; Linn, Srikandi, Clarke, & Smith, 1987; Nair, 2004). As well as abscesses, other types of periapical voids include cysts, fenestrations, and granulomata, and concerns have been raised about the incorrect use of these different terms in archaeological studies (Dias et al., 2007; Dias & Tayles, 1997; Nair, 2004). In particular, the majority of voids may be painless granulomata, with evidence suggesting that less than a third may be chronic abscesses (Ogden, 2008). However, because a granuloma can become a cyst, both can become an abscess, and there is disagreement as to how to define each type (see Dias et al., 2007); there will be times when a lesion is difficult to decipher in the archaeological record.

The frequency of periapical voids varies substantially among human populations, as well as nonhominin primate species (Cuozzo & Sauther, 2012; Dias & Tayles, 1997; Eshed et al., 2006; Lieverse, Link, Bazaliiskiy, Goriunova, & Weber, 2007; Miles & Grigson, 2003; Schultz, 1956; Stoner, 1995). Until recently, they had rarely been reported in the *Homo* fossil record (Gracia-Téllez et al., 2013; Lacy, 2014; Lacy et al., 2012; Leek, 1966; Margvelashvili, Zollikofer, Lordkipanidze, Tafforeau, & Ponce de León, 2016; Martinón-Torres et al., 2011; Rosas et al., 2006). There are also potential periapical lesions in other hominin genera (e.g., Haile-Selassie, 2001; Schwartz & Tattersall, 2005; Wood, 1991). The most important factor in extant primates, as a whole, is severe occlusal attrition (Legge, 2012). Great apes tend to have higher rates than do other primates, with the canine most frequently involved (Schultz, 1956).

In this study, we recorded the presence/absence of periapical voids in South African fossil hominins, as well as two species of extant great apes and modern humans. Our working hypothesis was that their presence in fossil hominins likely resulted from crown wear, given its ubiquity in many hominin specimens, rather than caries, which are comparatively uncommon (Grine, Gwinnett, & Oaks, 1990; Towle et al., 2019).

Materials and methods

All maxilla and mandible fragments available for study in the South African fossil hominin collections were observed, including specimens assigned to *Homo naledi*, *Paranthropus robustus*, *Australopithecus africanus*, and early *Homo*. All specimens are curated at the Ditsong National Museum of Natural History and University of the Witwatersrand. The comparative great ape samples (*Gorilla gorilla gorilla* and *Pan troglodytes*) are curated at the Powell-Cotton Museum in Kent, UK; all were wild shot early in the 20th century (Guatelli-Steinberg & Skinner, 2000; Macho & Lee-Thorp, 2014). The modern *Homo sapiens* sample is from a mediaeval cemetery in Gloucester, UK, and is curated at Liver- pool John Moores University. Table 1 lists the number of specimens studied and the number of teeth not recorded for periapical lesions due to the absence of associated alveolar bone or post-mortem dam- age. For specimen and species classifications, see Towle (2017).

Table 1. Number of teeth recorded for each species and those not recorded—due to lack of associated alveolar or post-mortem damage.

Species	# teeth recorded	# teeth not recorded
A. africanus	141	362
P. robustus	232	228
H. naledi	32	122
Early *Homo*	15	55
P. troglodytes	2508	7
G. gorilla gorilla	2099	5
H. sapiens	961	21

All lesions were photographed using a Dino-Lite® AM2111 hand- held microscope, 10 *g* to 50 *g* zoom magnification. Any ante-mortem bone voids present in a maxilla or mandible associated with a tooth root apex were recorded. Systemic diseases such as multiple myeloma and metastatic carcinoma were not recorded but have been described in the literature (e.g., Odes et al., 2018). A tooth had to have all the surrounding bone present to be included (Table 1). Methods suggested by Dias and Tayles (1997) and Ogden (2008) were used to describe lesions and to suggest an aetiology.

Only one fossil hominin specimen displays clear periapical voids, that is, SK 847, described as early *Homo* dated to 2.3–1.65 Ma (Tobias, 1991). Although the phylogenic

placement and associated material of this specimen have been debated, it is commonly placed in the genus *Homo* (e.g., Berger et al., 2015; Grine, Demes, Jungers, & Cole, 1993; Schwartz & Tattersall, 2003). It is usually referred to as SK 847, after two fragments were incorporated (Clarke & Howell, 1972; Grine et al., 1993). As well as the maxilla, the specimen also has much of the frontal cranium present (figure 9.1a) and has been associated with different mandibles (Clarke & Howell, 1972; Grine et al., 1993). In the anterior dentition, only the left lateral maxillary incisor remains, with severe wear evident (wear grade 8 in Smith, 1984; figure 1.1c). Alveoli and broken roots for several other teeth are present (Figure 1). In-depth descriptions of the specimen are available in Robinson (1953), Clarke (1979), and Schwartz and Tattersall (2003).

Results and discussion

Table 2 displays the prevalence of periapical lesions for each sample, divided according to anterior and posterior teeth. Only permanent teeth are included due to small sample sizes for deciduous teeth. In addition, only three deciduous teeth, all *P. troglodytes*, are associated with periapical voids. In *G. gorilla gorilla*, it is predominantly permanent canines affected (8.48% with periapical lesion). The same is evident for *P. troglodytes* (i.e., 4%), but the anterior dentition as a whole shows a high prevalence compared with posterior. In contrast, the posterior teeth are predominantly affected in modern humans. These results support dietary and behavioural studies in these groups. Caries is com- mon in the posterior teeth of most agricultural human samples, including this one, which likely explains the high rate of periapical lesions in this region of the dentition. *G. gorilla gorilla* is known to fracture canines regularly and also exhibit extensive anterior tooth wear and damage, to explain their pattern (Schultz, 1956). *P. troglodytes* not only have similar issues with their canines but also use their anterior teeth extensively in food processing, likely explaining the high prevalence of lesions (Hylander, 1975; McGrew, 1999; van Casteren et al., 2018). Therefore, the results for extant primates suggest that these bony lesions may be a useful indicator of diet, behaviour, and health in fossil samples.

On the basis of macroscopic observations, it is possible to conclude that the SK 847 individual likely had at least two/three periapical voids at the time of death; all are associated with the incisors and likely relate to extensive crown wear (Figure 1d). Future microcomputed tomography scans could provide more information. Several voids evidence

substantial post-mortem damage; however, this may relate to a prior periapical lesion, given the definite void associated with the left upper central incisor (Figure 1e). The left upper central incisor is absent, likely post-mortem, judging by the lack of alveolar resorption. There is also a potential lesion on the lingual sur- face, from what could have been a drainage channel associated with right lateral incisor. However, this void may instead be an unusual foramen, as noted by Robinson (1953; Figure 1b). The heavy wear on the remaining teeth, in particular the removal of most enamel on the left lateral incisor and presence of tertiary dentine, suggests the periapical voids resulted from pulp chamber perforation (Towle, 2019). They originate from the apices of the incisor roots so are unlikely to result from a systemic disease such as multiple myeloma (Dias & Tayles, 1997). The most complete void best fits the description of an abscess rather than cyst or granuloma, with a rounded thickened rim around the void (Figure 1e; Dias & Tayles, 1997; Ogden, 2008).

Table 2. Periapical lesion prevalence for each sample.

	A. africanus	***P. robustus***	***H. naledi***	**Early *Homo***	***P. troglodytes***	***G. gorilla gorilla***	***H. sapiens***
Posterior teeth							
No periapical lesion	94	161	22	10	1572	1299	548
Periapical lesion	0	0	0	0	20	9	17
% of teeth with lesions	0%	0%	0%	0%	1.26%	0.69%	2.91%
Anterior teeth							
No periapical lesion	47	71	10	3	886	761	368
Periapical lesion	0	0	0	2	30	30	7
% of teeth with lesions	0%	0%	0%	40.00%	3.28%	3.79%	1.86%
% of all teeth with lesions	**0%**	**0%**	**0%**	**13.33%**	**1.99%**	**1.86%**	**2.50%**

Robinson (1953) first described this specimen, which at the time consisted only of the maxilla (SK 80), with a focus on its morphology; the extreme incisor wear was also noted and described. Clarke (1979) concentrated on the morphology as well, though described the state of preservation and maxillary voids. He did not mention whether the latter was ante-mortem or post-mortem but reported potential periodontitis on the lingual aspect of the right lateral incisor (Clarke, 1979; Figure 1b). Thus, the present study builds on this research and suggests that the individual suffered from several connected dental issues, that is, extreme wear, dental abscesses, and potentially periodontal disease. Given the small sample size for early *Homo* in this study, it is not possible to conclude if these characteristics were common in this and other early individuals/species in this genera.

[Figure 1 here]

Extreme wear removed the enamel on the anterior teeth and much of the dentine, which ultimately led to exposure of the root canals when reparative tertiary dentine could not be formed quickly enough in response. Subsequently, based on clinical progression, periapical periodontitis would have occurred, caused by chronic root canal infection. Eventually, several periapical cysts would have formed in the anterior maxilla of this individual's mouth and ultimately to abscesses (Dias & Tayles, 1997). This process is common in modern humans, with maxillary anterior teeth most affected (Nair, 2004). Similar lesions caused by heavy wear have been found in archaeological samples of hunter–gatherers (Eshed et al., 2006; Lieverse et al., 2007), as well as in extant primates (Cuozzo & Sauther, 2012). Abscesses and other periapical voids have rarely been reported in fossil remains, but recent studies suggest that they may not be as uncommon as once thought (e.g., Gracia-Téllez et al., 2013; Lacy, 2014; Lacy et al., 2012; Margvelashvili et al., 2016; Martinón-Torres et al., 2011). In particular, such voids were described in another specimen of early *Homo* (i.e., Mandible D2600 from Dmanisi), which potentially belongs to the same species, *Homo erectus*, and is roughly contemporary with SK 847, dating to 1.77 Ma (Margvelashvili et al., 2016). Periapical voids have also been frequently described in later *Homo* (Gracia-Téllez et al., 2013; Lebel et al., 2001; Rosas et al., 2006), though not all were wear related, for example, Kabwe 1 (Lacy, 2014). Considerable wear and associated periapical lesions on the anterior dentition were likely common in a variety of *Homo* species, further suggesting that incisors and canines were used extensively in food processing or for nonmasticatory activities (Clarke, 2012; Clement, Hillson, & Aiello, 2012; Estalrrich & Rosas, 2013; Frayer et al., 2016; Lozano, Mosquera, De Castro, Arsuaga, & Carbonell, 2009; Wood & Strait, 2004).

The voids in the SK 847 maxilla are therefore of interest on several levels. First, at 2.3–1.65 Ma, this is one of the earliest clear examples of dental abscessing in fossil hominins yet known. Second, the number and severity of these voids suggest that the individual suffered with them for some time. That said, third, their severity and unhealed state might also indicate that they contributed to the individual's death, that is, septicemia (Gracia-Téllez et al., 2013). Finally, the lack of any periapical lesions in the remaining South African fossil hominin specimens, including large samples of *P. robustus* and *A. africanus*, suggests that this individual and perhaps early *Homo* on a broader scale practised a novel behaviour. She/he

may have regularly processed abrasive food items with her/his incisors (i.e., attrition) or, perhaps, used them for a nonmasticatory activity, such as a “third hand” (in which case, the wear would be characterized as abrasion).

In any event, this and alternate evidence of dentition-related behaviour in the South African collections, for example, anterior root grooves in an *A. africanus* specimen (Towle, Irish, Elliott, & De Groote, 2018) and high rates of enamel fractures in *H. naledi* (Towle, Irish, & De Groote, 2017), help personalize the study of our hominin ancestors and relatives. In this case, the SK 847 abscesses provide some mea- sure of individuality to this once-living individual.

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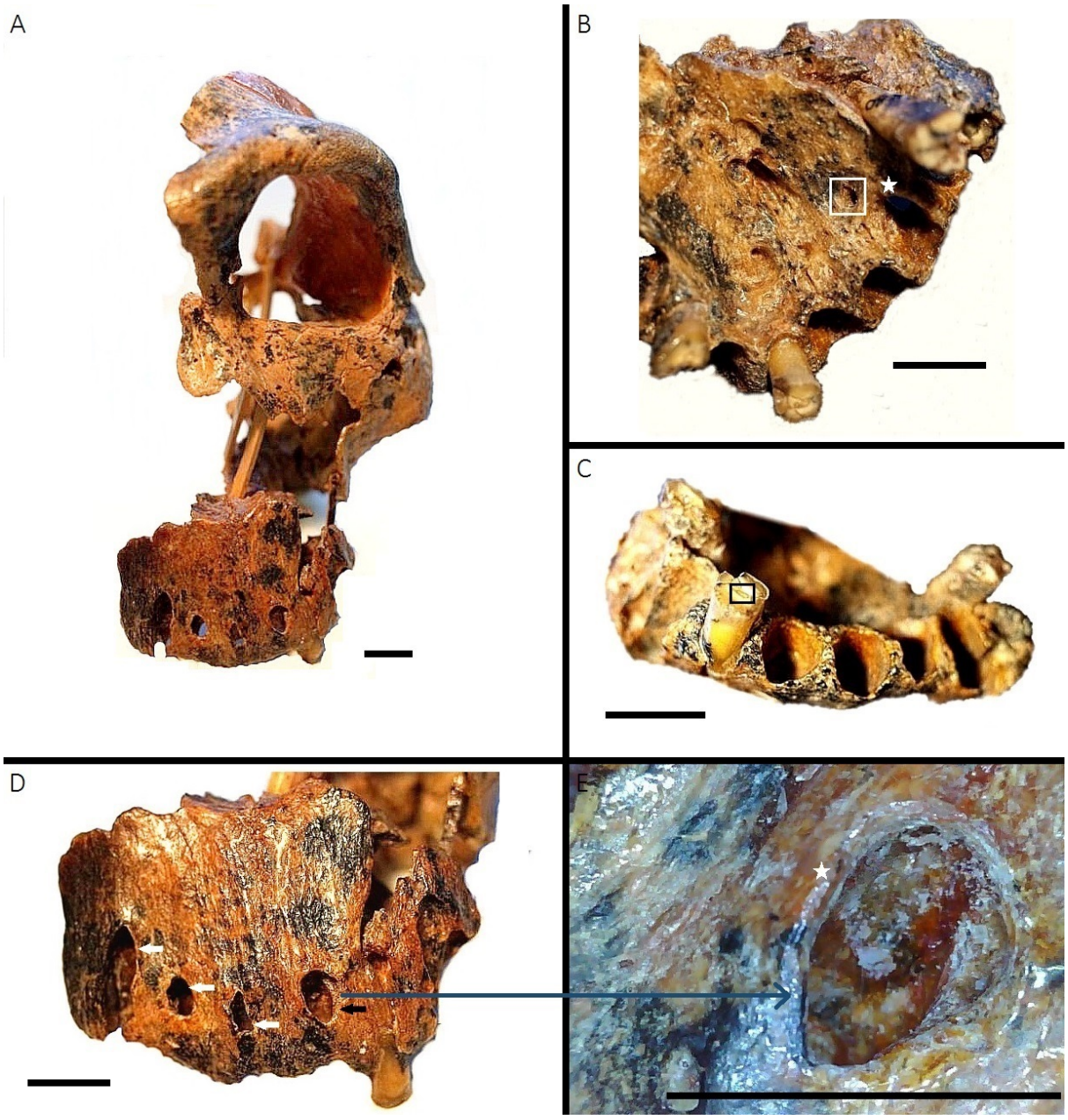

Figure 1. Specimen SK 847 (early *Homo*): A) overview of the entire specimen; B) lingual aspect. The white square shows location of possible periapical lesion and white star a potential area of periodontal disease; C) heavy wear on left lateral upper incisor. Black square highlights tertiary dentine formation; D) buccal periapical lesion (black arrow). White arrows indicate potential additional lesions with postmortem damage; E) detail of buccal abscess, showing thickened bone around circumference of the abscess (white star). All scale bars 1cm.