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A case of benign osteogenic tumour in *Homo naledi*: Evidence for peripheral osteoma in the U.W. 101-1142 mandible

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ABSTRACT

The reported incidence of neoplasia in the extinct hominin record is rare. We describe here the first palaeopathological analysis of an osteogenic lesion in the extinct hominin *Homo naledi* from Dinaledi Cave (Rising Star), South Africa. The lesion presented as an irregular bony growth, found on the right lingual surface of the body of the adult mandible U.W. 101-1142. The growth was macroscopically evaluated and internally imaged using micro-focus x-ray computed tomography (μCT). A detailed description and differential diagnosis were undertaken using gross and micromorphology, and we conclude that the most probable diagnosis is peripheral osteoma – a benign osteogenic neoplasia. These tumours are cryptic in clinical expression, though they may present localised discomfort and swelling. It has been suggested that muscle traction may play a role in the development and expression of these tumours. The impact of this lesion on the individual affected is unknown. This study adds to the growing corpus of palaeopathological data from the South African fossil record, which suggests that the incidence of neoplastic disease in deep prehistory was more prevalent than traditionally accepted. The study also highlights the utility of micro-computed tomography in assisting accurate diagnoses of ancient pathologies.

1. Introduction

We present a detailed case study and palaeopathological analysis of a mandibular exostosis present on the lingual aspect of the U.W. 101-1142 fossil specimen, initially identified by Laird and colleagues (2016) as a mandibular osteoma. This was recovered from the Dinaledi Chamber, Rising Star Cave, Cradle of Humankind, South Africa. Rising Star Cave is located within the dolomitic karst landscape of the Cradle of Humankind World Heritage Site, some 50 km outside of Johannesburg, South Africa (Fig. 1). Excavations at the site have, to date, yielded more than 1550 identifiable fossil elements (Berger et al., 2015; Randolph-Quinney, 2015). The fossils were derived from at least 15 individuals, a total likely to represent a small fraction of the fossils remaining in the chamber and awaiting excavation (Fig. 2). This discovery is the largest single fossil hominin assemblage found on the African continent to date (Berger et al., 2015; Randolph-Quinney, 2015). The context of the Naledi deposition in the cave has been described by Dirks and colleagues (Dirks et al., 2015, 2016), and the formation of the assemblage is interpreted as being due to deliberate body disposal by conspecifics (Dirks et al., 2015, 2016), a process known as funerary caching (after after Pettitt, 2011; Berger et al., 2017; Randolph-Quinney, 2015). Fossils from the Dinaledi Chamber have been attributed to the taxon *Homo naledi* (Berger et al., 2015; Laird et al., 2016). While highly primitive in terms of cranial capacity and body size, this taxon presents a mixture of primitive and derived characters that convincingly argue for inclusion in the *Homo* genus (Berger et al., 2015; Dembo et al., 2016; Laird et al., 2016; Schroeder et al., 2015).

The Dinaledi Chamber fossils have been shown to be late Middle Pleistocene in age. Based on optically stimulated luminescence (OSL) dating of the cave sediments, U-Th and palaeomagnetic dating of flowstones, and U-series and electron spin resonance (ESR) dating of

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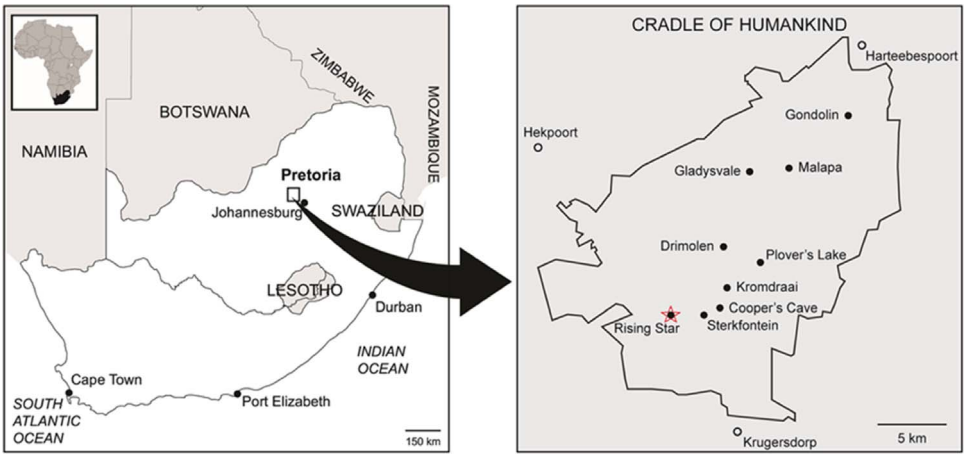

Fig. 1. Location of the Rising Star Cave system within the Cradle of Humankind, South Africa.

Fig. 2. Layout photograph of some of the Dinaledi Chamber fossils. The figure includes all of the material incorporated into the diagnosis of *Homo naledi*, and includes the holotype specimen, paratypes and referred material list in Berger and colleagues (2015). The fossil shown make up 737 partial or complete anatomical elements, many of which consist of several refitted specimens. Specimens not identified to element, such as non-diagnostic long bone or cranial fragments, are not shown. The 'skeleton' layout in the centre of the photo is a composite of elements that represent multiple individuals. The view is foreshortened and the table on which the bones are arranged is 120-cm wide for scale. Image, courtesy of John Hawks and taken with permission from Berger et al., 2015.

teeth, the skeletal remains from the Dinaledi Chamber were deposited between 236 ka and 335 ka (Dirks et al., 2017). This Middle Pleistocene date should not be viewed as representing first or last appearance of *Homo naledi*, whilst some researchers have suggested that the species may be of Lower Pleistocene origin or older, based on analyses of cranial morphology (Dembo et al., 2016; Thackeray, 2015). A second chamber within the Rising Star cave system has recently yielded further remains of *Homo naledi* (Hawks et al., 2017). This has been named the Lesedi Chamber, and has yielded the remains of at least three individuals which fall within the range of morphological variation exhibited by the Dinaledi Chamber fossils; for the moment the Lesedi Chamber fossils remain undated.

2. Materials

Specimen U.W. 101-1142 is an adult right mandibular fragment comprising the midpoint and proximal aspect of the body extending to the mandibular angle, including the RM_2 and RM_3, and a portion of the distal (inferior) ramus, excluding the coronoid, condyle processes and anterior mandibular body. This partial mandible has been attributed to *Homo naledi*; a detailed description of the morphology and metrics of the specimen can be found in Laird and colleagues (Laird et al., 2016). The specimen was recovered in a partially fragmented state, and reconstructed by Peter Schmidt. The largest fragment of U.W. 101-1142 preserves a damaged right corpus, RM_2, RM_3, and a portion of the right ramus. To this fragment, a piece of the gonial region and a small portion of the ramus have been refit (Fig. 3a and c). An isolated RM_1, U.W. 101-1304, fits into the preserved portion of the M_1 alveolus (Fig. 3f). Supporting their allocation to a single biological individual, the interproximal contact facets of U.W. 101-1304 and the U.W. 101–1142 M_2, match in size and shape. Other isolated teeth from the U.W. 101 assemblage may represent this individual as well, but their associations are less certain.

As judged by dental eruption and attrition, U.W. 101-1142/1304 is an adult. Further, though lacking dentine exposure, the M_3 cusp tips are blunted by wear, which corresponds to Smith's (1984) wear stage 2. The M_2 has tiny pits of dentine exposed over each of its buccal cusps; though, much of the occlusal fissure pattern remains (stage 3). The U.W. 101–1304 M_1 is worn and uncoalesced pits of dentin are exposed over each of the five cusps (stage 4) (Fig. 3c). Antemortem enamel chipping is also evident on all three molars. The allocation of U.W. 101-1142/1304 to *H. naledi* is supported by its dental morphology. For example, the molars have an $M_1 < M_2 < M_3$ size gradient, the hypoconulid on all molars is relatively large, all molars lack supernumerary cusps (Fig. 3f), the protostylid is present on M_2 and M_3 as a faint crest restricted to the mesiolingual corner of the crown, and a three-dimensional geometric morphometric analysis of the enamel-dentine junction shows that the U.W. 101–1142 M_2 falls into a unique region of phenotype space with the rest of the U.W. 101 molar teeth.

3. Methods

The specimen was evaluated macroscopically, and the morphology was compared to all other mandibular specimens of *Homo naledi* recovered to date. Initial external macro-photographic images were taken using a Canon 70D 20MP DSLR, with a 60 mm Canon EF f2.8 macro lens and ring-flash. Following macro-photography, images of the internal structure of the specimen were obtained using micro-focus X-ray computed tomography (μCt) at the Evolutionary Studies Institute of the University of the Witwatersrand. Scanning of the bone fragment