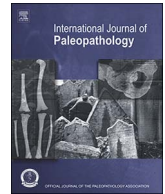




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journal homepage: [www.elsevier.com/locate/ijpp](http://www.elsevier.com/locate/ijpp)Root grooves on two adjacent anterior teeth of *Australopithecus africanus*Ian Towle<sup>a,\*</sup>, Joel D. Irish<sup>a,b</sup>, Marina Elliott<sup>b</sup>, Isabelle De Groot<sup>a</sup><sup>a</sup> Research Centre in Evolutionary Anthropology and Palaeoecology, School of Natural Sciences and Psychology, John Moores University, Liverpool, L3 3AF, United Kingdom<sup>b</sup> Evolutionary Studies Institute, University of the Witwatersrand, Wits, Johannesburg, 2050, South Africa

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## ABSTRACT

Tooth root grooves and other ante-mortem dental tissue loss, not associated with caries found on or near the cemento-enamel junction (CEJ), are commonly termed non-carious cervical lesions. Three main processes are implicated in forming these lesions: abrasion, dental erosion, and abfraction. As yet, these lesions have not been described in non-*Homo* hominins. In this study, South African fossil hominin collections were examined for evidence of any type of non-carious cervical lesion. Only one individual shows ante-mortem root grooves consistent with non-carious cervical lesions. Two teeth, a mandibular right permanent lateral incisor (STW 270) and canine (STW 213), belonging to the same *Australopithecus africanus* individual, show clear ante-mortem grooves on the labial root surface. These lesions start below the CEJ, extend over a third of the way toward the apex, and taper to a point towards the lingual side. The characteristics of these grooves suggest the predominant aetiology was erosive wear. In addition, they are extremely similar to clinical examples of dental erosion. These are the oldest hominin examples of non-carious cervical lesions and the first described in a genus other than *Homo*. Further, the lesions suggest that this individual regularly processed and consumed acidic food items.

## 1. Introduction

Non-carious cervical lesions (NCCLs), resulting from the loss of dental tissue at or near the cemento-enamel junction (CEJ), are not uncommon in the dentitions of recent human populations (Levitch et al., 1994; Wood et al., 2008; Grippo et al., 2012). They may result from several processes, the most commonly suggested of which are abrasion, dental erosion and abfraction (Litonjua et al., 2003; Michael et al., 2009). As such, when NCCLs are present in archaeological and, in this case, fossil hominin remains, they may provide insight into diet and behaviour.

Abrasion is the most common mechanism of NCCLs observed in archaeological samples; it results from non-masticatory contact of an object with the teeth, and commonly relates to cultural or therapeutic behaviour (e.g., Turner and Cacciato, 1998; Ungar et al., 2001; Novak, 2015; Estalrich et al., 2016). All NCCLs in fossil examples are currently attributed to abrasion and reported only in members of the genus *Homo*. The majority of these abrasion NCCLs are considered to be ‘toothpick grooves’ (Ubelaker et al., 1969; Boaz and Howell, 1977; Frayer and Russell, 1987; Brown and Molnar, 1990; Milner and Larsen, 1991; Bermudez de Castro et al., 1997; Turner and Cacciato, 1998; Ungar et al., 2001; Hlusko, 2003; Bouchneb and Maureille, 2004; Kaidonis et al., 2012; Lozano et al., 2013; Tillier et al., 2013; Ricci et al.,

2014; Sun et al., 2014; Frayer et al., 2017). Anterior teeth can be affected, but most of these grooves are present in the interproximal areas of the premolars and molars (Formicola, 1988; Frayer, 1991; Ungar et al., 2001), with buccolingual micro-striations often evident (Bouchneb and Maureille, 2004; Grine et al., 2000; Hlusko, 2003; Lozano et al., 2013; Estalrich et al., 2016; Sun et al., 2014). The enamel, dentine, and/or cementum are affected depending on groove depth and location, i.e., above, below or directly on the CEJ. The cause of these abrasive grooves is debated but the growing consensus is the use of a sort of toothpick, in which an item was deliberately placed regularly in certain locations, potentially to dislodge food or attempt to reduce pain (Formicola, 1988; Ungar et al., 2001; Lozano et al., 2013). Given the occurrence of such grooves in diverse populations, it is likely that a variety of instruments was used in forming these lesions (Frayer et al., 2017). Some, but not all, grooves are associated with dental pathology, including periodontal disease and caries.

Dental corrosion, or erosion as it is more commonly called, has been extensively researched in modern (e.g., Zero, 1996; Aubry et al., 2003; Oginni et al., 2003; Grippo et al., 2004) and archaeological human dentitions (e.g., Robb et al., 1991; Indriati and Buikstra, 2001; Ritter et al., 2009; Watson and Haas, 2017). It occurs through the chemical dissolution of dental tissues by acids of non-bacterial origin and can be caused by a range of factors, most notably low pH diets (Indriati and

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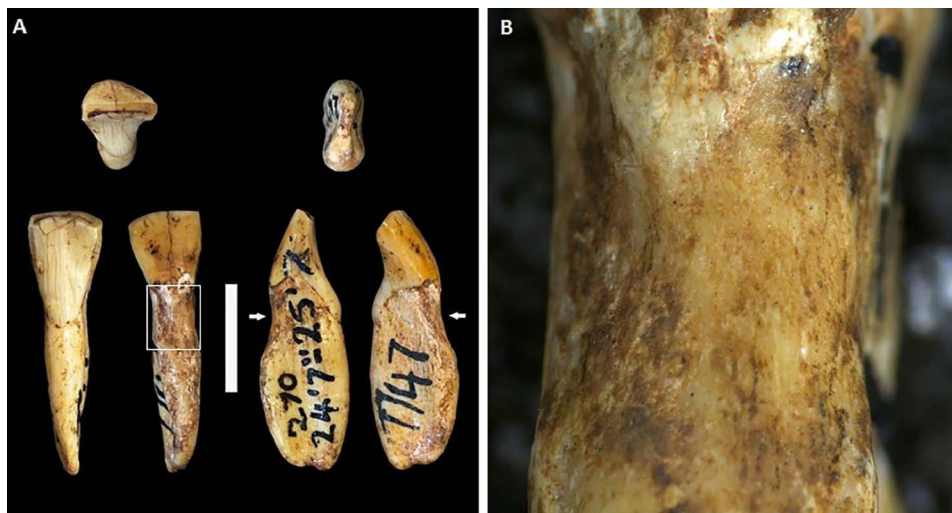


Fig. 1. STW 270 (*A. africanus*) right mandibular lateral incisor. A) Bottom row from left to right: lingual, labial, mesial, and distal. White arrows and square highlight the location of the groove. The white bar is 1 cm long. B) Close-up of the groove (white square in A), showing no directional striations and a smooth surface.

Buikstra, 2001; Oginni et al., 2003; Ritter et al., 2009; Watson and Haas, 2017). Endogenous factors can also create erosive lesions, including gastroesophageal reflux disorder and eating disorders (Loomba et al., 2014; Milosevic et al., 1997). Additionally, conditions that reduce the rate of saliva secretion can also lead to an increased chance of dental erosion (El-Marakby et al., 2017). Typically, endogenous acids create lingual lesions on anterior teeth whereas those associated with diet or non-masticatory activities commonly affect the labial surface (Loomba et al., 2014).

Abfraction is the term used to describe tissue breakdown in the cervical region of teeth from extreme or unusual occlusal loading from mastication, bruxism, or malocclusion (Lee and Eakle, 1984; Grippo, 1991; Grippo et al., 2012). This process is subject to debate, especially in archaeological specimens (Aubry et al., 2003; Michael et al., 2009; Urzúa et al., 2015; Hur et al., 2011). The reason is the lack of conclusive evidence that such processes could strongly influence NCCLs formation, with a lack of attributable lesions in pre-modern specimens. It is therefore possible that the wedged-shaped NCCLs lesions associated with abfraction may relate only to modern dental practices or diet (El-Marakby et al., 2017).

The position and shape of NCCLs can give insight into their aetiology. In particular, by comparing specimens with clinical examples it is possible to infer possible aetiologies in archaeological specimens. However, as evidenced in clinical studies NCCLs may have multifactorial origins, though the dominant factor will often create unique characteristics (Marinescu et al., 2017). Abfraction is characterised by wedged shaped lesions that usually affect the labial/buccal surface (Grippo et al., 2012). Abrasive wear is also often distinctive, with non-symmetric lesions that commonly show directional striations (Sun et al., 2014). Abrasive NCCLs are typically V-shaped, and in severe cases can take on a wedge appearance that superficially may resemble abfraction lesions (Loomba et al., 2014). Erosive NCCLs may also be non-symmetric, and typically yield shallow, smooth surfaces (Wood et al., 2008; Levitch et al., 1994). Abrasion and erosion together can lead to an increased likelihood and/or severity of lesions; most causes of erosive NCCLs will be influenced by abrasion, at least to some extent. Erosion weakens dental material, allowing even minimal abrasion to create extensive, further wear (Wu et al., 2017). The underlying dentine associated with erosion and abrasion in NCCLs is shiny, with the lesions more similar in appearance to the surrounding dentine in erosive cases than abrasive (Bader et al., 1993).

No NCCLs, to date, have been detailed in South African fossil hominins—*Homo* or otherwise (Wallace, 1974; Ungar et al., 2001). For this report, we re-examined the South African collections for evidence

of any NCCL type, in specimens assigned to *Paranthropus robustus*, *Australopithecus africanus*, *A. sediba*, *Homo naledi*, and early *Homo* (sensu lato). Of these, one individual is affected. The aetiology is discussed below and a differential diagnosis conducted.

## 2. Materials and methods

All teeth that had a complete, or nearly complete, CEJ were recorded for signs of NCCL's. The teeth in this study include a mandibular right permanent lateral incisor, STW 270, and a mandibular right permanent canine plus several other teeth collectively assigned to STW 213; all are thought to belong to the same individual (Moggi-Cecchi et al., 2006). The other, unaffected teeth from this individual are the mandibular first and second molars, premolars and left canine. These specimens originate from Sterkfontein Member 4 and date to 2.8–2.4 Ma (Pickering et al., 2004). Although many consider material from Member 4 to belong to *A. africanus*, others suggest multiple species may be present (e.g., Calcagno et al., 1999; Lockwood and Tobias, 1999; Wood and Richmond, 2000; Moggi-Cecchi, 2003; Grine et al., 2013; Fornai et al., 2015). That said, the specimens studied here are routinely described as *A. africanus*. The only prior mention of the antemortem grooves described here is from Moggi-Cecchi et al. (2006), where they were used to associate STW 270 with 213.

In this study, the teeth were first examined macroscopically, followed by microscopic observations using a Leica© DMS300 digital microscope (variable magnification ranging from 15 to 40×). Signs of postmortem damage, other pathology, wear and/or developmental defects on the teeth were also recorded and are described. Data were collected at the University of the Witwatersrand and the Ditsong Museum of South Africa.

## 3. Results

STW 270 exhibits wear on the incisal edge with a strip of exposed dentine (wear grade 4; Smith, 1984), suggesting that the tooth was in occlusion for some time. An antemortem, concave depression, i.e., shallow groove, is evident on the labial root surface just below the CEJ, which extends more than one third of the way toward the apex (Fig. 1A). Microscopic examination revealed no directional antemortem striations (Fig. 1B). The groove spreads around to the interproximal areas of the root, narrowing to a point towards the lingual side (Fig. 2). The process that created the groove does not appear to have affected other dental tissues, although slight postmortem damage towards the CEJ on the labial surface may mask some evidence. Comparisons with

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