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# PALEOPATHOLOGY OF MYCENAEAN TEETH FROM TWO ROBBED TOMBS OF KASTROULI LATE HELLADIC SETTLEMENT, GREECE

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## ABSTRACT

A set of teeth unearthed from two robbed tombs of Mycenean and archaic times; more than a dozen from Tomb A and a lower mandible from Tomb B, have been examined. Visual inspection, X-ray examination, infrared spectroscopy, and examination in monochrome light were carried out on the tooth samples. Most of the teeth unearthed from Tomb A showed low abrasion, with no particular pathological findings. However, some teeth with caries cavities and severe abrasions, resulting in the exposure of the underlying dentin, were also detected. Regarding the left side of a mandible located in Tomb B, the examination results showed that the bone was fractured and that he had gum disease. Therefore, we can speculate that this is a relatively healthy population in terms of oral hygiene, as no severe pathological findings were found.

**KEYWORDS**: Kastrouli, teeth, oral hygiene, paleopathological, molar, carries, X Rays

## 1. INTRODUCTION

The site of Kastrouli (Fig. 1) has been systematically investigated with the first archaeological excavation trenches and research focused on two tombs: a late Mycenaean and Archaic tombs that were robbed in the early 1990s and in a state of deterioration. Starting in 2016 a major digital heritage project was initiated (Sideris et al., 2017; Sideris 2022; Levy et al., 2018; Koh et al., 2020; Sideris & Liritzis, 2019; Xanthopoulou et al., 2021). Kastrouli is located approximately midway between Delphi and only 5 km from the Antikyra Bay providing an ideal "land and sea" study area. As Kastrouli had never been systematically investigated, to adequately record the damaged tombs, the tools of cyber-archaeology were used to establish a state-of-the-art research infrastructure based on digital data capture, curation, analyses, and dissemination (Levy et al., 2018; Howland et al 2022). Kastrouli (E375419.559, N4250792.352), a small, fortified site in the Phokis region of central Greece (near the modern village of Desfina), was the focus of excavations in the summer of 2016 (July 20–August 3; Fig. 1) as well as in subsequent season 2017, 2018 in the context of an at-risk cultural heritage site. During covid the works during 2019-2021 period was restricted to conservation of artifacts. An ancient fortification wall encompassing an area of 1.67 ha defines the size of the site where both archaeological features and ceramic sherds are found in abundance (Liritzis et al. 2016, 2021; Koh et al., 2020; Sideris 2022),

To date, two tombs from the Kastrouli site have been studied (Tomb A and B, Fig. 1). The skeletal material collected from the Kastrouli site was poorly preserved. That is because the environmental conditions in Greece are destructive for bone conservation due to calcareous soils and the annual range of climatic variations from dry/hot to wet/cold. However, the anthropological study showed that Tomb A contains at least 15 adult individuals, two subadults, and two prenatals. In Tomb B, only one adult individual was found. A detailed description of the anthropological study of Tomb A is given in a previous article when presenting the skeletal findings of the excavation (Chovalopoulou et al., 2017).

As a result of the poor preservation and comingled nature almost no single bone was found intact. Nevertheless, numerous teeth were identified. That is related to the fact that teeth are the most resistant skeletal elements to mechanical and chemical damage. Therefore, teeth play a significant role in paleontology and anthropology as they provide a lot of information related to age, sex, health, nutrition, and evolutionary relationships of extinct species. This article presents the findings of a thorough study of the health of the population's teeth, which was conducted by the surgeon dentist Mr. Ioannis Lilakos.

*Figure 1. a) Left the Tomb A in Kastrouli. (Photograph courtesy of Thomas E. Levy.et al 2018, 2022), b) Right the tomb B from south-west (Sideris 2022, fig.21)*

## 2. MATERIAL & METHODS

A brief description of the Kastrouli tombs follows:

Tomb A: A hybrid rock-cut and built chamber tomb, excavated at the westernmost part of the fortified area, contained an undisturbed commingled burial of at least fifteen adult individuals. The main diagnostic pottery form is the stirrup jar, and the small finds include Phi and Psi figurines, steatite beads, and fragments of gold foil. The period of the original use of the tomb falls between the LH IIIA 2 and the LH IIIC Early or Advanced (Sideris et al. 2017, figs. 16-22). There is some evidence that the tomb may have been reused in the Middle Geometric Period. The luminescence dating project of tomb and ceramics reconfirms the Late Mycenaean age and reuse of the tomb almost uninterrupted in later periods (Liritzis et al., 2018, 2016). The excavation of the commingled human burial was a difficult and lengthy process, since most of the bones were desiccated, very fragile and often disintegrated into small chips just after being exposed. The long bones (humerus, femur and tibia, and more rarely - radius and ulna) were relatively better preserved. Skull and facial bones, as well as teeth (free or still attached on fragments of the maxilla or mandible) were also collected. According to the anthropological report (Chovalopoulou et al., 2017) the skeletal remains from the commingled layer of the tomb belonged to at least fifteen adult individuals (both sexes represented), plus some subadult individuals including an infant and an unborn child. Table 1 lists the tooth samples from tomb A studied.

*Table 1. Tooth samples from tomb A.*

| Sample code | Identification |
|---|---|
| 56465521 | Upper jaw molar |
| 33673270 | Upper jaw premolar |
| 46983967 (L106) | Upper jaw premolar and molar |
| 85859700 | Several teeth (incisors, canines, premolars, molars) |

**Tomb B** had been largely destroyed by looters. Several small sherds with painted spirals and linear decoration have been collected from the eastern rim of the trench left behind from the illegal excavation. A Psi figurine was retrieved from the same area during the excavation (Sideris 2022, figs. 23-26). The human bones scattered all around and collected from the most distant areas of the tomb belong, according to the anthropological study, to a single adult male individual. A prenatal individual identified from a single fragment of a right femur does not relate necessarily to the original burial, since a prenatal individual has been identified in the adjacent Tomb A as well and part of its contents, no doubt, have been scattered around during looting (Chovalopoulou et al. 2017, table 2; Sideris et al. 2017; Sideris 2022). All the finds from the Tomb B suggest a date in the LH IIIC, and most probably in its early phase. It was constructed for its single occupant, who was almost certainly a very prominent member of the Kastrouli community, in striking contrast with the much earlier Tomb A and its 19+ individuals. At the end of the excavation season, both Tombs A and B were fenced for their protection. Table 2 lists the tooth samples from Tomb B studied by Mr. Lilakos.

*Table 2. Tooth samples from tomb B.*

| Identification |
|---|
| Left side of a mandible bearing the left incisor, the canine, the premolars, and the molars |

Visual inspection, X-ray examination, infrared spectroscopy, and examination in monochrome light were carried out on the tooth samples.

## 3. METHODS, RESULTS & DISCUSSION

For the radio-diagnostic examination and imaging of the dental and periodontal tissues, digital posterior alveolar X-rays were performed, for which a KODAK 2200 Intraoral Xray System (Generator) used as a source, a digital sensor (Sensor) Kodak RVG6100 Digital Radiography System, as well as the imaging program KODAK Dental Imaging Software v.6.12.11.0. The exposure data of all X-ray irrafiations performed are: 70KV, 7mA, exposure time 37ms, which corresponds to a radiation of dose area product of 8.93mGy*cm$^2$ per X-radiograph (Figure 2).


*Figure 2. The X ray generator setting and some features (© I.Lilakos)*

Regarding **Tomb A**, the tooth sample with code 56465521 showed low abrasion, with no particular pathological findings (Fig. 3). Similar results were obtained from tooth samples with codes 33673270 and 46983967 (L106) (Figs 4 and 5, respectively). However, teeth with severe abrasions resulting in the exposure of the underlying dentin (Figures 6 and 7) and teeth with caries cavities on the adjacent and chewing surface (Fig. 8), were also identified.

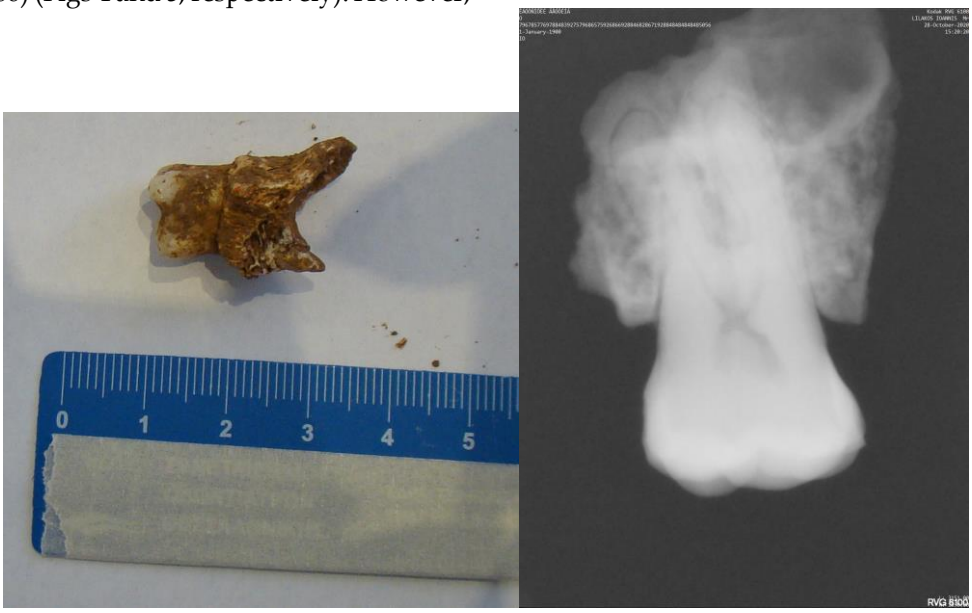


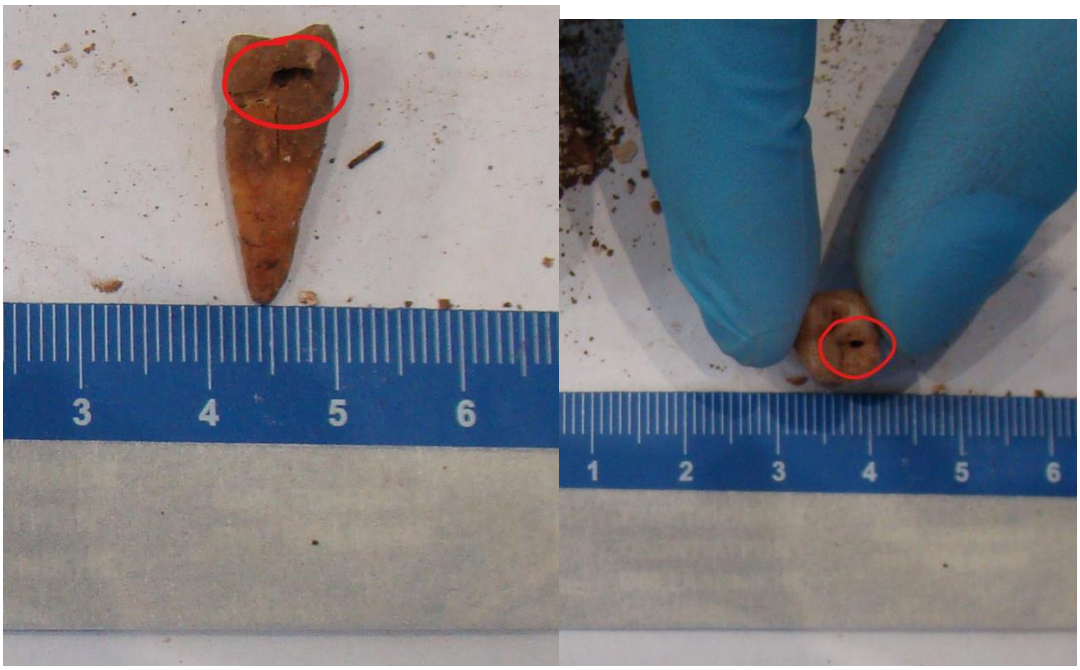

*Figure 3. Mandibular molar from Tomb A showing low abrasion, with no particular pathological findings.*


*Figure 4. Mandibular premolar(tomb A) showing low abrasion, with no particular pathological findings.*


*Figure 5. Mandibular premolar and molar (tomb A) showing low abrasion, with no particular pathological findings.*

*Figure 6. Severe abrasions (tomb A).*

*Figure 7. Severe abrasions on the chewing surface resulting in the exposure of the underlying dentin (tomb A).*



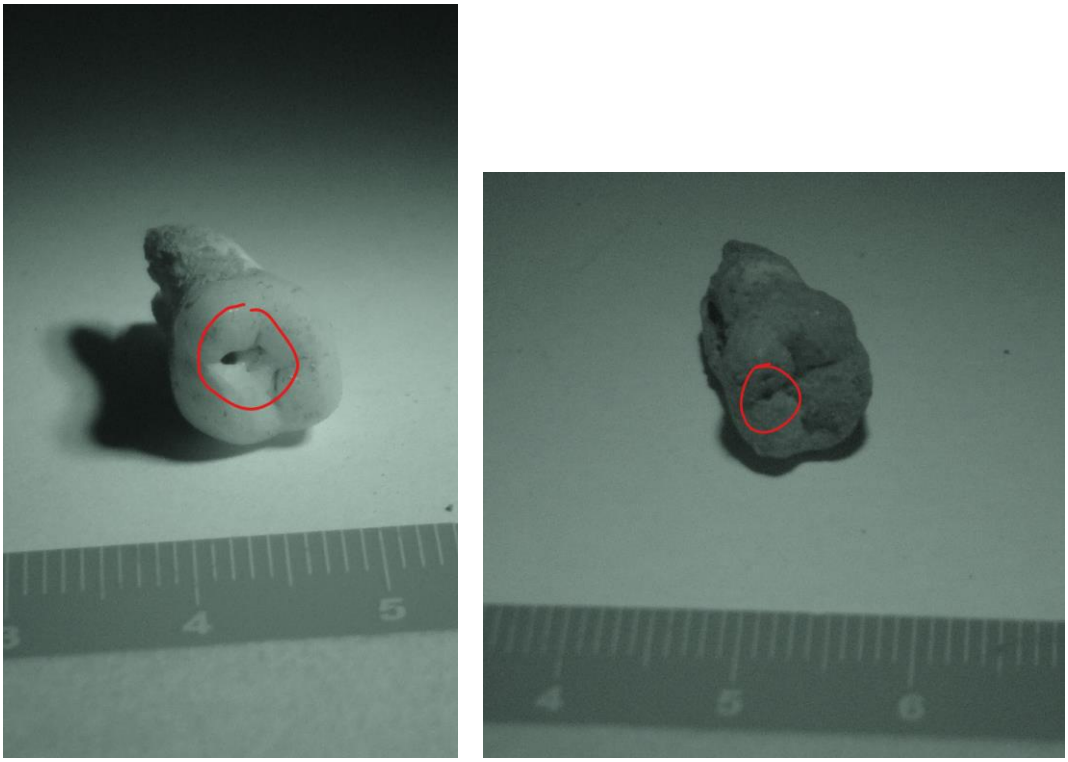


*Figure 8. Caries cavities on the adjacent and chewing surface (tomb A).*

Regarding the left side of a mandible located in **Tomb B**, the results of the examination showed that the bone was probably fractured (Fig. 9) and that he had gum disease (Fig. 10). In addition, an X-ray examination of the molar region showed that the degree of abrasion of the chewing surface was severe and carious lesions were identified on the distal surface of the premolar and the proximal surface of the molar (Fig. 11). Finally, during a radio-graphic examination, a periapical lesion was identified, which may indicate tissue inflammation due to the fracture of the 1st premolar while the individual was still alive (Fig. 12).

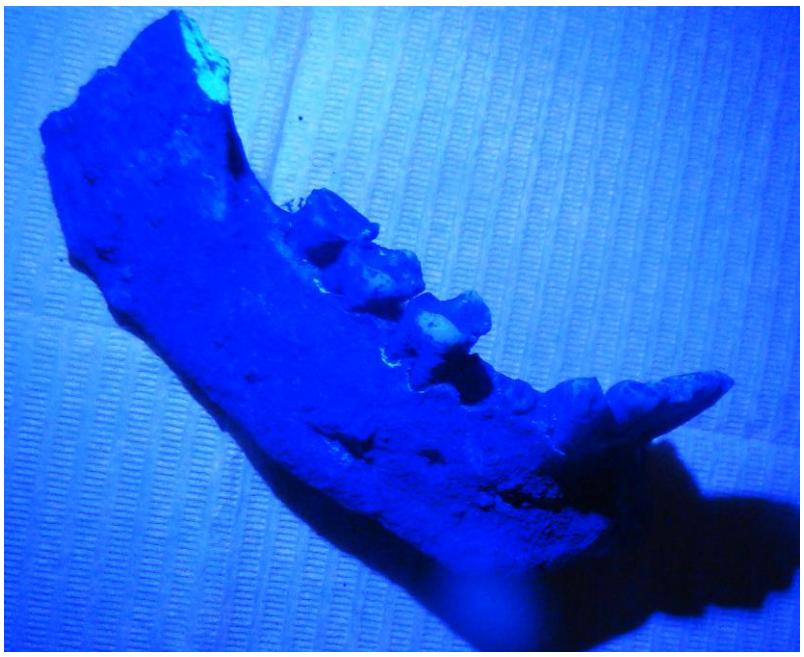


*Figure 9. An examination under monochromatic light (about 460nm) reveals the locations where the bone was fractured (tomb B)*

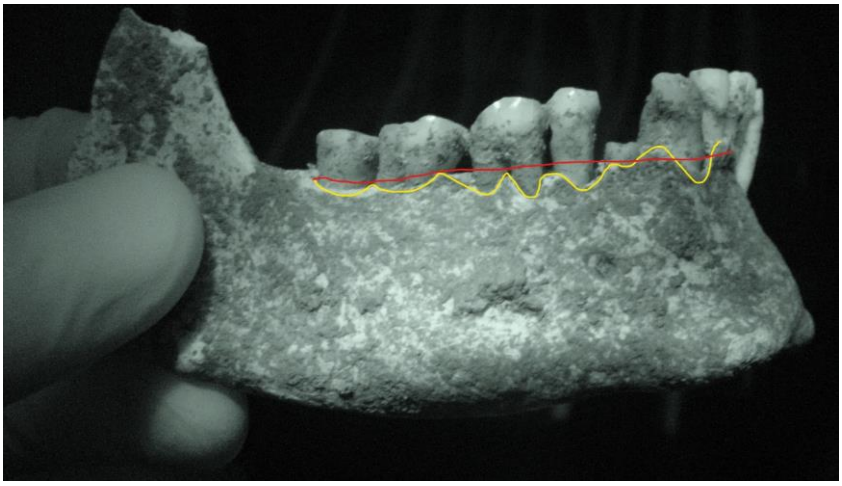


*Figure 10. The yellow outline marks the edge of the bone, while the red marks the approximate height where the alveolar crest should be located. This reveals the bone deficit due to periodontal disease (tomb B).*

*Figure 11. An X-ray examination of the molar region. Severe and carious lesions identified on the distal surface of the premolar and the proximal surface of the molar (tomb B).*

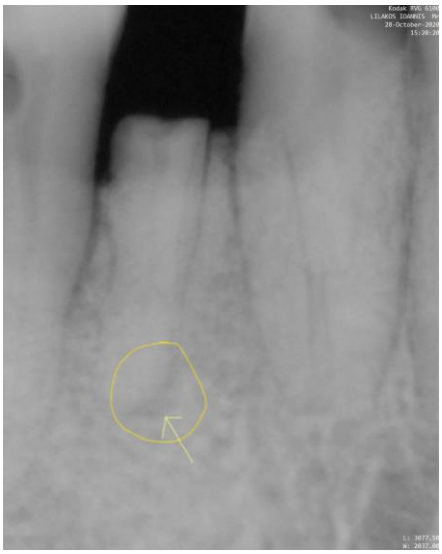


*Figure 12. A periapical lesion identified after a radiographic examination (tomb B).*

Noteworthy is the fact that no enamel defects were observed. Enamel hypoplasia occurs only while the teeth are developing, and can be caused by hereditary anomalies, localized trauma, or systemic metabolic (Goodman and Rose 1991, 279–294). According to Papathanasiou (2005, 196), this observation allows us to assume that Kastrouli's population, especially children, was in good health. Furthermore, a comparative bioarchaeological analysis revealed a clear tendency of Central and Southern Greece to display decreased frequencies of enamel defects,

compared to those of northern communities (Michael et al., 2021).

Regarding nutrition, we can surmise that Kastrouli's population didn't follow a high-protein diet since the teeth had dental caries, but there was no calculus present. Dental caries is characterized by the irreversible and gradual chemical decay of dental tissues by acids released by bacterial fermentation of carbohydrates, while dental calculus is calcified bacterial plaque and accumulates on the teeth faster when there is a high protein diet favoring an alkaline oral environment (Lukacs 1989, 283).

Concerning the abrasion detected, it is worth noting that abrasion starts from the moment the permanent teeth come through. The pace and pattern of the abrasion depend on the stages of tooth development, their morphology, size, the structure of the crown, the dental traction, the use, and finally, the quality of food. Finally, periodontal disease is the chronic inflammation of the periodontal soft tissue and the alveolar bone. It is a root cause of tooth loss and is due to many factors such as genetic predisposition, environment, hygiene conditions, and cultural factors. However, no tooth loss was observed in this sample.

Further research could focus on the dried/mummified molar pulps identified (Fig. 13), which can be examined microscopically for the presence of cells and/or genetic material for sex identification of the individual. In addition, the cavity of the caries lesion of #46 (Fig. 14) has a remnant, which is likely to be food encapsulated, and in this case, it can be used to get information about their diet.

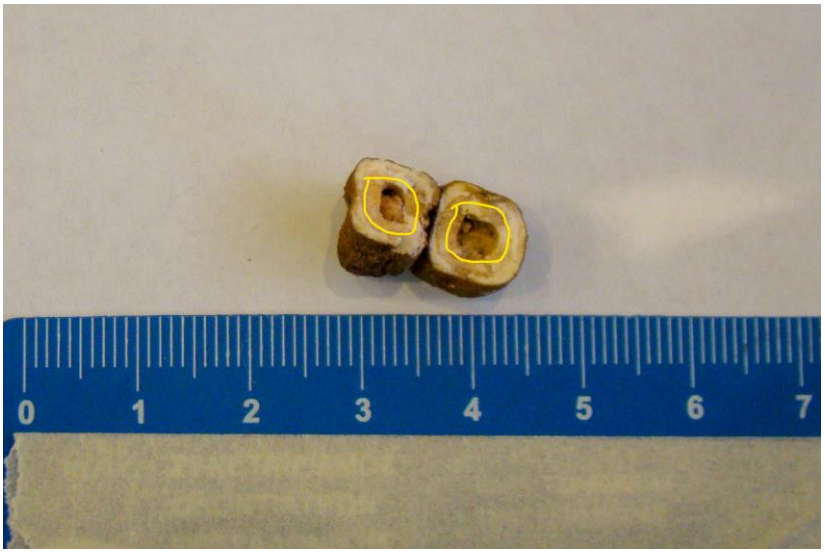



***Figure 13. Dried/mummified molar pulps.***

***Figure 14. Remnant in the cavity of the caries lesion of #46 was detected.***

It is known a relationship between dietary variation and social stratification (Goodman 1998; Cucina and Tiesler 2003), and the dental status indicators of health status and nutrition (Larsen 1997; Hillson 1996).

Based on the discussion made of Mycenaean burial practices, if the architecture and richness of tombs is

a direct measure of access resources during life. In relation to previous dental work on Mycenaean people and based on our knowledge of Mycenaean food and dietary studies[1], thus, in some tombs the individuals have a higher protein diet (including meat from wild and domestic animals, dairy products, pulses, and potentially marine life) with less dependence on carbohydrate-rich cariogenic foods. They should therefore show fewer dental pathologies (about general relationship between dental pathology and nutrition, see Larsen 1997 and Hillson 1996). Conversely, individuals from tombs with simpler architecture and fewer grave goods should show higher levels of dental pathology. For example, in the analysis of tombs at Pylos (chamber tombs and the tholos tombs; and a fiery destruction of Pylos in LH IIIC, ca 1180 BC, similar to Kastrouli) there are 68 partial or complete dentitions that can be evaluated dental analysis. Teeth were judged as lost antemortem when the alveolar bone exhibited substantial remodeling to the degree that no root sockets were functional. Caries presence, determined by visual inspection with hand lens magnification was tallied by individual tooth. Linear enamel hypoplasia, also assessed by visual inspection with hand lens magnification was denoted as present or absent. The work on Pylos tombs in Schepartz et al., (2009) indicates that there are significant differences between the dental health of males and females. Moreover, Shepartz et al., (2017) identify mortuary treatments that serve as indicators of social differentiation in terms of at least two clear-cut macro-class distinctions, based on bone and dental analysis. The analysis shows that the lower social strata possessed significantly poorer quality diets and that poor oral health was especially common among women. Those of high status evidently enjoyed greater access to protein as constructions of gender may have cross-cut vertical status differentiation. Similar findings from the cemetery of Kallithea Laganidia in Achaea, which was in use from LH IIIA to LH IIIC like the two Kastrouli tombs, betray a constant pattern in the correlation of social stratification and gender differentiation with the dental health (Graff 2011, 104-109). The periodontal disease detected in the Kastrouli samples, however, does not seem to have the heavy dental loss effect known from other Mycenaean sites, such as Aghia Triada (Tsilivakos et al. 2002). Ongoing isotopic study of the Kastrouli samples is under development (Chovalopoulou et al., 2022). The present case study adds usefully to the Late Helladic / Mycenaean issues regarding nutrition, palaeopathology and tomb type. Similar prehistoric guidelines prove useful to practicing human osteologists in their descriptive analyses of prehistoric specimens and stimulate meticulous collection of these kinds of data. Broader anthropological questions regarding inter-group differences in tooth status and tooth loss, which were unachievable in the past due to the lack of extensive data (Lukacs and Hemphill 1990), start by now to become reality (Schmidt et al. 2019), by combining large data sets and individual case-studies such as that of Kastrouli.

## 4. CONCLUSION

The nutrition of Kastrouli's population didn't follow a high-protein diet since the teeth had dental caries, but there was no calculus present. The degree of abrasion of the chewing surface was severe and carious lesions were identified on the distal surface of the premolar and the proximal surface of the molar and depends on the stages of tooth development, their morphology, size, the structure of the crown, the dental traction, the use, and finally, the quality of food. The periodontal disease, which was noticed, as it causes tooth loss, yet, no tooth loss was observed in one sample. No enamel defects were observed, and this allows us to assume that Kastrouli's population, especially children, were in good health.

## AUTHOR CONTRIBUTIONS

Conceptualization, I.Liritzis.; methodology, I.Lilakos.; software, I.Lilakos.; validation, I.Liritzis., I.Lilakos., M.Ch., T.L.; formal analysis, I.Lilakos., M.Ch.; investigation, I.Lilakos., M.Ch., I.Liritzis, T.E. Levy, A.S; resources, I.Liritzis.; data curation, I.Lilakos; archaeological context and tombs dating: A.S, T.E.L.; writing—original draft preparation, I.Lilakos., I.Liritzis; writing—review and editing, I.Lilakos., I.Liritzis., M.Ch, A.S., T.E.L.; visualization, I.Lilakos., M.Ch., I.Liritzis; supervision, I.Liritzis., M.Ch.; project administration, I.Liritzis; funding acquisition, no funding. All authors have read and agreed to the published version of the manuscript.

[1] Mycenaean food resources come from diverse sources, including Linear B tablets, frescos, faunal studies, paleobotanical studies, and staple isotope analyses of human bone. See Wright 1987, 2004.

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