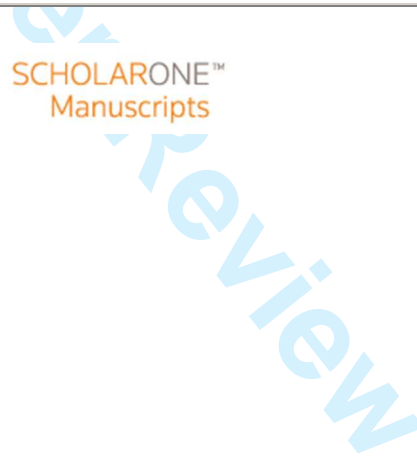


**Periapical lesions in intentionally modified teeth in a skeletal sample of enslaved Africans (Lagos, Portugal)**

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2 **Periapical lesions in intentionally modified teeth in a skeletal sample of enslaved Africans**  
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4 **(Lagos, Portugal)**  
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37 **Key words:** Dental modifications, periapical cyst, granuloma, dental infection, African slaves, 15<sup>th</sup>-  
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39 17<sup>th</sup> centuries.  
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## Abstract

Intentional dental modifications are alterations of teeth usually performed as a ritual for aesthetic or identity purposes. However, the execution of the technique is not exempt from risk, and can be related to a higher prevalence of dental pathology, more specifically through the exposure of the dental pulp and consequent periapical inflammation. With the aim of analysing the relationship between intentional dental modifications and periapical inflammation, the current study evaluated 81 skeletons (49 females, 19 males, and 13 individuals of unknown sex) of enslaved Africans from Lagos, Portugal (15<sup>th</sup>-17<sup>th</sup> centuries), of which 50 (61.7%) had intentionally modified teeth. In all, 2285 sockets and 2063 teeth were observed. Two hundred and three intentionally modified anterior teeth (27.2%) were identified. The differential diagnosis of periapical lesions was made following Dias and Tayles (1997), Dias et al. (2007), and Hillson (2001). Twenty five individuals (30.9%) and 54 teeth (25 anterior and 29 posterior) showed macroscopic evidences of periapical lesions. In the anterior dentition, intentional modification was identified as the probable aetiology of 17 (68.0%) periapical lesions, mostly granulomata or cysts, but also abscesses. The association between intentional modifications of the dentition and the presence of periapical lesions was found in both the maxilla and mandible. These results suggest that this cultural practice can predispose teeth to periapical inflammation, which may cause pain and sensitivity to cold, heat, and pressure, and probably had a negative impact on the quality of life of these individuals.

**Key words:** Dental modifications, periapical cyst, granuloma, dental infection, African slaves, 15<sup>th</sup>-17<sup>th</sup> centuries.

## 1. Introduction

Excavations performed in 2009 at the Valle da Gafaria site, located outside the medieval walls of Lagos, in southern Portugal, revealed an urban discard deposit dated from the 15<sup>th</sup>-17<sup>th</sup> centuries. Among discarded objects and food residues, several human remains were found. In all, 158 individuals were exhumed, including males and females, adults and sub-adults, many of them aged less than 30 years (for more details about this archaeological assemblage see Wasterlain et al., 2015).

Morphometric analysis of the skulls led us to attribute an African origin to these individuals (Coelho, 2012), later confirmed by DNA analysis performed in two individuals (number 125 and number 166) recovered in the discard deposit burials from Valle da Gafaria (Martiniano et al., 2014). An AMS C14 date obtained for one individual resulted in 450 +/- 40 BP, Cal AD 1420-1480, Cal BP 540-470, Beta – 276508, which is compatible with the first historical reports of caravels arriving at Lagos with enslaved Africans (Tinhorão, 1997; Henriques, 2009). All the findings suggest that these bodies were probably African slaves of the period just prior to the transatlantic slave trade, who arrived at Lagos harbour and were discarded in the urban deposit after death (for more details, see Wasterlain et al., 2015).

Several of the individuals exhumed from Valle da Gafaria presented dental alterations, not attributed to accidental trauma, functional wear, or post-mortem fracture. Wasterlain et al. (2015) performed an exhaustive investigation on such alterations and concluded that all modifications were consistent with intentional filing of the mesial and/or distal borders of both incisors and canines. Intentional dental modifications (IDM) have been recorded in many different cultures and time periods (Almeida, 1953; Santos, 1962; Dias and Dias, 1964; Pindborg, 1969; Redinha, 1974; Inoue et al., 1995; Finucane et al., 2008; Reichart et al., 2008, among others). This cultural practice may be related to rites of passage, differential status, group identification, mourning, or embellishment (Milner and Larsen, 1991; Finucane et al., 2008; Barnes, 2010).

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2 In Wasterlain et al. (2015), 55.8% of the 113 analysed individuals presented dental  
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4 modifications on their anterior dentition, with 42.9% exhibiting modifications on both upper and  
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6 lower teeth. The most frequently modified teeth were the incisors, followed by the canines. Dental  
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8 intentional modifications were observed in both sexes and all age-groups. Despite the impossibility  
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10 to infer a specific provenance for these slaves or the motivation/function behind this cultural  
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12 practice, Wasterlain et al. (2015) concluded that the observed patterns of dental modifications were  
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14 consistent with sub-Saharan African practices.

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17 From a clinical point of view these dental changes can be quite harmful, compromising both  
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19 the tooth and the support structures. Several possible consequences have been described, such as the  
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21 injury of the apical neurovascular bundle, pulp necrosis (caused by the exposure of the pulp to a  
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23 broad spectrum of micro-organisms, higher caries incidence in the modified surface, or thermal  
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25 aggression to the exposed dentin), loss of masticatory function, dental enamel hypoplasia in the  
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27 permanent teeth, post-avulsion lock-jaw, alveolar-dental fracture, and apical and/or root fractures  
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29 (Martins and Martins, 1986). In very young individuals in whom the apex closure has not been  
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31 completed, such modifications may lead to dental necrosis and subsequently abscess formation,  
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33 ultimately resulting in the tooth loss (Roseiro, 2013).

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37 Although there are several publications describing IDM in present-day and past populations,  
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39 almost none discusses the complications post-modification procedures. There are a few exceptions  
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41 though. For example, in a sample of intentionally modified teeth recovered in two Brazilian  
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43 cemeteries (cemetery of Pretos Novos in Rio de Janeiro and Sé church of Salvador, Bahia), Liryo et  
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45 al. (2011) found a low frequency of association between intentional dental modifications and  
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47 periapical cavities. Recent anthropological and ethnographic studies in modern populations of  
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49 Mozambique who still perform these rituals have shown a possible association with a higher risk of  
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51 dental pathology, like caries and infections (Roseiro, 2013).

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55 The aim of this study is to present an additional image of the quality of life of these  
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57 individuals. This will enrich the scanty osteoarchaeological and paleopathological documentation  
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1 on the enslaved people that arrived Portugal between the 15<sup>th</sup> and the 17<sup>th</sup> centuries, adding to the  
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3 few descriptions available for the relationship between intentional dental modifications and  
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5 periapical inflammation. On the other hand, it is believed that data presented in this study are not  
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7 only of anthropological relevance but also of clinical importance, since intentional dental  
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9 modification is a cultural practice still performed amongst several African ethnic groups.  
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## 12 13 14 15 **2. Material and Methods**

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17 For this study a sample of the Valle da Gafaria's collection (Lagos, Portugal) analysed by  
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19 Wasterlain et al. (2015) was selected, in order to include only individuals aged more than 12 years  
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21 old with at least four observable teeth (N = 81). The age-at-death was estimated on the basis of the  
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23 epiphyseal fusion of the femoral head (Ferembach et al., 1980), third molar eruption (Ozle et al.,  
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25 2007), spheno-occipital syncondrosis fusion (Shirley and Jantz, 2011), morphologic changes in the  
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27 pubic symphysis (Brooks and Suchey, 1990), and auricular surface of the ilium (Lovejoy et al.,  
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29 1985). Sexual diagnosis was made through the metric and morphological analysis of the skull and  
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31 innominate (Ferembach et al., 1980; Uytterschaut, 1986; Buikstra and Ubelaker, 1994; Bruzek,  
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33 2002; Murail et al., 2005).  
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37 Initially, teeth were examined for presence, post- and ante-mortem loss, and eruption  
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39 problems (partial eruption, anomalous eruption, or no eruption as a result of young age, impaction  
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41 or agenesis). All fully erupted teeth were examined under good lighting conditions by careful visual  
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43 inspection (Hillson, 2001) for the presence of intentional dental modifications (IDM). Special care  
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45 was taken to exclude unintentional modifications as ante-mortem or post-mortem fractures, dental  
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47 caries, and masticatory or occupational wear (for more details see Wasterlain et al., 2015).  
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51 Cavities in the bone around the apical foramen at the apex of the roots (or around a lateral  
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53 foramen at the site of a root) were macroscopically inspected, and their location recorded. A total of  
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55 43 periapical digital x-rays were performed (RVG- Radiovisiography System, Trophy x-ray unit;  
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57 voltage: 70 kV; mean time exposure: 0.125 s). As radiographic analysis of all maxilla/mandible was  
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1 not performed, whenever possible teeth were removed from their sockets in order to expose hidden  
2 periapical cavities (those without opening). The differential diagnoses of periapical lesions were  
3 made following Dias and Tayles (1997), Dias et al. (2007), and Hillson (2001), taking into account  
4 the appearance of the wall of the cavity, the lesion radius (measured in mm with a graduated probe),  
5 and the nature of the opening (special care was taken to distinguish sinus from openings made or  
6 enlarged by post-mortem damage). Although Dias and Tayles (1997) have defined a periapical  
7 granuloma as a cavity with a radius smaller than 3 mm with smooth walls, and a radicular cyst as a  
8 larger cavity of the same type, Hillson (2001) warned that it is possible for a granuloma to be larger  
9 and a cyst smaller, admonishing the use of the size of the lesion as a distinctive factor between  
10 granulomata and cysts. Therefore, in this paper, all cavities with smooth walls and circumscribed  
11 margins were indistinctively registered as granulomata/cyst. Cavities with roughened walls, ragged  
12 margins and/or a bony sinus leading to the subperiosteal surface were identified as abscesses (Dias  
13 and Tayles, 1997). The probable aetiology (dental caries, dental wear, trauma, intentional dental  
14 modification) of the lesions was also recorded.

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33 The statistical significance of the recorded values was tested with independent samples chi-  
34 square. Statistical analysis was conducted by using the IBM SPSS statistics® program (version  
35 22.0).

### 3. Results

#### *Individuals' biological profile*

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46 The biological profile of the individuals selected for the present study can be observed in  
47 Table S1. Of the 81 individuals under analysis, 49 (60.5%) were classified as females, 19 (23.5%)  
48 as males, and in 13 (16.0%) it was not possible to estimate sex. Age-at-death ranges between 12  
49 years and 50 years. In nine cases, the poor state of preservation and/or incompleteness of the  
50 skeletons made it impossible to estimate age-at-death but in each case it was confirmed that these  
51 individuals were older than 12 years at time of death. An African ancestry could be confirmed in the  
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63 individuals for whom this kind of analysis could be performed (Coelho, 2012; Navega et al., 2015). In the selected sample, 50 individuals (61.7%) had intentionally modified teeth.

### *Teeth sample*

In all, 2285 sockets and 2063 permanent fully erupted teeth (757 anterior and 1306 posterior; 1027 upper and 1036 lower) were analysed (Table 1). It should be noted, however, that 51 of these tooth sockets were damaged post-mortem impairing their evaluation. Of the observable sockets, the exact same number of teeth (N = 96, 4.2%) were lost post-mortem and before death. Eruption problems (partial eruption, anomalous eruption or complete failure to erupt as a result of young age, impaction or agenesis) were observed in 30 tooth positions (1.3%).

### *Intentional Dental Modifications*

Both women (61.2%) and men (63.2%) presented IDM. No differences were found between the two sexes (Chi-square = 3.471; df = 4; P <0.482). Only anterior teeth were culturally modified. Of the 757 anterior fully erupted teeth, ten could not be evaluated for the presence of IDM due to gross carious lesions or severe dental wear. Of the 747 anterior teeth (361 upper and 386 lower) analysed, 203 (27.2%) were modified. Anterior upper teeth were more modified (39.6%) than lower ones (15.5%) (Chi-square = 54.602, df = 1, P <0.000).

### *Periapical lesions*

In Table 2, the number and type of periapical lesions, their location, and the different ways in which the area of bone loss has been exposed to view, or otherwise detected, are presented. Twenty five (30.9%) of the 81 individuals presented macroscopic cavities in the alveolar bone compatible with periapical inflammation. In all, 54 periapical lesions were found. The majority of these individuals (N=17) registered only one or two lesions; however, one individual (no. 136) exhibited five lesions.



1 Most osteolytic lesions (77.8%) were consistent with a diagnosis of granuloma or cyst.  
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3 Seven (13.0%) were diagnosed as periapical abscesses, and only five (9.3%) were considered  
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5 residual lesions as they were remodelling due to the loss of the corresponding tooth. None of the  
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7 cavities had roughened, ragged margins, involving a large irregular area, which could suggest  
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9 osteomyelitis. Besides, no necrotic bone with an involucrum or multiple sinuses draining to the  
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11 surface were found.  
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14 Most lesions (79.6%) were visible on the buccal/labial plate of the alveolar process. None  
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16 could be observed only on the lingual plate. Four cavities (7.4%) showed an opening to both  
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18 cortical plates of the alveolar process, and one lesion on the maxilla appeared to have  
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20 communication with the maxillary sinus. In six cases the periapical lesions had no opening in the  
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22 cortical bone, and could only be observed after the removal of the tooth from its socket.  
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25 Females were relatively more susceptible to this condition (40.8% affected) than males  
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27 (26.3%). However this difference was not significant (Chi-square test: 1.238; d.f. =2; p = 0.266).  
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29 No periapical cavities were found in those individuals whose sex could not be estimated.  
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32 Although upper teeth were slightly more affected by periapical lesions (3.1%) than the lower  
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34 ones (2.1%), no significant differences were found between the maxilla and the mandible (Chi-  
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36 square test: 2.109; d.f. =1; p = 0.146). Similarly, anterior teeth (3.2%) were not significantly more  
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38 affected by periapical lesions than posterior teeth (2.2%) (Chi-square test: 1.888; d.f. =1; p = 0.169).  
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41 Concerning the aetiology of the periapical lesions (Table 3), 24 (44.4%) were related to  
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43 decayed teeth and 17 (31.5%) were associated with modified teeth. This can be observed in Figure  
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45 1, which provides an anterior view of the maxilla of the individual no. 120 with all upper incisors  
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47 intentionally modified and periapical lesions related to both upper central incisors. In the  
48  
49 corresponding x-ray (Figure 2) there are oval radiolucent areas related to the apices of the modified  
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51 teeth. In 11 lesions it was not possible to infer the aetiology due to ante-mortem (N = 6) or post-  
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53 mortem tooth loss (N = 5). In two other cases, the teeth were present without apparent pulp  
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55 involvement. In these 13 lesions the aetiology was recorded as unknown.  
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2 The possible aetiology of the periapical lesions was distinct for anterior teeth and posterior  
3 teeth. From the 29 lesions located in the posterior dentition, 75.9% were related to dental caries  
4 whereas 68.0% of the 25 anterior teeth with periapical lesions were intentionally modified.  
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8 The most affected teeth were the central incisors (29.6% of total lesions) and the first molars  
9 (24.1% of total lesions): the majority of the central incisors (81.3%) were intentionally modified  
10 whereas most first molars (53.8%) were decayed.  
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15 Since this study aims to investigate the relationship between intentional dental modifications  
16 and periapical lesions, and such cultural practice was exclusively observed in the anterior dentition  
17 of the Lagos's individuals, it is crucial to analyse only the anterior dentition in order to understand  
18 if the modified teeth were more prone to periapical lesions. In fact, it was confirmed that anterior  
19 modified teeth were significantly more affected by periapical lesions (9.3%) than unmodified teeth  
20 (0.4%) (Chi-square test: 39.466; d.f. =1;  $p < 0.000$ ). The association between intentional  
21 modifications of the dentition and the presence of periapical lesions was found in both the maxilla  
22 (Chi-square test: 11.405; d.f. =1;  $p = 0.001$ ) and mandible (Chi-square test: 32.912; d.f. =1;  $p <$   
23  $0.000$ ).  
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35 In the present sample, most modified teeth (139; 76.4%) presented removal of both mesial  
36 and distal incisal angles. Thirty-three teeth (18.1%) had only the mesial edge removed, and 10  
37 (5.5%) showed only the distal angle modified. However, no association was found between the  
38 presence of periapical lesions and the pattern of dental modification (Chi-square test: 1.795; d.f. =2;  
39  $p = 0.408$ ).  
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#### 48 **4. Discussion**

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50 Given that an important archaeological assemblage of African individuals recovered from  
51 Lagos (Portugal), who lived between the 15<sup>th</sup> and 17<sup>th</sup> centuries, had intentional dental  
52 modifications, it was important to assess the relationship between this cultural practice and  
53 periapical inflammation to better understand the impact of such lesions on the quality of their lives.  
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2 In this investigation only those aged more than 12 years old and with at least four observable teeth  
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4 were selected. Therefore, the sample analysed in the present study comprises 81 individuals of the  
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6 158 found in Valle da Gafaria, Lagos, Portugal. Intentional dental modifications were almost  
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8 equally recorded in women and men, and the anterior upper teeth were significantly more modified  
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10 than the anterior lower. The same trend was observed by Wasterlain et al. (2015) with the entire  
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12 collection.  
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14  
15 Concerning periapical inflammation, a relatively high percentage of the analysed individuals  
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17 (30.9%, n = 25) presented macroscopic cavities in the alveolar bone compatible with periapical  
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19 inflammation. In many instances, the periapical lesions were related to decayed teeth (44.4%), but  
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21 in a considerable number of cases they were associated with modified teeth (31.5%). More  
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23 interestingly, when this pathological condition was exclusively observed in the anterior dentition of  
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25 the Lagos's individuals, it was confirmed that anterior modified teeth were significantly more  
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27 affected by periapical lesions (9.3%) than unmodified teeth (0.4%). Moreover, it was noted that  
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29 periapical lesions predominantly affected intentionally modified teeth regardless of the number of  
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31 dental angles removed.  
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35 In a sample from the cemetery of Pretos Novos, Rio de Janeiro (Brazil), only a periapical  
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37 abscess was found associated with the modified teeth. Furthermore, in a sample from the Sé church,  
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39 Bahia (Brazil), just 1.5% of the loci showed apical cavities. It should be highlighted, however, that  
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41 in both Brazilian samples, the two conditions (IDM and periapical lesions) could just be observed  
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43 concomitantly in a relatively low number of cases because many teeth were loose (Liryo et al.,  
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45 2011). In other words, it is possible that many of the modified teeth were associated with periapical  
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47 lesions but as the corresponding jaws are absent makes it is impossible to retrieve that information.  
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51 In contrast, in 2008, Reichart et al. examined IDM in 33 skulls from the Berlin Museum of  
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53 Medical History, which were collected in Cameron around the turn of the 20<sup>th</sup> century. In this  
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55 sample, pulp exposure was observed in 30.3% of the modified teeth whereas periapical osteitis or  
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radicular cysts were found in 27.3% of the cases. As in the present study, all lesions were located overlying the apex of the modified anterior teeth.

Similarly, in a Mesoamerican pre-Hispanic sample, a positive relationship between periapical inflammation and IDM was found (Amado, 1995; Olvera et al., 2010). In this case, the teeth were drilled with inlays and it was suggested that the high temperatures originated by friction had been a causative factor of the periapical inflammation. As already mentioned, in the Lagos's sample there is no evidence of such practice, nor staining, or ablation. All modifications are consistent with filing (for more details, see Wasterlain et al., 2015). This specific practice may be also quite harmful, by exposing the pulp to a broad spectrum of micro-organisms and therefore leading to the pulp necrosis, or other consequences (Goose, 1963; Martins and Martins, 1986).

In an ethnographic study conducted in Angola several decades ago, Almeida (1937) noted that immediately after a dental modification procedure of filing, there would be only slight pain and minor bleeding. However, he reported dental caries, gingivitis, pyorrhoea, and jaw lesions as common long-term consequences. Nevertheless, it has also been suggested that many teeth suffering violent trauma (accidental or wilful, such as dental modification) may not develop periapical abscesses due to defence mechanisms, namely deposition of secondary dentine, which limits the exposure of the pulp and the consequent periapical infection (Goose, 1963; Dias and Tayles, 1997; Hillson, 2001, 2008; Roseiro, 2013). In the present sample, there were cases where this could have happened. For example, Figure 3 shows the right upper central incisor of individual no. 44, with the mesial incisal angle removed. This tooth was not associated with any periapical lesions. However, the analysis of the periapical x-ray image (Figure 4) showed an alteration of the dental pulp morphology on the mesial pulp horn. This was probably due to the deposition of irregular secondary dentine in response to the aggression, leading to the modification of the normal contour of the pulp chamber, the pulp remaining vital. A similar description was made by Goose (1963) for one modified tooth from West Africa.

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In 2007, Fabian and Mumghamba conducted a study among living adults from South East Tanzania in order to determine the relationship between tooth and lip mutilations (piercing the upper lip and inserting a wooden stick) and the prevalence of tooth loss and the associated oral mucosal lesions, respectively. Concerning dental modifications, they concluded that this practice did not lead to significant tooth loss. In the present study, it was not possible to perform such investigation since it is impracticable to discern between the several possible causes of ante-mortem tooth loss in skeletal material.

Periapical lesions start to develop close to the tooth root in the middle of the maxilla/mandible and expand to the outer border of the bone. Depending on the severity of the inflammatory process, the bone defect caused by odontogenic infection does not necessarily have to be visible on the outer border of the maxilla/mandible (Dias and Tayles, 1997). That is the reason why radiographic methods have been considered the most accurate way of determining the prevalence of periapical lesions. In the anthropological literature it is commonly stated that if x-rays are not used in dry skulls, false low prevalence rates can be established (Hillson, 2001, 2005). In fact, in six cases of the present study the periapical lesions had no opening in the cortical bone, and could only be observed after the removal of the tooth from its socket. Besides, periapical lesions were more frequently visible on the buccal/labial plate of the alveolar process (79.6%), particularly of the anterior dentition. This is probably due the higher density of the lingual cortical bone in this section. Considering that radiological analysis of all individuals/teeth was not performed, the frequency of periapical inflammation in the Lagos's individuals could be somewhat higher than that presented here.

Most periapical lesions observed in the present sample were cavities with smooth walls and circumscribed margins, being therefore diagnosed as possible granulomata or cysts (77.8%). A lower percentage (13.0%) of cavities had roughened walls, ragged margins and/or a bony sinus leading to the subperiosteal surface, being identified as dental abscesses. This result is in

1  
2 accordance with the expected. Dias and Tayles (1997) highlighted that most periapical cavities  
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4 would be occupied by relatively benign lesions such as granulomata and apical periodontal cysts.  
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6 In the pre-antibiotic era, odontogenic infections could be very serious conditions that were  
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8 often life-threatening (Dias and Tayles, 1997). It is possible that the low frequency of dental  
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10 abscesses and complete absence of osteomyelitis in the Lagos's sample are due to the non-survival  
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12 of those individuals who developed these more serious conditions. In fact, both acute abscesses and  
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14 osteomyelitis will not result in bony changes because there is not enough time for the stimulation of  
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16 osteoclastic resorption (Dias and Tayles, 1997; Hillson, 2001). If the host immune response is  
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18 inadequate or if the virulence of the infecting agent is high, other potentially lethal complications  
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20 may occur from an untreated abscess, namely cellulitis, systemic bacteraemia, and ultimately  
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22 generalized septicaemia (Dias and Tayles, 1997). In opposition to the abscess, which is  
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24 characterized by localized severe pain, tooth extrusion, together with systemic effects (e.g., fever,  
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26 enlarged and tender lymph nodes, and general malaise), both periapical granulomata and apical  
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28 cysts are relatively asymptomatic. Although there may be some minor symptoms such as slight pain  
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30 during masticatory activities, there are no systemic consequences (Dias and Tayles, 1997; Hillson,  
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32 2001). While recognizing that many of these injuries, especially in its chronic phase, have no  
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34 symptoms, it is believed that several may have affected the morbidity of these individuals in some  
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36 way. Finally, in five cases (9.3%) the lesions were classified as residual. As already described by  
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38 other authors (Dias and Tayles, 1997; Ortner, 2003; Dias et al. 2007), periapical lesions may be  
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40 observed without an apparent causative source of infection. In such cases, the septic tooth had  
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42 exfoliated (or was extracted due to associated pain), and the socket has remodelled.  
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## 50 51 **5. Conclusion**

52 It is believed that the individuals recovered in the Valle da Gafaria, Lagos (15<sup>th</sup>-17<sup>th</sup>  
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54 centuries), were enslaved, captured somewhere in sub-Saharan Africa, bought and shipped by the  
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56 Portuguese from multiple locations, and brought to the harbour of Lagos (Fonseca, 2010; Caldeira,  
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2013). It is not known exactly how many slaves were transported on each ship. A vessel of 60 tons could carry a maximum of 220-255 slaves, between adults and children. It is known, however, that the ships' capacity was often largely superseded (Caldeira, 2013). The slaves were frequently tied and accommodated in overcrowded spaces with insufficient ventilation. Moreover, the several weeks of journey (the exact duration is unknown) were characterized by scarcity of water and food (Smallwood, 2008; Caldeira, 2013). Those who did not die during the journey – and the historical sources refer to values sometimes exceeding 39% (Mendes, 2004) – arrived extremely debilitated. The Lagos's sample provides a great opportunity to learn more about the relationship between intentional dental modifications and periapical inflammation in these captive individuals. Not only are there few studies that analyse this relationship but Lagos has the largest osteological sample in the World that allows for this research. Despite the impossibility of performing systematic radiological analyses of all individuals/teeth, the results here presented suggest that the cultural practice of intentional dental modification can predispose teeth to periapical inflammation, which may cause pain and sensitivity to cold, heat and pressure. These symptoms probably had a negative impact on the quality of life of the enslaved individuals exhumed from a deposit of urban waste of the Valle da Gafaria. Besides the difficult journey in sub-human conditions, these individuals would have had tooth sensitivity and/or pain, which would hinder a normal mastication. In cases of abscesses, the systemic effects, such as persistent fever, enlarged regional lymph nodes, and general malaise, would further affect the quality of life of these individuals and could even lead to the development of fatal conditions.

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5 The authors state that they do not have any conflict of interest to declare.  
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## 10 Supporting Information

11 Supporting tables: Table S1.

12 Table S1. Biological profile of the selected individuals exhumed from the deposit of urban waste in  
13 Valle da Gafaria (Lagos, Portugal).  
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Table 1. Teeth present, missing ante-mortem, lost post-mortem, and with eruption related problems in each tooth type.

Tooth type	Present		Lost AM		Lost PM		ERP		Total
	n	%	n	%	n	%	n	%	n
Central incisor	231	81.6	15	5.3	37	13.1	0	0	283
Lateral incisor	257	90.5	4	1.4	22	7.7	1	0.4	284
Canine	269	94.4	2	0.7	13	4.6	1	0.4	285
First premolar	273	95.1	7	2.4	7	2.4	0	0	287
Second premolar	275	95.2	9	3.1	2	0.7	3	1.0	289
First molar	253	88.5	28	9.8	5	1.7	0	0	286
Second molar	261	90.6	23	8.0	4	1.4	0	0	288
Third molar	244	86.2	8	2.9	6	2.1	25	8.8	283
Total	2063	90.3	96	4.2	96	4.2	30	1.3	2285

Lost AM – Lost ante-mortem.

Lost PM – Lost post-mortem.

ERP – Eruption related problems.

Table 2. Number and type of periapical lesions, location and the different ways in which the area of bone loss has been exposed to view, or otherwise detected in the selected individuals exhumed from the deposit of urban waste in Valle da Gafaria (Lagos, Portugal).

Individual no.	Number of lesions	Tooth*	Type of lesion†	Area of bone loss
32	1	11	G/C	Buccal
38	4	16	A	Buccal and Lingual
		26	A	Buccal
		42	A	Buccal
		46	G/C	Buccal
39	4	11	G/C	Buccal
		16	G/C	Buccal
		22	G/C	Buccal and Lingual
		46	R	Buccal
44	2	25	G/C	Buccal and Lingual
		36	R	Buccal
				Sinus
60	2	26	A	communication
		36	G/C	Buccal
69	1	21	G/C	Buccal and Lingual
75	4	26	R	Buccal
		35	A	Buccal
		36	G/C	Buccal
		47	G/C	Buccal
78	4	15	G/C	Buccal

		18	G/C	Without opening
		35	G/C	Buccal
		45	G/C	Buccal
79	2	18	G/C	Buccal
		27	G/C	Without opening
82	1	22	G/C	Without opening
94	1	35	A	Without opening
95	2	21	G/C	Buccal
		31	G/C	Buccal
98	1	34	G/C	Buccal
100	3	11	G/C	Buccal
		21	G/C	Buccal
		41	G/C	Buccal
107	1	21	G/C	Buccal
120	2	11	G/C	Buccal
		21	G/C	Buccal
125	2	21	G/C	Buccal
		22	G/C	Without opening
133	1	32	G/C	Buccal
136	5	13	R	Buccal
		26	G/C	Buccal
		33	G/C	Buccal
		35	G/C	Buccal
		44	G/C	Buccal
148	1	36	G/C	Buccal

150	2	11	G/C	Buccal
		31	G/C	Without opening
151	1	44	G/C	Buccal
157	3	22	G/C	Buccal
		26	R	Buccal
		35	A	Buccal
160	3	21	G/C	Buccal
		31	G/C	Buccal
		42	G/C	Buccal
170	1	17	G/C	Buccal

\* The dental nomenclature used in this table was the two digit system proposed by the

*Fédération Dentaire Internationale*

† G/C – Granuloma/cyst; A – Abscess; R – Residual lesion; IDM – Intentional Dental Modification



Table 3. Possible etiology of the periapical lesions, by tooth type, in the selected individuals exhumed from the deposit of urban waste in Valle da Gafaria (Lagos, Portugal).

Tooth type	Caries		Dental Modification		Unknown		Total
	n	%	n	%	n	%	
Central incisor	1	6.2	13	81.3	2	12.5	16
Lateral incisor	0	0.0	4	57.1	3	42.9	7
Canine	1	50.0	0	0.0	1	50.0	2
First premolar	3	100.0	0	0.0	0	0.0	3
Second premolar	8	100.0	0	0.0	0	0.0	8
First molar	7	53.8	0	0.0	6	46.2	13
Second molar	3	100.0	0	0.0	0	0.0	3
Third molar	1	50.0	0	0.0	1	50.0	2

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<b>Total</b>	<b>24</b>	<b>44.4</b>	<b>17</b>	<b>31.5</b>	<b>13</b>	<b>24.1</b>	<b>54</b>
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Figure 1. Maxilla (anterior view) of individual no.120 from the deposit of urban waste of the Valle da Gafaria (Lagos, Portugal), with all upper incisors intentionally modified and periapical lesions related to both upper central incisors.

1930x1286mm (72 x 72 DPI)

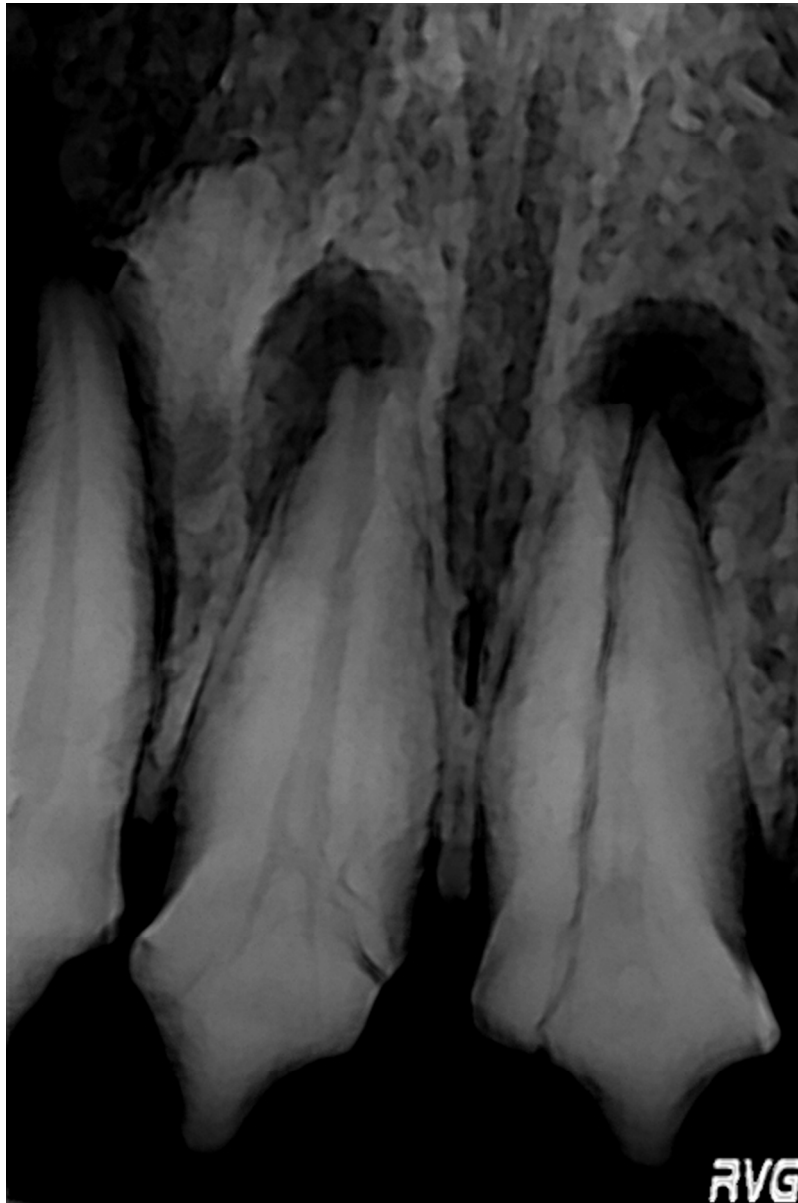


Figure 2. Radiograph of the upper central incisors of individual no.120 from the deposit of urban waste of the Valle da Gafaria (Lagos, Portugal), where it can be observed oval radiolucent areas related to the apices of the modified teeth. Note that both teeth presented post mortem fractures.  
500x975mm (26 x 20 DPI)



Figure 3. Upper right central incisor (anterior view) of individual no.44 from the deposit of urban waste of the Valle da Gafaria (Lagos, Portugal) with the mesial incisal angle removed.  
1625x1219mm (72 x 72 DPI)

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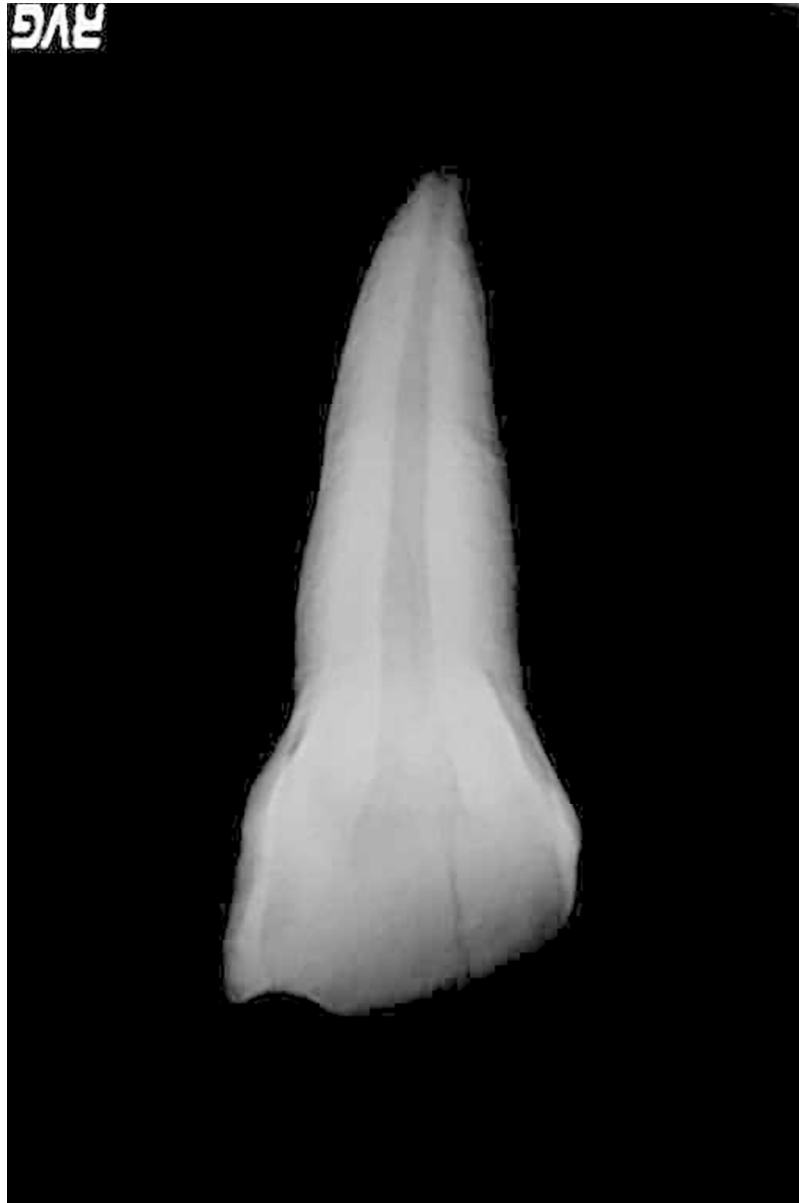


Figure 4. Radiograph of the upper right central incisor of individual no. 44 from the deposit of urban waste of the Valle da Gafaria (Lagos, Portugal), where it can be observed an alteration of the dental pulp morphology on the mesial pulp horn.  
500x975mm (26 x 20 DPI)