Coll. Antropol. **31** (2007) 2: 379–385
Original scientific paper

Pathology of the Mandibles and Maxillae from Archaeological Context: Discrepancy between Diagnoses Obtained by External Inspection and Radiological Analysis

Marija Djurić[1] and Zoran Rakočević[2]

[1] Laboratory of Anthropology, Institute of Anatomy, School of Medicine, University of Belgrade, Belgrade, Serbia
[2] Department of Radiology, School of Dentistry, University of Belgrade, Belgrade, Serbia

A B S T R A C T

The goal of this research was to investigate the type and frequency of mandibular and maxillary lesions that could not be diagnosed relying solely on external macroscopic observation. The sample comprised of 189 maxillae and 182 mandibles from a late-medieval graveyard. The material was examined both macroscopically and radiologically, using traditional X-ray facilities, orthopantomographs, and a dental X-ray unit. The total number of lesions detected by radiography was 103, with the majority of them (90.3%) showing no external macroscopic features. The most frequently detected diseases were periodontal inflammatory lesions (64.1%), followed by developmental anomalies of the teeth (22.3%). The results of this study revealed that radiography allowed the detection of many underlying pathological lesions of the jaws that otherwise were not detected through external macroscopic examination.

Key words: *maxilla, mandible, radiography, jaw diseases, skeletal remains*

Introduction

The mandible and the teeth are typically the best preserved elements of the skeleton in archaeological contexts. While paleopathological studies devoted much attention to the teeth, the jaws did not attract any significant research effort. Possibly due to easier diagnostics of tooth diseases, i.e. the majority of tooth lesions investigated in anthropological studies, such as dental caries, attrition, root exposure and enamel hypoplasia, could be analyzed by external visual inspection alone[1–14]. However, diseases of periodontal structures and some types of jaw lesions are not observable by visual macroscopic inspection, and require radiographic examination[15–20]. These are the lesions that mainly affect the internal structure of the jaws without a tendency to involve the bone surface (*i.e.* central lesions, such as central eosinophile granuloma, histiocytosis X, central hemangioma, impacted teeth, metastatic lesions, odontogenous tumors and cysts). Moreover, some of the internal processes change the macroscopic bone features only in the advanced stages of disease when cortical laminas are affected (*i.e.,* osteosarcoma, osteomyelitis, ameloblastoma). Prevalence of these conditions is systematically underestimated if radiological examination is not done.

The aim of this study was to investigate the frequency and the type of lesions of the maxilla and mandible from an osteoarchaeological sample that are detectable only by radiographs, and to evaluate the need for systematic radiography of jaws from an archaeological context.

Materials

Material in the study comprised of 286 individual skeletons of adults of both sexes, from the late-medieval graveyard of Stara Torina, located in northern Serbia. These populations lived in rural community being mostly involved in agriculture activities, particularly the cereal growing. Of the 286 well preserved individuals, examined 85 had both maxillae and mandibles, 104 had only maxillae, and 97 only mandibles.

Received for publication October 24, 2005

Methods

A total of 189 maxillae and 182 mandibles were examined for signs of disease by macroscopic external observation and by radiography, using traditional X-ray facilities, orthopantomograph, and a dental X-ray unit. In this study we did not analyze dental caries, enamel hypoplasia, alveolar bone loss due to periodontal disease, and other conditions that are usually easy to recognize by external observation of teeth and jaws.

In order to apply the most appropriate method for various specimens in the study we used the following radiographic procedures:

a) for complete skulls – ortopantomography;
b) for isolated maxilla – intraoral cross-sectional maxillary occlusal projections, and intraoral lateral maxillary occlusal projection;
c) for isolated mandible – extraoral radiographs in the modified lateral oblique (right and left) views, and
d) for anterior portion of the isolated mandible – intraoral bisecting-angle technique.

The panoramic radiographies were taken with a Siemens Orthopantomograph 10E using minimum tube voltage (55 kV), and tube current of 5–7 mA/s for the exposure. For standard radiography we used Seldix 325/550 radiology device with tube voltage of 15–50 kV, and tube current of 40–70 mA/s. Intraoral radiographies were taken by Gendex dental X-ray unit.

Ortopantomography provided images of both jaws simultaneously, occlusal relationship of teeth, and well visualization of the shape of lesions due to orthogonal projection, i.e. central x-ray is at right angle to the projection plane (film), which is parallel to the plane of jaws. However, ortopantomography of dried skulls presents two problems: the lack of soft tissue (particularly of massive structures of oral cavity) which could lead to overexposure of X-ray film, and difficulty to maintain the skull in the correct position[20]. A thin aluminum foil was positioned over the x-ray outlet to compensate for the lack of radiation absorption by the missing soft tissue, as it was recommended by Du Chesne [21]. The optical quality of image was still unsatisfactory, particularly in the frontal regions of the jaws, so we further improved technique by positioning another foil on external aspect of frontal part of jaws, and by using the combination of green-sensitive film and blue-emitting intensifying screen.

Other radiographic methods used in this study demonstrated some advantages regarding the easy handling and positioning of the fragmented specimens, easy selection of the optimal technical conditions for radiography (tube voltage, filtration and exposure time), and better optical quality of images, which was important for assessing structural changes of the bone lesions in the jaws.

In radiographic interpretation of jaw images we used the same descriptive patterns that are essential for reaching diagnosis in clinical practice: location, symmetry and number of lesions, size and shape of the lesion, margins of the lesion, contents of the lesion, and relationship to adjacent structures (teeth, supporting structures of the teeth, cortex, periost, sinuses, mandibular canal).

Results

External inspection and radiographic findings demonstrated various lesions in 13 out of 189 maxillae (6.9%), and 79 out of 182 mandibles (43.4%). The frequency of different lesions in the sample is presented in Table 1. The total number of lesions (103) is larger than number of specimens involved (13 maxillae and 79 mandibles) because several of the specimens presented multiple lesions.

The most frequently detected lesions were inflammatory in origin (64.1% of total number of lesions), followed by developmental anomalies of the teeth (22.3%). Both types of lesions were mostly discovered in mandibles. Tumors and tumor-like lesions, all found in the mandibles, accounted for only 13.6% of total pathological conditions. The frequency, distribution and way of detection of particular types of lesions are presented in Tables 2 and 3.

As discussed below, there is a significant difference in diagnostic abilities between macroscopic observation and radiography. The total number of lesions detected by radiography was 103, with majority of them (90.3%) unobservable using external examination. Tumors and tumor-

TABLE 1
DISTRIBUTION OF DIFFERENT TYPES OF LESIONS IN INVESTIGATED SAMPLE

Group of lesion	Maxilla	Mandible	Total	
	(N=189)	(N=182)	(N=371)	%
Developmental anomalies	5	18	23	22. 3
Periodontal inflammations	10	56	66	64.1
Tumors and tumor-like lesions	0	14	14	13.6
Total	15	88	103	100

TABLE 2
THE LESIONS DETECTED ONLY ON RADIOGRAPHS COMPARED TO THE LESIONS VISIBLE BY EXTERNAL OBSERVATION ONLY

Type of detection	Developmental anomalies	Periodontal inflammations	Tumors and tumor like lesions	Total	%
External observation	4	6	0	10	9.7
Only on radiographs	19	60	14	93	90.3
Total	23	66	14	103	100

TABLE 3
FREQUENCY AND TYPE OF DETECTION OF DIFFERENT GROUPS OF LESIONS IN INVESTIGATED SAMPLE

Type of disease	Location		Type of detection	
	Max	Mand	External observation	Radiography only
		Developmental anomalies		
Anodontia	0	3	0	3
Unerupted teeth	3	10	3	10
Taurodontism	1	1	0	2
Dilaceration	1	3	0	4
Developmental lateral periodontal cyst	0	1	1	0
		Periodontal inflammations		
Radicular cyst or granuloma	0	5	3	2
Residual cyst or granuloma	1	4	1	4
Other periapical inflammation	3	10	2	11
Apical condensing osteitis	0	26	0	26
Hypercementosis	1	6	0	7
Periapical cemental dysplasia	0	1	0	1
Traumatic periodontitis	5	4	0	9
		Tumors and tumor like lesions		
Odontoma	0	9	0	9
Myxoma	0	1	0	1
Bone cyst	0	2	0	2
Aneurismal bone cyst	0	2	0	2

-like lesions were detected exclusively on radiographs (Figure 1a,b). While the evidence of periodontal inflammations (Figure 2a,b,c) was detected macroscopically (6 of 66) in 9% of the cases, out of 23 developmental anomalies (Figure 3a,b,c) only four (17%) were observable by external examination.

Discussion

The lesions affecting the internal structures of the jaws and tooth root were not visible by external inspection. In some cases, lesion size, its location adjacent to the cortical bone, or perforation of the cortical lamina due to post-mortem damage in the soil, rendered them observable.

The first group of diseases in this material – developmental anomalies, we classified as anomalies of number, position and shape of the teeth, and developmental cysts. Diagnosis of missing teeth by external observation is easy to establish, but to distinguish between anodontia and unerupted teeth usually requires radiography. Although there are some clinical experiences that suggest the nature of hypodontia (for example, small retromolar space is indicative for anodontia of third molar), such diagnoses are not reliable. In this study, we succeed in distinguishing between anodontia and unerupted teeth only in three cases by external observation due to fenestrations of the thin labial cortical lamina that make teeth visible in the exterior of the mandible (Figure 4a,b).

Fig. 1. Odontogenic myxoma in premolar region: a) external view; b) radiography – multilocular radiolucency with ill defined borders and trabeculae tending to intersect at right angles, and a slight displacement of surrounding teeth is present.

Fig. 2. Residual granuloma: a) external buccal view, b) external oral view, c) radiography – well defined radiolucency with a distinct sclerotic margin in edentulous area of the mandible.

Fig. 3. Impacted tooth non-observable by external examination: a) external buccal view; b) external oral view; c) radiography.

Anomalies of the shape found in this material comprised taurodontism and dilaceration of the roots, both related to tooth root, and not detectable by external examination. Prevalence of taurodontism reported in modern populations varied from 0.25% to 5.6% [22]. However, different quantitative studies of samples from archaeological context have employed different index values to measure and categorize taurodontism, which makes comparative assessment and frequency count of this trait somewhat problematic[19]. Paleopathological significance of the trait lays in its sporadic association with genetic malformations, such as Klinefelter syndrome, Wolf-Hirschhorn syndrome, Lowe syndrome, and Down syndrome[24–26]. However, we have not found any signs of those diseases in the sample.

Developmental periodontal cyst is a rare odontogenic cyst usually found in the premolar area of the mandible[27]. In modern clinical cases it usually causes no symptoms, but a very slight buccal expansion sometimes can be palpated[22]. In our material, it was detected by external macroscopic observation due to perforation of the cortical lamina caused by size and location of the cyst adjacent to the alveolar ridge (Figure 5a,b). Nevertheless, relations of adjacent third molar to retromolar space and anterior border of ramus, that was clearly visible on radiography, allowed reliable differentiation between developmental periodontal cyst and osteolysis in pericoronitis.

Classification of periodontal inflammations used in this study is not completely identical to those applied in clinical practice. Here, it is based on radiological features, etiology, and relationship of lesion to the teeth. For

Fig. 4. Impacted tooth observable by external examination due to perforation of cortical lamina: a) external view; b) radiography.

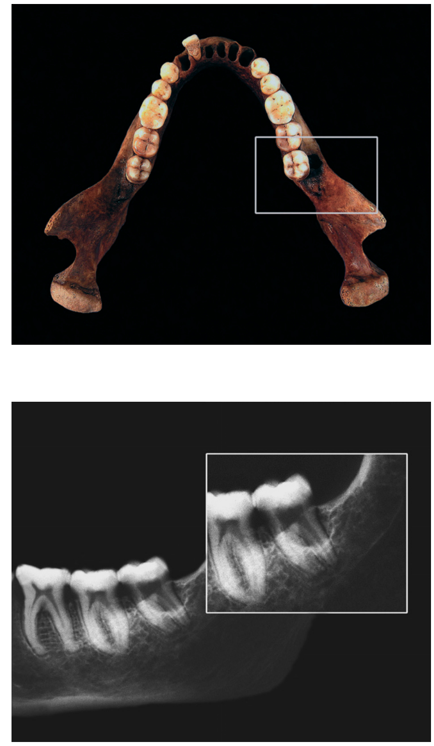

Fig. 5. Lateral developmental periodontal cyst located buccodistal to the third molar. a) perforation of cortical plate is seen in the occlusal external view; b) radiography shows small, round, well--corticated radiolucency.

example, granulomas and cysts are scored in the same category due to their similar radiological appearance (Figure 6). Granulomas and cysts cannot be differentiated by radiological features alone, except the size, i.e. larger lesions are most likely to be cysts[28]. In osteoarchaeological material »abscess cavity« is frequently used to describe periapical cavities, which was criticized by Dias and Tayles[30]. The authors proposed useful criteria to distinguish various periapical cavities in skeletal material, but their description is limited to the lesions observable by external examination. In our sample radicular cysts and granuloma were noticed by external examination in three out of five cases detected by radiography. In all three cases size of lesion and perforation of the thin buccal wall of the cavity due to postdepositional damage in the soil allowed observation.

The conditions which required clinical assessment and histology to differentiate were categorized as »other periodontal inflammations«, and in this study comprised apical periodontitis and abscess caused by contamination from pulp canals, and local periodontitis resulting from inflammation through periodontal pocket. All conditions are limited only to the alveolar bone surrounding the root and therefore the lesions are not visible by external examination. Periapical inflammations in investigated sample were mostly associated with carious teeth (5 cases), and periodontal disease (4 cases), or rare, with advanced attrition (1 case), and crown fracture with open pulp cavity (1 case). In two cases it was associated with postmortem tooth loss. The only anthropological study to date that compared periapical diseases on samples from prehistoric and historic periods showed that apical periodontitis correlated mainly with caries and condensing osteitis[30].

Comparison with the modern clinical study recently conducted in Serbia is not possible due to different count methods employed, i.e. the frequency of periapical lesions in that study was 2.3% of total number of teeth observed[31]. Among 286 individuals investigated in our study (only 85 had both the maxilla and the mandible preserved), periapical cyst, granuloma or inflammation was found in 18 cases, suggesting that frequency of these

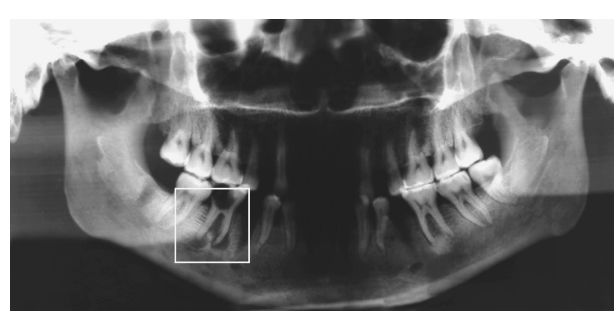

Fig. 6. Periapical granuloma associated with caries of the first mandibular molar: ortopantomography.

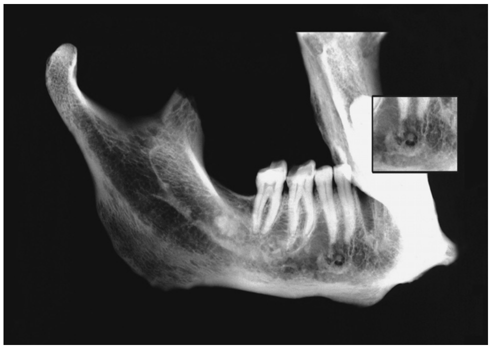

Fig. 7. Cystic odontoma below the roots of premolars: radiography.

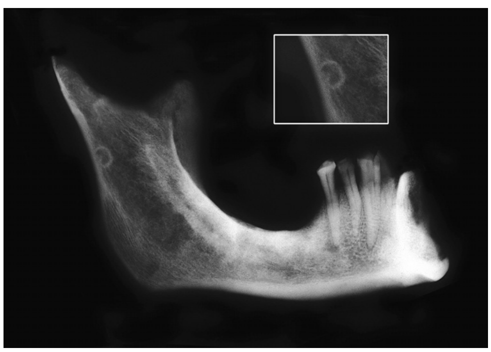

Fig. 8. Depression of the parotid gland resembling bone cavity: radiography.

lesions were probably lower in archaeological than in contemporary population. It could be related to lower frequency of caries in medieval period compared to modern populations.

Apical condensing osteitis, found exclusively on mandibles, was the most frequent reactive lesion in this sample. This finding is consistent with clinical studies where this condition was found predominantly in the mandible than in the maxilla[32]. These lesions were only visible radiographically since the changes are microscopic and located within the bone.

Similar explanation could be offered for periapical cemental dysplasia, the lesion containing cementum-like tissue (originated from periodontal ligament) that surrounds teeth roots. We found it in six mandibles and one maxilla. Literature suggests similar frequency of hypercementosis in modern clinical cases (1.7%) with mandibular first molar most frequently affected[28]. In our material both the first mandibular molar and the second mandibular premolar were involved. This finding is significant in paleopathological context as hypercementosis may result not only from local factors (such as tooth mobility, inflammation, trauma from occlusion), but also from systemic disorders, including Paget's disease and hyperpituitarism[34].

The cause of periodontitis also may be mechanical and we identified 9 cases of periodontitis due to occlusal trauma in this study. The lesions are characterized by widening of the complete periodontal ligament space, with intact or thicker lamina dura, unobservable by external examination. In the sample under investigation it was usually associated with severe wear of the occlusal surface of involved teeth, suggesting traumatic etiology[35].

The majority of tumors in this sample were of odontogenic origin, and the majority of odontoma were of cystic form, i.e. associated with the development of a dentigerous cyst. Contrary to clinical studies where odontomas were seen more frequently in the maxilla[22], in our material they were all located in the mandible (Figure 7). In the context of this study, an important feature is that odontoma demonstrates very slight tendency to cause mild expansion of the cortex; Kaugers and colleagues [36] observed it in 8% of clinical patients. In our material none of the tumors was observable by external examination of jaws.

Signs of some systemic diseases (e.g., Paget disease, histiocytosis X, hyperparathyroidism), and hereditary syndromes (variants of osteogenesis imperfecta, Gorlin syndrome, Ehlers-Danlos syndrome type 1, Gardner syndrome), some of which affecting more frequently tooth roots compared to tooth crowns[33], we have not found in the sample.

In addition, the interpretation of radiographs of osteoarchaeological skeletal material requires an experienced radiologist, because the pseudopathological changes can result in misdiagnoses. Such radiological changes may result from anatomical variations (Figure 8), interment environment, or post-excavation specimen handling.

Conclusion

The results of this study show that radiography allowed detection of many underlying pathological lesions of the jaws that otherwise were undetectable by external inspection, and suggest that the overall picture of dental health patterns of archaeological populations is likely distorted when relying solely on external observations.

Acknowledgement

We are grateful to Ministry of Science of Republic of Serbia for their financial support.

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M. P. Djurić

Laboratory of Anthropology, Institute of Anatomy, School of Medicine, University of Belgrade, 4/2 dr Subotića, 11000 Belgrade, Serbia
e-mail: marijads@eunet.yu

PATOLOŠKE PROMJENE NA MAKSILAMA I MANDIBULAMA IZ ARHEOLOŠKOG KONTEKSTA: NESLAGANJE IZMEĐU DIJAGNOZA POSTAVLJENIH VANJSKIM POSMATRANJEM I RADIOLOŠKOM ANALIZOM

S A Ž E T A K

Cilj ove studije je ispitati vrstu i učestalost lezija maksila i mandibula koje ne mogu biti dijagnosticirane samo na bazi vanjske opservacije. Uzorak se sastoji od 189 maksila i 182 mandibule iz kasno srednjovjekovnog groblja. Materijal je ispitivan makroskopski i radiografski uz upotrebu standardne radiološke opreme, aparata za panoramsku radiografiju i dentalne radiografske jedinice. Ukupan broj uočenih lezija putem radiografiranja bio je 103, a većina ovih promjena (90,3%) nije pokazivala vanjske manifestacije. Najčešće detektirano oboljenje bile su periodontalne inflamatorne lezije (64.1%), praćene razvojnim anomalijama zuba (22.3%). Rezultati studije su pokazali da je radiografiranje omogućilo detekciju mnogih lezija u čeljustima koje nisu mogle biti otkrivene vanjskim makroskopskim ispitivanjem.