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RESEARCH ARTICLE

Periapical foreign body findings – histological and radiological comparison

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ABSTRACT

Objective: This study aimed to clarify the perceptibility of periapical foreign materials in imaging compared with histopathology. We hypothesized that dentoalveolar imaging is sufficient to detect periapical foreign bodies.

Material and Methods: Radiological and histopathological records of patients diagnosed with periapical granuloma or radicular cyst from 2000 to 2013 were evaluated retrospectively. Patients with histologically verified foreign bodies were included in the study and their pathological samples and radiological images were reviewed. The outcome variable was radiologically detectable foreign material. The predictor variables were histopathological diagnosis, type of inflammation, type and number of foreign bodies, imaging modality, and site of foreign material.

Results: Compared to the histopathological diagnosis of foreign bodies as the gold standard, the level of radiologic detectability was mild. Histologically verified foreign material could be detected by imaging in 32/59 (53.5%) patients. Histological diagnosis, type of inflammation, type or number of foreign bodies, imaging modality or site of foreign material had no association with radiological detectability ($p > 0.05$).

Conclusions: According to our results, histopathology is a more accurate diagnostic tool than radiology in periapical foreign bodies or foreign body reactions. Clinicians should keep in mind the limitations of imaging when setting the diagnosis and planning treatment.

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Diagnostic imaging; histopathology; foreign body; periapical granuloma; radicular cyst

Introduction

Foreign bodies are external objects entrapped as a result of trauma or therapeutic interventions in the human body [1]. Most commonly, the foreign bodies observed in the periapical region result from accidental extrusion of root canal materials, including endodontic sealers, medicaments, retrograde filling materials, or sometimes even dental instruments such as broken endodontic files or irrigation needles [1–3]. On the other hand, plant-based material, such as cellulose, can cause foreign body reactions called oral pulse granuloma [4,5]. Entrapped foreign materials rarely cause inflammatory response since they are inert by nature and often small [1]. Although root canal medication and filling materials do not usually cause foreign body reaction, if foreign materials are too large for phagocytosis by macrophages, they may become encapsulated as a host response [6–8]. In the upper or lower jaws, foreign material can be found in the periapical region and surrounding tissues in inflammatory lesions, cysts, and granulomas [9].

Apical periodontitis or more commonly periapical lesion is the most common inflammatory lesion in the jaws. Apical periodontitis occurs when microbes, such as bacteria, encounter the tooth pulp and, as the pulp goes necrotic and infected, the bacteria migrate to the tissues surrounding the apex of the tooth *via* the root canal. Periapical lesions are classified histologically as either an abscess, granuloma, or cyst [10]. Periapical granuloma can develop into a cyst. Radicular cyst is separated from periapical granuloma by cyst epithelium originating from the epithelial components of the odontogenic apparatus or its remnants [11,12].

Periapical granuloma and radicular cyst are often asymptomatic and thus found incidentally in x-ray image, where these are seen as periapical radiolucency [5,13]. Conventional imaging methods in periapical diagnosis include panoramic radiography (PAN), periapical radiography (PA), and cone beam computed tomography (CBCT) [1,14]. In addition, computed tomography (CT) may support the clinical examination when diagnosing periapical lesion [15,16].

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Earlier studies have revealed challenges with imaging diagnostics concerning foreign material perception. Based on the literature, up to one-third of foreign bodies remain undetected during primary radiological imaging [1,7,8,14,17]. Detection of foreign bodies is affected by size and composition of the foreign material, superimposition of anatomic structures, and the imaging modality applied [1].

Several studies have compared the diagnostic accuracy of imaging with histopathology in periapical lesions [18–20]. For example, radicular cyst cannot be distinguished from granuloma radiologically [21,22]. Therefore, histopathological study is required to confirm the diagnosis of periapical lesion [16,21–25]. Additionally, different imaging techniques and visibility of foreign bodies have frequently been investigated [1,17,26,27]. However, there is a lack of comparative studies on the diagnostic accuracy of imaging, especially in periapical foreign bodies.

The aim here was to clarify perceptibility of periapical foreign bodies in imaging compared with histopathologically confirmed periapical foreign materials. We hypothesized that dentoalveolar imaging is sufficient to detect periapical foreign bodies.

Materials and methods

Study design

This retrospective study was based on patients with histologic diagnosis of granuloma or cysts associated with the presence of foreign bodies. Data were collected from the pathology archives of HUSLAB (provider of clinical laboratory services for Helsinki University Central Hospital) and the imaging archives of HUS Medical Imaging Center between 2000 and 2013. Excluded were patients without imaging available and patients with poor image quality.

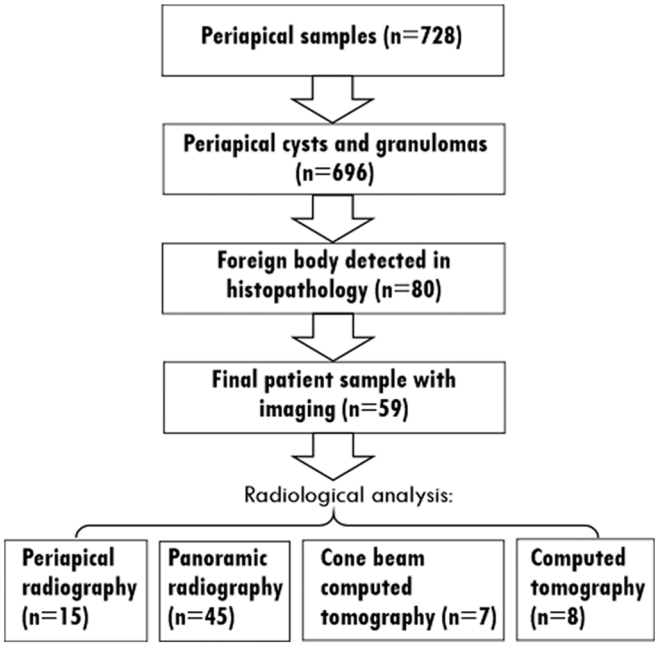

Figure 1. Research sample.

The outcome variable was radiologically detectable foreign material. The predictor variables were histopathological diagnosis (granuloma or radicular cyst), type of inflammation (fibrotic, mild, moderate, abundant), type of foreign body (amalgam, calcium hydroxide ($Ca(OH)_2$), other root canal filling material, plant-based material, and oral pulse granuloma (OPG)), imaging modality (PA, PAN, CBCT, CT, or combination of these), location of foreign material (maxilla or mandible), and region of foreign material (incisors, premolars, molars).

Histological samples and analysis

Periapical samples ($N = 728$) were re-evaluated by authors S.V. and J.H. for foreign bodies (Figure 1). Despite the retrospective nature of the study, we did not have all the data available straight from the database. In addition, we wanted to evaluate the samples to confirm the findings related to the inflammatory response. Thus, the foreign body was analyzed at the same time and sometimes it was missing in the histological report.

Analysis of radiological images

PA, PAN, CBCT, and CT images (Figure 1) were retrospectively viewed independently by two authors S.A. and P.H. At the time when images were analyzed, S.A. and P.H. were blind to the histological data. In case of disagreement, consensus was reached.

Statistical analysis

IBM SPSS Statistics for Windows, version 28.0 (IBM Corp., Armonk, NY, USA) was used to perform data analysis. Comparative analyses were done by using cross-tabulation and Chi-square tests. *P*-value less than 0.05 was considered statistically significant.

Ethical considerations

The use of tissue samples was approved by the Helsinki University Hospital Ethics Committee, the study protocol was approved by the Helsinki University Hospital Research Board (HUS/58/2020), and the samples were provided by Helsinki Biobank. Due to the retrospective nature of the study, patient consent was not required.

Results

In total, 59 patient cases with histologically verified foreign material and with available radiological imaging data were included in the study (Figure 1). The age of patients ranged between 16 and 83 years (mean 52) and 51% of patients were male. In 16 of these patients (27.1%), two imaging modalities had been used. Altogether 15 PA, 45 PAN, 7 CBCT, and 8 CT images were included in the final analysis.

Foreign material was radiologically detected in 53.5% of patients. Based on the histological re-evaluation, the most

common foreign materials were $Ca(OH)_2$ (43.0%) and polarizing root canal material (33.0%) (Table 1). Inflammation type varied; 20.3% of the samples were graded as fibrotic, and the remaining inflammation types ranged from mild (32.2%) and moderate (32.2%) to abundant inflammation (15.3%). None of the patients had findings of acute inflammation or abscess. Two different types of foreign material were detected in only 4 cases (7.0%); all other cases contained a single material. Statistical differences between histological diagnosis, type of inflammation, type or number of foreign bodies, and radiological detectability were not found ($p > .05$).

The associations between imaging modality and the site of foreign material for radiological detectability are presented in Table 2. Native X-ray images (PA/PAN) were available in 75.0%, 3D images (CBCT/CT) in 10.0%, and both X-ray and 3D images in 15.0% of patients. The most common modality used was PAN (60.0%). Slightly better detectability was found in the maxilla (56.0%) than in the mandible (44.4%). Most frequently, foreign materials were detected in either incisor (42.0%) or molar (41.0%) regions, however, differences remained non-significant.

Discussion

In the present study, of the 59 patients with histopathologically confirmed periapical foreign material, in 32 patients (53,5%) foreign body was radiologically detectable. Our hypothesis that dentoalveolar imaging is sufficient to detect periapical foreign material was thus only partly confirmed as foreign bodies remained undetectable in 46.5% of patients. Albeit the number of available CT and CBCT images was low in this study, no clear benefit from 3D imaging was observed.

Table 1. Associations between histopathological features and radiological detectability.

		Radiologically detectable:				
		No		Yes		
	Total (*n*)	*n*	%	*n*	%	*p*-value
All cases	59	28	47.5	31	53.5	
Histological diagnosis						.573
Radicular cyst	38	17	45.0	21	55.0	
Granuloma	21	11	52.4	10	47.6	
Type of inflammation						.845
Fibrotic	12	7	58.3	5	41.7	
Mild	19	8	42.0	11	58.0	
Moderate	19	9	47.4	10	52.6	
Abundant	9	4	44.4	5	55.6	
Count of foreign materials						.614
One material	55	27	49.0	28	51.0	
Two materials	4	1	25.0	3	75.0	
Foreign material*						
Amalgam	8	3	37.5	5	62.5	.709
Calcium hydroxide	27	13	48.0	14	52.0	.922
Polarizing root canal material	21	9	43.0	12	57.0	.599
Plant-based material	2	1	50.0	1	50.0	1.000
Oral pulse granuloma	5	3	60.0	2	40.0	.661

*Total count of foreign materials: 63.

Table 2. Associations between imaging modality, site of foreign material and radiological detectability.

		Radiologically detectable:				
		No		Yes		
	Total (*n*)	*n*	%	*n*	%	*p*-value
Imaging*						.687
X-ray	44	22	50.0	22	50.0	
3D	6	3	50.0	3	50.0	
X-ray and 3D	9	3	33.3	6	66.7	
Imaging modalities**						
PA	15	7	46.7	8	53.3	.943
PAN	45	22	49.0	23	51.0	.693
CBCT	7	3	43.0	4	57.0	1.000
CT	8	3	37.5	5	62.5	.709
Jaw						.409
Maxilla	41	18	44.0	23	56.0	
Mandible	18	10	55.6	8	44.4	
Region						.331
Incisor	25	11	44.0	14	56.0	
Premolar	10	7	70.0	3	30.0	
Molar	24	10	41.7	14	58.3	

*X-ray = PA/PAN, 3D = CBCT/CT.
**total count of images: 75.
PA: periapical radiography; PAN: panoramic radiography; CBCT: cone beam computed tomography; CT: computed tomography.

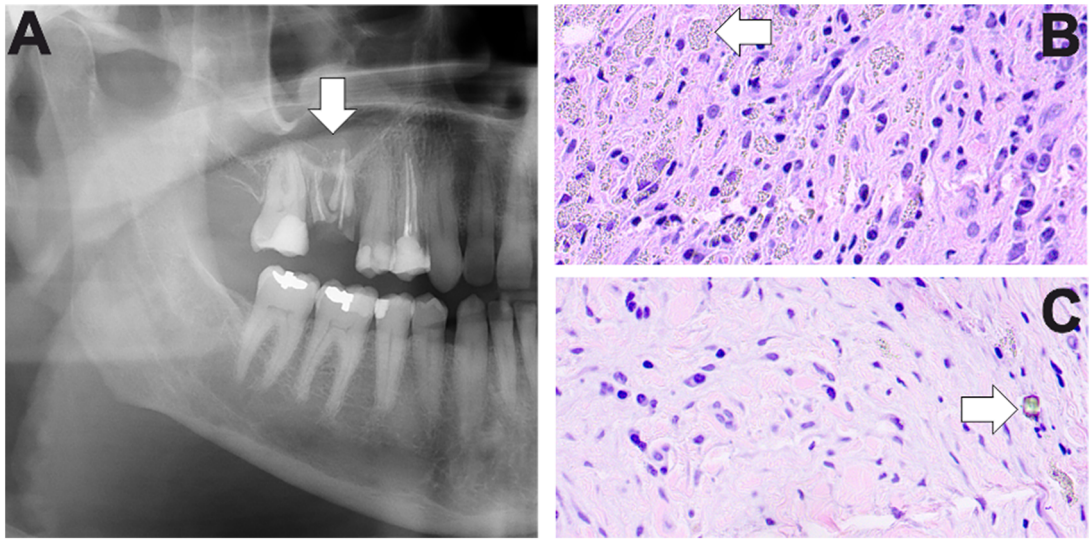

Figure 2. A: Root filling material detected in the maxillary first molar region in panoramic radiography (arrow) B: Calcium hydroxide in histology (arrow) C: Polarizing root filling material in histology (arrow).

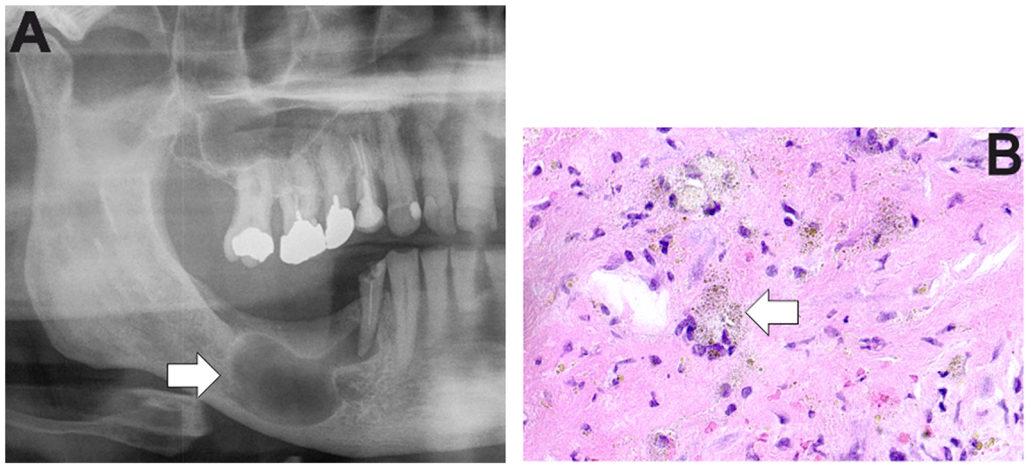

Figure 3. A: No foreign body detected in the radicular cyst in the mandibular molar region (arrow) B: Calcium hydroxide detected in histology (arrow).

Slightly better diagnostics were found in CT (62.5%), whereas CBCT accuracy was similar to that of PA.

Our study supports earlier findings that foreign bodies are often difficult to diagnose radiologically. It has previously been presented that one-third of foreign material remains undiagnosed radiologically [1,7,8,14,17]. Despite an evident deficiency in the radiological detectability of periapical foreign bodies, no obvious explanatory factors emerged in our study.

Here, the most common foreign body was root canal filling material ($Ca(OH)_2$) and polarizing root filling material), in line with earlier studies [2,3]. In contrast to our results, Omezli et al. [1] found amalgam to be the most common material (30.0%); in our study, the prevalence of amalgam was only 13.0%. This difference may be due to research design, as Omezli and colleagues [1] evaluated the overall foreign body prevalence in PAN. The discrepancy may also arise from the fact that amalgam is not nowadays routinely used for retrograde fillings in our country. Today, more biocompatible materials are preferred [28], which may partly explain the low incidence of amalgam observed here. Considering the radiological detectability between materials, differences were not found. Unexpectedly, despite amalgam being radiopaque, it was not always detectable in imaging, presumably because the amount of amalgam was limited. Likewise, the very small amount of root filling material may have hindered radiological detection in some patients even if image quality was originally similar (Figures 2 and 3).

Superimposition of anatomical structures in PAN and PA, contrary to CT and CBCT, may affect image interpretation [1]. Especially in PAN imaging, unsuccessful patient positioning may cause interpretation errors. Additionally, as our patient material originated partly from the early 2000s, technical properties of the PAN device may have affected the interpretation despite the exclusion of poor-quality images. Surprisingly, in three patients the foreign material (amalgam and $Ca(OH)_2$) could not be detected with CT either, although 3D imaging is the most accurate imaging method available. This may be due the small amount of foreign material, which has also been suggested in earlier studies [1,29].

Even though the statistical difference remained non-significant, a trend towards better foreign body detectability was found in the maxilla (56.0%) than in the mandible (44.4%). Buccal and thick compact bone in the mandible may explain the slight difference. On the other hand, more anatomical superimpositions in the maxilla than in the mandible may complicate foreign material detection in PAN. For example, the floor of the maxillary sinus may overlap with periapical area of premolars and molars, hindering detection of foreign bodies. In our study, foreign materials in the premolar region were detected radiologically in only 30.0% of cases.

Limitations of our study comprise the relatively small number of patients analyzed, and the variable radiological methods applied. More data would have been needed to recommend the specific use of different imaging modalities. A future research aim is to analyze the reliability of certain imaging modalities in foreign body diagnostics with a larger sample material when available.

Based on our results, histopathology is more accurate diagnostic tool than radiology when suspecting foreign material to be present. None of the patients in our study had histopathological signs of acute inflammation, so it can be interpreted that symptomless lesions can be monitored and re-evaluated. In conclusion, clinicians should bear in mind the limitations of imaging in periapical foreign body diagnostics.

Ethics approval

The study protocol was approved by the Helsinki University Hospital Research Board (HUS/58/2020).

Patient consent

Patient consent was not required due to the retrospective nature of the study.

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Disclosure statement

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