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ORIGINAL ARTICLE

Assessment of correlation between clinical, radiographic, microbiological, and histopathological examinations in identification of pulpal diseases - a single-centre study

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KEYWORDS

Dental pulp;
Histopathology;
Microbiology;
Inflammation

Abstract *Aim:* This study aimed to analyse the presence of pulpitis using different techniques and compare the findings of the various examination methods.

Methods: A total of 108 patients were enrolled and randomly divided into two groups: 56 patients whose pulp samples were sent for histopathological analysis and 52 patients whose samples were sent for microbiological analysis. All participants underwent endodontic procedures, with clinical evaluation and assessment using periapical radiography. Bacteria were isolated and identified using agar culture and VITEK 2 identification cards.

Results: Histopathology confirmed chronic pulpitis in 33 samples (58.9%) and acute pulpitis in 23 samples (41.1 %). For chronic pulpitis, the histopathological diagnosis agreed with the clinical evaluation diagnosis in 65.2% of cases, and a similar percentage of agreement was observed for acute pulpitis. Chronic pulpitis was observed in 34.8% of patients on clinical examination; however, according to histopathology, these cases were acute. Dilated blood vessels were detected in 56.5% of patients with acute pulpitis and 15.2% of patients with chronic pulpitis. Neutrophilic leucocytes were observed in 43.5% of patients with acute pulpitis and 69.7% of patients with chronic pulpitis. Lymphocytes were observed in 17.4% of acute pulpitis samples but zero chronic pulpitis samples. Microbiological analysis identified gram-positive bacilli in 22 samples, gram-positive cocci in 51 samples, and fungi in 2 samples. Acute pulpitis was typically found to be associated with anaerobic *Clostridium bifermentans*, aerobic *Streptococcus mitis*, and *Granulicatella elegans*, whereas chronic pulpitis was more often associated with two facultative anaerobes, *Streptococcus oralis* and *Streptococcus mitis*.

Conclusion: Comparison of clinical, radiographic, and histological examination techniquesrevealed several notable discrepancies. Radiographic imaging only suggested the presence of pulpal pathologies; therefore, histopathological analysis of the pulp material was still ultimately required

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to verify the clinical diagnosis and exclude other pathologies. Although histopathology remains the gold standard for assessing pulpal disease, performing additional examinations may provide the most comprehensive, and perhaps the most effective, approach.

1. Introduction

Pulpitis is inflammation of the dental pulp caused by opportunistic infection with commensal microorganisms. Soft tissue inflammation is accompanied by molecular factors associated with vascular and cellular mediators. As the disease progresses, these pathological processes can exacerbate vertical bone loss (Rechenberg, 2016). Normally, commensal microflora are not dangerous; however, dental caries can enable these microorganisms to enter the pulpal space and thus cause infection (Bjørndal, 2019).

Based on the signs and symptoms of pulpitis, four different clinical conditions can be identified: normal, reversibly inflamed, irreversibly inflamed, and necrotic pulps (Raoof, 2022). Reversible pulpitis is characterised by localised necrosis in the absence of bacteria, whereas irreversible pulpitis involves bacterial irritants and/or their by-products along with acute inflammatory cells, such as neutrophils (Richert, 2022; Yu and Abbott, 2016). Therefore, different treatments can predict the vitality of the pulp, allowing for repair. Patients can recover from reversible pulpitis after bacterial removal. When the pulp is irreversibly inflamed, however, recovery may not be achievable (Iaculli, 2022; Staquet, 2011; Graves, 2011; Nakanishi, 2011).

Histological examination remains the gold standard for diagnosis of pulpitis (Donnermeyer, 2022). However, the findings on histological and clinical examination may not always agree, in which case radiographic and microbiological testing are conducted. Current procedures for assessing inflammation level include a combination of clinical and radiographic examinations. Clinical examination allows forclose inspection and evaluation of the degree of sensitivity exhibited by the inflamed pulp in response to thermal, electrical, and painful stimuli. These procedures, which can be performed in the practice setting, have not recently changed (Levente Giuroiu, 2015). However, as they do not evaluate the inflammatory status of the pulp, histological examination remains necessary (Donnermeyer, 2022). As said, the potential of assessing the actual histopathological status to determine the condition of the pulp remains controversial (Alghaithy and Qualtrough, 2017). However, it has been confirmed that the combination of clinical sensitivity testing procedures and radiographic examination provides insufficient reliable data to deduce the inflammatory status of the pulp (Mejare, 2012). Since accurate diagnosis is crucial to ensure that the correct root canal treatment is applied, the aim of the current study was to characterise and compare different techniques for the analysis of pulp disease.

2. Materials and methods

This prospective study was conducted over a period of 3 years at the Specialist Dental Polyclinic of the Family Medicine Center in Pristina, University Clinical Center (QKMF) in Pristina, Republic of Kosovo. The study design was approved by the Ethics Committee of the Faculty of Dentistry, UBT College, under number 007, dated 22/7/2019, and the study procedures followed the regulations of the Declaration of Helsinki. All patients provided informed consent.

The population from which the study sample was selected consisted of patients who had been referred for endodontic treatment of periodontal lesions. This population comprised patients from different parts of the country of varying ages, sexes, professions, and social statuses. The study enrolled 108 patients, who were then randomly divided into two approximately equal groups using a coin toss. The first group (Gr-I) included 56 patients whose pulp samples were sent for histopathological analysis, and the second group (Gr-II) included 52 patients whose pulp samples were sent for microbiological analysis.

Clinical evaluation was performed prior to histopathological or microbiological analysis. A diagnosis was determined for each patient based on clinical signs and symptoms as well as assessment with periapical radiography (diagnosis of RTG). Histopathological analysis of the pulp samples was conducted to verify the clinical diagnosis and exclude other pathologies. To validate the reliability of the radiographic examination procedure, the compatibility of the radiographic and histopathological diagnoses was assessed. Microbiological analysis of pulp pathologies was then performed to identify the most common types of microorganisms.

2.1. Determination of pulpitis and selection of cases

Clinical endodontic data, including pulp vitality, percussion, sensitivity to thermal and electrical stimuli (both for a duration of 15 ms), and reaction to pain were collected from each patient at their baseline visit. The preliminary protocol involvedselection of patients with both acute and chronic pulpitis. Thus, clinical examination and radiographic assessment were performed to evaluate the appearance and degree of bone destruction and determine the type of diseased teeth, the quadrant in which the teeth were located, the presence of signs and symptoms, and the type of pathology are determined by the appearance and size of the bone destruction.

2.2. Preparation of material for histopathological analysis

After the endodontic procedure, the teeth were cleaned with saline solution (0.9% NaCl) and access to the exposed pulp chamber was achieved. The pulp was extirpated from the tooth using a barbed approach. The tissue sample was immediately placed in a fixative solution (10% neutral-buffered formalin) at least ten times the volume of the sample to stop tissue autolysis before the sample reached the histopathology laboratory.

The biopsy material was placed in a specialised container and accompanied by a sheet including patient data, instructional diagnosis, location from which the biopsy was taken, and date of biopsy is received by the laboratory. To avoid bias in the pathologist reviewing the sample, the sheet did not specify the RTG diagnosis, only whether the patient presented with acute or chronic pulpitis.

2.3. Preparation of material for microbiological analysis

Samples were collected from the tooth canal using guttapercha and transported in Portagerm BioMerieux® aerobic and anaerobic transport tubes within 2 h of sampling. The samples were then cultured in solid nutrient media such as blood agar and Schaedler agar and liquid media such as thioglycollate broth and Schaedler broth.

Isolation and identification of aerobes were performed using blood agar culture. In the absence of direct growth, subculturing was performed using thioglycollate broth. After incubation for 18–24 h under microaerophilic conditions, microscopic examination and identification were performed using a VITEK 2 compact analyser (BioMerieux, France) with gram-positive and gram-negative cards.

Isolation and identification of anaerobic bacteria was conducted in Schaedler broth and on Schaedler agar. After 48 h of incubation under anaerobic conditions, microscopic examination and identification was performed with VITEK 2 ANC ID cards. The atmosphere for cultivation was generated using an Anoxomat System™ (MART Microbiology BV, Netherlands). The material was processed at the Laboratory of Microbiology, Faculty of Medicine, Pristina.

2.4. Statistical processing

Data were analysed using SPSS version 21 (IBM, New York, USA). The findings were presented numerically and processed as frequencies among individual variables.

3. Results

Overall, 108 patients with pulpal pathologies were enrolled in the analysis (Table 1). Of the total samples, 51.9% of the patient samples were sent for histopathological analysis, while the remaining 48.1% were sent for microbiological analysis. Approximately half of the patients had acute, and the other half chronic, pulpitis. Most patients were asymptomatic at the time of evaluation, while 26.9% complained of pain with cold testing and 22.2% complained of pain with heat testing. According to radiographic imaging, 41.7% of the cases had lesions, and almost one-quarter presented with deep lesions that expanded beyond the pulp into the root canals.

The results of the clinical examinations, sensitivity to thermal and electrical stimuli, and pain testing are shown in Table 2. Palpation and percussion showed fewer positive responses than thermotesting and electro-testing. Most positive responses were obtained by thermotesting. All patients who complained during electrotesting were confirmed by thermotesting. The results of the radiographic examinations are shown in Table 3. The majority of patients with periapical lesions were asymptomatic (90.9%). There were 25 patients with deep lesions that expanded into the root canals. These

Table 1 Basic characteristics of 108 patients who were enrolled in the study.

Characteristics	N = 108
Gender	
Male/Female	55 (50.9%)/53 (49.1%)
Age [years] (range)	28 (10–68)
Place of residence	
Urban (city)	78 (72.2%)
Rural (village)	30 (27.8%)
Histopathological analysis	56 (51.9%)
Microbiological analysis	52 (48.1%)
Acute pulpitis (X-ray)	51 (47.2%)
Female	29 (56.9%)
Male	22 (43.1%)
Chronic pulpitis (X-ray)	57 (52.8%)
Female	24 (42.1%)
Male	33 (57.9%)
Anamnesis	
Asymptomatic	50 (46.3%)
Feeling cold-induced pain	29 (26.9%)
Feeling heat-induced pain	24 (22.2%)
Throbbing pain	5 (4.6%)
Changes observed on X-ray	
Periapical shadow	33 (30.6%)
Periradicular shadow	5 (4.6%)
Lesion	45 (41.7%)
Deep lesion	25 (23.1%)

patients experienced pain with cold or heatt, or feltthrobbing pain. In contrast, one-quarter of patients with lesions or deep lesions were asymptomatic according to pain testing.

Histopathological analysis (Table 4) revealed differences in pathology between acute and chronic pulpitis. Histopathological analysis confirmed chronic pulpitis in 33 samples (58.9%), but diagnosed 23 samples (41.1%) with acute pulpitis. Dilated blood vessels were detected in 56.5% of the acute pulpitis cases and 15.2% of the chronic pulpitis cases. Neutrophilic leucocytes were present in 43.5% of patients with acute pulpitis and 69.7% of patients with chronic pulpitis. Lymphocytes were observed in 17.4% of samples with acute pulpitis, whereas none were observed in any cases of chronic pulpitis.

Moreover, the correlation with clinical evaluation was not 100%. Namely, 15 cases (65.2%) were diagnosed with acute pulpitis based on clinical evaluation and histopathology. Clinical examination diagnosed 8 (34.8%) patients with chronic pulpitis, but histopathology diagnosed them as acute. Chronic pulpitis was diagnosed by clinical examination and histopathology in 25 (69.7%) patients and acute pulpitis in 10 (30.3%).

Table 5 presents the results of the microbiological analyses and the most common types of isolated microorganisms encountered in pulpal pathologies. Anaerobic bacteria were detected in 52 samples, while aerobic bacteria were detected in 61 samples. Acute pulpitis was confirmed in the majority of infections with anaerobic *Clostridium bifermentans* and aerobic *Streptococcus mitis* and *Granulicatella elegans*, while chronic pulpitis was confirmed with the isolation of *Streptococcus oralis* and *Streptococcus mitis* (Table 6).

4. Discussion

Research on the acute and chronic pathologies of pulpitis and histopathological changes is important, as it relates to choos-

Table 2 Comparison of anamnesis symptoms with different examination methods.

		Anamnesis			
		Asymptomatic (n = 50)	**Feeling cold-induced pain (n = 29)**	**Feeling heat-induced pain (n = 24)**	**Throbbing pain (n = 5)**
Electrotest	negative	44 (88.0%)	8 (27.6%)	13 (54.2%)	2 (40.0%)
	positive	6 (12.0%)	21 (72.4%)	11 (45.8%)	3 (60.0%)
Thermotest	negative	44 (88.0%)	0	2 (8.3%)	0
	positive	6 (12.0%)	29 (100%)	22 (91.7%)	5 (100%)
Palpation	negative	50 (100%)	24 (82.8%)	12 (50.0%)	3 (60.0%)
	positive	0	5 (17.2%)	12 (50.0%)	2 (40.0%)
Percussion	negative	50 (100%)	29 (100%)	14 (54.2%)	3 (60.0%)
	positive	0	0	11 (45.8%)	2 (40.0%)

Table 3 Comparison and matching of symptoms from anamnesis and radiographic imaging.

Anamnesis	**Radiographic imaging**			
	Periapical shadow (n = 33)	**Periradicular shadow (n = 5)**	**Lesion (n = 45)**	**Deep lesion (n = 25)**
Asymptomatic (n = 50)	30 (90.9%)	2 (40.0%)	12 (26.7%)	6 (24.0%)
Feeling cold-induced pain (n = 29)	0	0	26 (57.8%)	3 (12.0%)
Feeling heat-induced pain (n = 24)	3 (9.1%)	3 (60.0%)	7 (15.6%)	11 (44.0%)
Throbbing pain (n = 5)	0	0	0	5 (20.0%)

ing the appropriate treatment. The aim of our study was to analyse pulp disease using different techniques and to determine the differences between the forms of examination.

Table 4 Results of histopathological examination.

		Histopathological diagnosis	
		Acute pulpitis	**Chronic pulpitis**
Fibrotic tissue	yes	23 (100%)	33 (100%)
Dilated blood vessels	no	10 (43.5%)	28 (84.8%)
	yes	13 (56.5%)	5 (15.2%)
Necrotic foci	no	22 (95.7%)	26 (78.8%)
	yes	1 (4.3%)	7 (21.2%)
Leucocyte infiltrates	no	10 (43.5%)	22 (66.7%)
	yes	13 (56.5%)	11 (33.3%)
Lymphoplasmacytic infiltrates	no	14 (60.9%)	10 (30.3%)
	yes	9 (39.1%)	23 (69.7%)
Neutrophilic leukocytes	no	13 (56.5%)	26 (78.8%)
	yes	10 (43.5%)	7 (21.2%)
Debris	no	22 (95.7%)	29 (87.9%)
	yes	1 (4.3%)	4 (12.1%)
Odontoblasts	no	22 (95.7%)	33 (100%)
	yes	1 (4.3%)	0
Microcalcifications	no	16 (69.6%)	23 (69.7%)
	yes	7 (30.4%)	10 (30.3%)
Lymphocytes	no	19 (82.6%)	33 (100%)
	yes	4 (17.4%)	0
Plasma cells	no	20 (87.0%)	33 (100%)
	yes	3 (13.0%)	0
Macrophages	no	21 (91.3%)	28 (84.8%)
	yes	2 (8.7%)	5 (15.2%)
Hyalinized fibrous tissue	no	23 (100%)	32 (97.0%)
	yes	0	1 (3.0%)

Based on clinical analysis, the results showed that pulpitis was detected less frequently in women (49%) than in men (51%), which is not consistent with the data of Wang et al. (2004), in which 57.6% were female and 42.2% were male. Nevertheless, the distribution among sexes was relatively similar with a 50–50 split in all reports. The correlation between histological and clinical evaluations was not 100%. Namely, 65.2% of the patients were diagnosed with acute pulpitis based on both clinical evaluation and histopathology. Chronic pulpitis was detected in 34.8% of cases diagnosed by clinical examination; however, histopathology instead reflected acute pulpitis. Chronic pulpitis was diagnosed by clinical examination and histopathology in 69.7% of cases. Overall, a correlation was observed in approximately two-thirds of patients. Meanwhile, in a study by Ricucci et al. (2014), the authors evaluated the reliability of the clinical diagnosis of healthy pulp, reversible pulpitis, or irreversible pulpitis, and whether this correlated with the findings of histological examination. They found that the clinical diagnosis matched the histological diagnosis of normal pulp and reversible pulpitis in 57 of the 59 (96.6%) samples, but matching for irreversible pulpitis was only observed in 27 of the 32 (84.4%) samples. Their study found much higher rates of correspondence than our study.

Few studies have investigated the correlation between clinical diagnosis and histopathological evaluation of the inflammatory processes in the pulp (Ricucci, 2014; Cisneros-Cabello and Segura-Egea, 2005). Perhaps for this reason, the gold standard for the combination of clinical examination and histopathological classification has not been established. However, reliable conclusions are still required; therefore, the relationship between clinical and histopathological findings should be determined. A study by Giuroiu et al. (2015) showed that the two examinations reached the same diagnosis in 35 of

Table 5 List of isolated anaerobic and aerobic microorganisms.

Anaerobic bacteria	**N = 52**
Clostridium barotii	6 (11.5%)
Clostridium bifermentans	7 (13.5%)
Clostridium butyricum	2 (3.8%)
Clostridium clostridioforme	1 (1.9%)
Clostridium histolyticum	1 (1.9%)
Clostridium sporagenes	3 (5.8%)
Fusobacterium martiferum	1 (1.9%)
Lactobacillus gasseri	1 (1.9%)
Sterile	30 (57.7%)
Aerobic bacteria	**N = 61**
Aerococcus viridans	1 (1.6%)
Candida spp.	2 (3.3%)
Enterobacter cloacae	3 (4.9%)
Enterococcus fecalis	3 (4.9%)
Gemella morbillorum	4 (6.6%)
Granulicatella adiscens	2 (3.3%)
Granulicatella elegans	6 (9.8%)
Kocuria kristinae	2 (3.3%)
Kocuria Rosea	1 (1.6%)
Leuconostoc mesenteroides spp. *cremoris*	2 (3.3%)
Pedicoccus pentosaceus	1 (1.6%)
Psuedomonas aeroginosa	2 (3.3%)
Staphylococcus lentus	2 (3.3%)
Sterile	3 (4.9%)
Streptococcus anginosus	4 (6.6%)
Streptococcus lentus	1 (1.6%)
Streptococcus mitis	9 (14.8%)
Streptococcus mutans	1 (1.6%)
Streptococcus oralis	6 (9.8%)
Streptococcus pneumoniae	1 (1.6%)
Streptococcus sanguini + P2s	1 (1.6%)
Streptococcus sanguinis	4 (6.6%)

51 cases (68.6%), which is similar to our rate. Another reported an even lower rate, 49.5% of 109 cases (Garfunkel, 1973). Meanwhile, other studies demonstrate great correlation between clinical and histopathological diagnoses, with agreement in 96.6% of normal pulp/reversible pulpitis and 84.4% of irreversible pulpitis cases (Ricucci, 2014). These differences can be explained by the reactivation of chronic lesions (Bergenholtz, 2002). Clinical examinations consist of thermal and electrical stimuli that induce minor-to-moderate pain. These symptoms suggest acute pulpitis. However, most patients are typically asymptomatic, so symptoms may not be discovered in the anamnesis of the patient (Michaelson, 2002). Pulp diseases are clinically evaluated on the basis of patient history, visual examination of the mouth and tissues, clinical tests, and radiography (Alapati, 2006; Allen, 1989). Based on the analysis and evaluation of clinical data in our study, 26.9% of the patients complained of pain with cold testing, 22.2% with heat testing, and only 4.6% complained of throbbing pain. The remaining patients did not exhibit any symptoms. The quality of the examination depends on the patient's ability to accurately indicate their current condition and the clinician's ability to interpret the information gathered during anamnesis. Commonly used clinical tests in endodontics include percussion, palpation, and pulp vitality tests using heat, cold, and pulp electrotests. Seltzer et al. (1963) showed that no reciprocal relationship exists between the vitality test and pulp histology; despite reporting no history of symptoms,

Table 6 Percentage of anaerobic and aerobic microorganisms by type of pulpitis.

		Clinical diagnosis	
		Acute pulpitis	Chronic pulpitis
Anaerobes	*Clostridium barotii*	2 (7.7%)	4 (15.4%)
	Clostridium bifermentans	5 (19.2%)	2 (7.7%)
	Clostridium butyricum	2 (7.7%)	0
	Clostridium clostridioforme	1 (3.8%)	0
	Clostridium histolyticum	1 (3.8%)	0
	Clostridium sporagenes	3 (11.5%)	0
	Fusobacterium martiferum	1 (3.8%)	0
	Lactobacillus gasseri	1 (3.8%)	0
	Sterile	10 (38.5%)	20 (76.9%)
Aerobes	*Aerococcus viridans*	1 (3.3%)	0
	Candida spp.	2 (6.7%)	0
	Enterobacter cloacae	1 (3.3%)	2 (6.5%)
	Enterococcus fecalis	1 (3.3%)	2 (6.5%)
	Gemella morbillorum	2 (6.7%)	2 (6.5%)
	Granulicatella adiscens	1 (3.3%)	1 (3.2%)
	Granulicatella elegans	4 (13.3%)	2 (6.5%)
	Kocuria kristinae	1 (3.3%)	1 (3.2%)
	Kocuria Rosea	1 (3.3%)	0
	Leuconostoc mesenteroides spp. *cremoris*	1 (3.3%)	1 (3.2%)
	Pedicoccus pentosaceus	0	1 (3.2%)
	Psuedomonas aeroginosa	0	2 (6.5%)
	Staphylococcus lentus	1 (3.3%)	1 (3.2%)
	Sterile	0	3 (9.7%)
	Streptococcus anginosus	2 (6.7%)	2 (6.5%)
	Streptococcus lentus	1 (3.3%)	0
	Streptococcus mitis	13.3%	5 (16.1%)
	Streptococcus mutans	1 (3.3%)	0
	Streptococcus oralis	1 (3.3%)	5 (16.1%)
	Streptococcus pneumoniae	1 (3.3%)	0
	Streptococcus sanguini + P2s	1 (3.3%)	0
	Streptococcus sanguinis	3 (10.0%)	1 (3.2%)

12.0% of patients still responded positively to electrotesting and thermotesting. All patients who complained of cold-associated painresponded positively to the thermotest, and 72.4% responded positively to the electrotest. Petersson et al. (1999) showed that pulp vitality tests can produce false-positives or false-negatives. Part of the clinical testing process also involves interpretation of a patient's subjective response to a stimulus. However, patient responses may be inaccurate, vague, or even exaggerated. All these factors must be considered when performing a clinical evaluation for pulpal disease and are, as mentioned, a major reason for discrepancies between clinical and histopathological evaluations. The current study showed that a periapical shadow was observed in radiographs in 30.6% of the cases examined. Meanwhile, in 23.1% of cases, only a deep lesion was observed. Goldman et al. (1972) measured interobserver reliability in detecting pulpal diseases on radiography and found it to be low (47%). It is also important to note that many lesions can appear on radiographs as periradicular diseases.

Structural variations are often among the undefined factors that complicate the clinical radiographic diagnosis of pulpitis. Thus, clinical radiographic diagnoses often do not match histological diagnoses (Simon, 2006; Huumonen and Orstavik,

2002). Acute inflammation of the pulp may appear chronic, and vice versa; chronic inflammation can also exacerbate acute inflammation. Histopathological analysis revealed chronic pulpitis in 58.9% of patients, while 41.1% were diagnosed with acute pulpitis. Fibrotic tissue was observed in all samples regardless of the duration of pulpitis, and dilated blood vessels were present in 56.5% of acute and 15.2% of chronic pulpitis cases. Neutrophils were present in 43.5% of acute pulpitis cases, whereas 69.7% of chronic pulpitis cases had lymphoplasmacytic infiltrates. Lymphocytes were observed in 17.4% of samples with acute pulpitis and zero samples of chronic pulpitis. This may be due to changes in the properties of the etiological agents, the appearance of new factors, and either reduction or improvement of the body's defences. Characteristic changes of acute pulpitis are primarily exudativein nature; while characteristic changes of chronic pulpitis are primarily infiltrative, proliferative, and degenerative. Of the cases diagnosed as acute pulpitis through histopathology, 65.2% had also been diagnosed clinically as acute, while 34.8% had been diagnosed as chronic pulpitis on clinical examination. The cases of chronic pulpitis diagnosed by clinical examination (69.7%) were also histopathologically confirmed. The inconsistency of clinical and radiographic diagnoses with histopathological diagnoses stems may also be related to the fact that radiography is a two-dimensional reflection of three-dimensional structures, and thus, clinical and biological changes may not be discernible radiographically [26]. Therefore, dentists who are unable to obtain a histopathological diagnosis of their cases may also be misled by clinical data and radiographic images, resulting in an inability to provide their patients with a reasonable explanation for failures of endodontic treatment as well as non-endodontic interventions. After comparing the data of RTG analysis with those of histopathological analysis, based on the results, it can be concluded that the radiographic diagnosis often does not match the histopathological diagnosis; therefore, RTG cannot be considered a reliable diagnostic method. According to the RTG data, radiographic diagnosis only corresponded to histopathological analysis in 66.6% of the cases; therefore, even according to RTG, radiography was inadequate to make a definitive diagnosis. It is also difficult to assess the association between clinical symptoms and the severity of pulpal inflammation and establish the value of pulpal testing for heat/cold stimulation (Mejàre, 2012).

Our study had several limitations. The sample size was relatively small, encompassing 108 patients within a 3-year timeframe. We would like to highlight that not all patients scheduled for endodontic treatment at our centre were willing to participate. Moreover, the examination methods used in our research are well-established standards for the diagnosis of pulpal pathologies; however, new studies are showing that, in the field of periodontology, diagnostic procedures using biomarkers from saliva or other samples can detect occurrence and monitor progression of oral diseases. In addition, it might be interesting to include these biomarkers and compare them with the gold standards for the detection of pulpitis. Furthermore, patients who were included in the analysis came from different regions, were of different ages and sexes, and had various professions and social statuses. These factors may also have influenced the results to a certain extent but were not taken into consideration when interpreting the results. Moreover, we did not track the use of antibiotics or analgesics for other systemic diseases. Nevertheless, we believe that these potential confounders were not sufficiently powerful to significantly influence our results.

5. Conclusions

The obtained results show that radiographic images only suggest a diagnosis of pulpal pathologies. Therefore, the material taken from the pulp should be sent for histopathological analysis to verify the clinical diagnosis and exclude other pathologies. Due to difficulties in establishing a correct diagnosis based solely on clinical examination, histopathology remains the gold standard for assessing pulpal disease. The clinical and histological classification of pulpal conditions revealed good agreement, especially in cases with no disease or reversible disease. This means that classification of pulpal conditions as normal pulp, reversible pulpitis, or irreversible pulpitis has a high chance of guiding correct therapy in most cases. However, there is still a need for refined and improved methods for reliable diagnosis of pulpal pathologies.

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Ethical statement

The study design was approved by Ethics Committee from the Faculty of dentistry, UBT College, under the number 007, dated 22/7/2019. The procedures were following regulations of the Declaration of Helsinki. The patients were informed and asked to participate in the study prior inclusion, so they gave consent agreement for participation.

CRediT authorship contribution statement

Merita Barani: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Xhevdet Aliu:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. **Nexhmije Ajeti:** Data curation, Investigation, Methodology, Writing – review & editing. **Lumturije Asllani:** Conceptualization, Supervision, Validation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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