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Association between Clinical Symptoms and Histological Features of Molars with Acute Pulpitis

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Introduction: Diagnosis of dental pulp status on the basis of clinical signs in many cases helps clinicians to better resolve patient problems. Various studies have shown no correlation between clinical and histologic findings. The aim of the present study was to evaluate the associations between clinical findings and histological features in extracted decayed teeth with acute pulpitis. **Materials and Methods:** One hundred permanent cavitated human teeth with mature apices and pulpitis, which were extracted for reasons not related to the present study, were evaluated. Demographic, clinical, and radiographic data were collected using pre-designed questionnaires. After tooth extraction, 5 micron-thick slices were prepared for microscopic assessment. General pathologist evaluated reactions to stimuli in all areas of the pulp tissue under a light microscope. When present, inflammation was classified according to the type and spread of cell detected and other histological findings, such as abscess formation, pulp stones, and pulpal fibrosis, were also recorded. **Results:** We found significant associations between pain characteristics, such as pain type and duration, and histological status. Acute inflammation, severe chronic inflammation, and liquefactive necrosis increased with pain severity. Various histological sections showed the absence of pulpal inflammation. **Conclusions:** We found a good agreement of patients' pain histories and pain characteristics with histological pulp status. Thus, the use of specified CHARTs and SCALEs that help patients provide the most accurate responses to questions about pain would aid the diagnosis of pulp status. In cases with an accurate pulpal diagnosis, the clinicians can manage pulpal protection when it is possible.

Keywords: Dental pulp; Signs and Symptoms; Histology; Diagnostic test; Decay

Introduction

Pulpitis is characterized by pulpal inflammation in response to irritants of microbial, chemical or physical (mechanical and thermal) origin.[1] Accurate diagnosis of the pulp condition in teeth compromised by caries, dental procedures or other forms of injury is crucial for proper decision making about treatment. Determination of whether the pulp is vital or necrotic, and whether it is reversibly or irreversibly inflamed, especially in connection with carious or traumatic exposure of the tissue, is important,[2] as immediate therapeutic intervention is essential for the maintenance of pulp vitality.[3] However, the loose pulp tissue is protected by enamel and dentin, which have high degrees of mineralization. Thus, its direct inspection and palpation, as well as pathological assessment, are difficult.

Determination of the reliability of clinical diagnosis of pulp disease is important.[4, 5]. The pulp status can be evaluated most accurately by examination of histological sections of the involved tissue to assess the extent of inflammation and the presence of necrosis. Unfortunately, in the clinical scenario, this approach is often impractical or infeasible.[6] Thus, the clinical diagnosis of pulp disease poses a challenge in dentistry.[7] Pulp assessment strategies often involve sensitivity testing, most commonly thermal testing and electric pulp testing (EPT).[8] Endodontic diagnoses are made based on the patient history, clinical observations and diagnostic test results. Dental pulp tests provide valuable diagnostic and treatment planning information for dental clinicians. Pulp sensibility testing, even with its limitations, remains very helpful in endodontic diagnosis [6].

Various classification systems are used to establish diagnoses of

pulpal disease. The terms used thus far stem from histopathology [9]. The most currently used and generally accepted classification of pulpitis is based on the treatment prognosis. Pulpitis is deemed to be reversible when the pulp condition can be predicted to return to normal after removal of the irritant stimulus. In teeth with irreversible pulpitis, restoration of the normal pulp condition by removal of the irritant alone is very unlikely [1].

Few studies in the mainstream literature have focused on the relationship between pathological and clinical statuses in dental pulp diseases. Available studies have drawn attention to the lack of concurrence between the clinical and histological pictures [10], likely due to the use of classifications based on the type and severity of pulpal inflammation [7]. The current gold standard for the determination of pulpal health status is histological examination [11].

Findings in a systematic review [4] suggest that the terminology of reversible and irreversible pulpitis should be re-evaluated and the question of how we can accurately consider whether the pulpal status is reversible or irreversible is still unresolved.

Accordingly, the aim of this study was to evaluate associations between clinical findings and histological features in decayed human extracted teeth.

Materials and Methods

Participants

The Ethics Committee of Mashhad University of Medical Sciences, approved the proposal of this study (ID: 940452) which was conducted at Dental Research Centre, Faculty of Dentistry. All participants provided written informed consent. One hundred permanent molar teeth were selected according to the inclusion and exclusion criteria as follow:

Inclusion clinical Criteria:

- Aged over 18-year-old
- Maxillary or mandibular decayed molar teeth
- Diagnosed as pulpitis (hyper sensitive to cold and heat tests)
- Scheduled for extraction (diagnosed to be extracted in the department of Oral and Maxillofacial surgery for the reasons not related to present study. For example: patients who did not intend to keep their painful tooth or third molars which were not in occlusal contacts)

Exclusion Criteria:

- Taken analgesics less than 6 hours before examinations
- Could be maintained with any type of treatment
- Diagnosed as a necrotic pulp
- Diagnosed as a periapical abscess
- Present a sinus tract related to the target teeth
- Present a periodontal disease
- Teeth with anomalies or root resorptions

All clinical and radiographic examinations, and also the extractions were carried out at the university's Oral and Maxillofacial Surgery Department, Faculty of Dentistry.

Clinical data collection and assessment

Clinical data, including demographic characteristics, chief complaints, tooth number, medical and dental histories, pain characteristics (severity, type and duration), and results of intra- and extra-oral examinations, sensibility tests and percussion and radiographic examinations, were collected using pre-designed questionnaires. A single examiner (M.D.) performed all clinical examinations. Patients were asked to rate the severity of pain using a verbal analogue scale. The pain type was classified as stimulatory or spontaneous and as sharp or dull. The duration of pain (in minutes) was defined as the time elapsed from the onset of pain until its resolution. The number of days for which the tooth had been symptomatic was also recorded.

Heat and cold sensitivity tests were performed using a rubber cup rotating in a hand-piece at slow speed (NSK, Nakanishi Inc., Tokyo, Japan) and Endo-Ice (Frisco Spray; ad-Arztbedarf GmbH, Frechen, Germany) sprayed onto a cotton pellet. One healthy tooth of each patient was tested as a control to establish a baseline normal response before the target tooth was tested. Before testing all teeth were isolated with cotton rolls and dried thoroughly. The testing site was limited to the middle of the buccal surface, and stimuli were applied for 5 s. In case of no response after 1 min, all tests were repeated at the occlusal and cervical thirds to ensure that the patient had no response to the stimuli. EPT was performed using an electric pulp tester (Parkell, Edgewood, NY, USA) according to the manufacturer's instructions. The probe was placed on the intact tooth structure and toothpaste was used as the conducting medium. The strength of the current eliciting a response was recorded. Thermal testing was performed, and patients' responses were recorded. Percussion testing was first performed with finger pressure on the occlusal surface or incisal edge. In the absence of a response, it was repeated with a mirror handle. Patient responses to stimuli were recorded using a 4-point scale ranging from 0 to 3 (0, no response; 1, mild to moderate pain; 2, severe pain that is relieved after stimulus removal; 3, severe pain that persists after stimulus removal). After completion of the clinical examination, a periapical radiograph was taken and the presence or absence of periodontal ligament widening was evaluated.

Histological processing and evaluation

Following clinical and radiographic examinations, the teeth were extracted gently under local anaesthesia (2% Persocaine-E, 2% lidocaine+epinephrine at 1:800,000; Pharmaceutical Mfg. Co., Tehran, Iran). Immediately after extraction, each tooth was placed buccolingually in a vice as long as cracks was created to allow complete penetration of 10% formalin (Merck KGaA, Darmstadt, Germany) to the pulp.

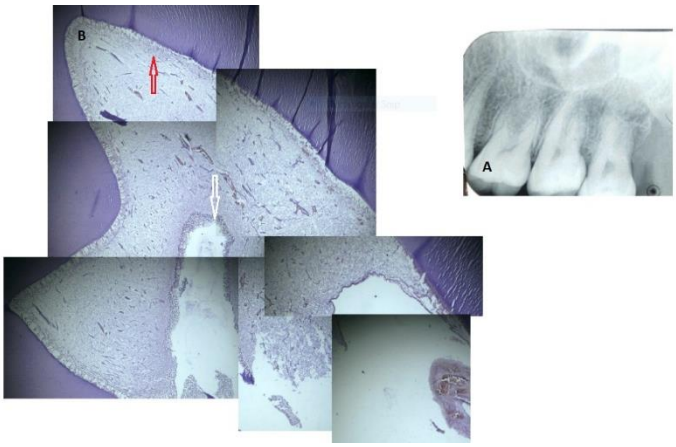

Figure 1. Maxillary third molar with deep caries and severe pain; *A*) periapical radiograph; *B*) Composed histological features of pulp chamber (H&E. original magnification 40×). Healthy pulp (red arrow). Abscess formation (white arrow)

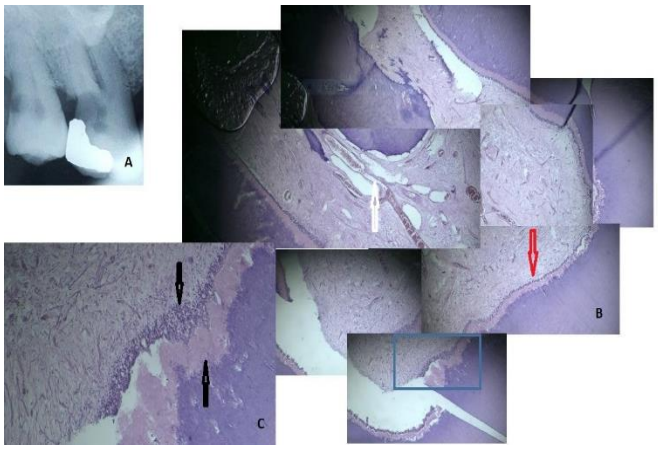

Figure 2. Maxillary second molar with severe pain; *A*) Radiographic view; *B*) Composed histological features (H&E. original magnification 40×). Healthy pulp (red arrow). Abscess formation (white arrow); *C*) Higher magnification (400×) of depicted area in B. (black arrow: thickening of odontoblastic layer and pre-dentin)

The teeth were immersed in 10% formalin solution at 4°C for at least 1 week. The specimens were then stored in ethylenediaminetetraacetic acid for 4 months for hard tissue demineralization. The solution was stirred three times a day and changed daily. To ensure that complete demineralization had occurred, radiographs were taken and compared with control radiographs of the intact teeth. The teeth were then rinsed under running water, dehydrated in ascending grades of ethanol, cleared in xylene (Merck KGaA, Darmstadt, Germany) and double embedded in paraffin blocks. The blocks were then sectioned longitudinally and serially into 5-µm-thick slices. Each section was stained with hematoxylin and eosin for histological analysis [12].

A general pathologist evaluated the specimens under a light microscope (Nikon, Tokyo, Japan). Pulpal reactions to stimuli were evaluated in all areas of the pulp tissue (coronal and radicular). When present, inflammation was classified according to the type of cell detected and presence of chronic lymphoplasmacytic inflammation. A sporadic cell pattern was taken to indicate mild chronic inflammation, and accumulations of cells were taken to indicate severe chronic inflammation. Acute inflammation was diagnosed when neutrophils were observed. Necrosis was classified as liquefactive based on abscess formation or as coagulative based on the loss of pulp architecture or lack of pulpal cell nuclei. Other histological findings, such as pulp stones and pulpal fibrosis, were also recorded when present.

Statistical analysis

The data were analysed using the R software. Within-group comparisons were made using Kruskal Wallis and between-group comparison using Fisher's exact test, because of independent numerical variables definition. *P* values < 0.05 were considered statistically significant.

Results

Of the hundred teeth evaluated, twelve teeth were excluded during the crack creation for better penetration of formalin. Thus, the analysis included data on 88 teeth from 30 males and 58 females with a minimum age of 26 and maximum of 67 with a mean age of 37.6 (SD=4.8) years.

Figures 1 and 2 shows the histological feature of pulpal tissue in molars with pulpitis. Healthy pulp tissue with normal features can be recognised a little further away from inflamed pulp tissue. The palisade odontoblastic layer as well as normal vessels and pulp cells scattering mention the normal pulp tissue and are observed alongside the damaged pulp tissue.

Thermal and percussion test results were not associated with histological status. Association between incidence of sensitivity to electric pulp test and coagulative necrosis was summarized in Table 1. It shows 85.7% of cases without coagulation necrosis were less sensitive to pulp tester in comparison of control group.

Acute inflammation and severe chronic inflammation were most prevalent among patients who reported sharp and spontaneous pain. Fifty-two percent of specimens from patients who reported pain durations >60 min showed acute inflammation on histological analysis (Table 2), and 61% showed severe chronic inflammation (Table 3). Sixty-one percent of specimens from patients who reported pain durations <1 min had pulpal regions without inflammation.

Based on the results of this study, there is significant association between pain characteristics, such as type, duration, and their histological pulpal status.

Discussion

A small number of studies has assessed the correlation between clinical and histological pulp status [1, 3, 7, 13-19].

For a lengthy period, a poor correlation between clinical and histologic data has been reported [15, 18, 20]. Seltzer *et al.* [13] examined correlations among patients' pain histories, responses to percussion, cold and heat; EPT results; and histological status. They found no clear correlation of any clinical symptom with histological patterns of dental pulp. Other studies have also failed to demonstrate such associations, including those between specific pain characteristics (*e.g.* sharp/dull, intermittent/continuous, and throbbing/diffuse) and histopathological pulp status [3, 17, 18]. Consequently, the profession has accepted that it is not possible to classify accurately the pulp condition of painful teeth, or to differentiate clearly between pulps that can be saved without definitive root canal treatment.

In current study, to evaluate the histological status, we used the criteria which determined in Ricucci and Colleague's study [21]. Using defined criteria for clinical and histologic classification of pulp conditions and strict laboratory methodologies, current study revealed significant relationships between pain characteristics, such as type, duration, and histological pulp status. According to our findings, following accurate clinical and radiographic examinations, precise treatment plan will be more likely expected.

To evaluate the correlation between clinical findings and histological status, a recent study [1] found the clinical diagnosis of reversibility/irreversibility of pulp inflammation was associated exclusively to the presence/absence of bacterial penetration; no correlation was indicated between clinical symptoms and the extent of pulp degeneration.

Naseri and colleagues [16] reported that untreatable pulp conditions were correlated significantly with lingering sharp responses and no response to cold stimulus. We found no similar correlation with thermal and percussion test results, presumably due to the use of different histological criteria.

Previous studies have evaluated the predictive value and accuracy of sensibility tests for the identification of pulp vitality or necrosis. The cold test has shown >90% accuracy [6, 22], and the heat test and EPT have shown 86% and 76% accuracy, respectively [22-24]. In these studies, pulp vitality and necrosis have been assessed by direct inspection of pulp tissue in the pulp chamber during access cavity preparation. In our study, sensibility test results were analysed to differentiate among histological pulp statuses, which will aid clinicians' treatment decisions (*e.g.*, conservative treatment, extirpation of pulp tissue, or root canal treatment).

Alghaderi and colleagues [25] suggest coronal pulpotomy treatment can be remarked as an intermediate treatment option in manipulating carious vital pulp exposures of permanent teeth with mature root apices. This option may also serve as an alternative to extraction when root canal treatment cannot be affordable for low income and uninsured patients.

We found many areas with odontoblastic layer and/or pre-dentin thickening in the irritated pulp of decayed teeth, which support the conservative treatment in inflamed and/or painful teeth.

Table 1. Summary of communication between incidence of electric sensitivity and coagulative necrosis.

Variables		Index	Electric Pulp Test Sensitivity				Total
			<control tooth	=control tooth	Less than 3 scores from control tooth	More than 3 scores of control tooth	
Coagulative Necrosis	_	N (%)	18 (85.7%)	13 (92.9%)	26 (100%)	27 (100%)	84 (95.5%)
	+	N (%)	3 (14.3%)	1 (7.1%)	0 (0%)	0 (0%)	4 (4.5%)
Total		N (%)	21 (100%)	14 (100%)	26 (100%)	27 (100%)	88 (100%)
P-value=0.036							

Table 2. Summary of communication between incidence of pain duration and acute inflammation

Variables		Index	Duration of Pain					Total
			< one minute	Between 1-10 min	>10-30 min	>30-60min	>60 min	
acute inflammation	_	N (%)	30 (83.3%)	11 (73.3%)	4 (57.1%)	4 (57.1%)	11 (47.8%)	60 (68.2%)
	+	N (%)	6 (16.7%)	4 (26.7%)	3 (42.9%)	3 (42.9%)	12 (52.2%)	28 (31.8%)
Total		N (%)	36 (100%)	15 (100%)	7 (100%)	7 (100%)	23 (100%)	88 (100%)
P-value=0.042								

Table 3. Summary of communication between incidence of pain duration and chronic inflammation

Variables		Index	Duration of Pain					Total
			< one minute	Between 1-10 min	>10-30 min	>30-60 min	>60 min	
chronic inflammation	_	N (%)	30(83.3%)	7(46.7%)	4(57.1%)	4(57.1%)	9(39.1%)	60(60.9%)
	+	N (%)	6(16.7%)	8(53.3%)	3(42.9%)	3(42.9%)	14(60.9%)	28(39.1%)
Total		N (%)	36(100%)	15(100%)	7(100%)	7(100%)	23(100%)	88(100%)
P-value=0.005								

The identification of diseases in their earliest stages allows clinicians to commence the most conservative management techniques and to avoid complexities and expenses that may arise when a disease is quitted undiagnosed and untreated for a longer period. The results of the current study show good agreement of patients' pain histories and pain characteristics with histological pulp status. Thus, the use of specified charts for scaling the clinical data that help patients provide the best responses to questions about pain would aid the diagnosis of pulp status. Unfortunately, there is still a lack of studies to determine the exact correlation between clinical and histological features in decayed teeth.

We used human teeth scheduled for extraction, not only those scheduled for root canal treatment, to ensure that the sample represented a variety of pulp conditions. Vital pulp with no periradicular lesion in cases evaluated was the most important limiting factor in this study.

Conclusion

Within the limitations of the present histologic study, we conclude that the accurate clinical and radiographical examinations provide the most conservative treatment planning, therefore the healthy pulp tissue in inflamed teeth can be preserved.

Conflict of Interest: 'None declared'.

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