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ORIGINAL ARTICLE

Association between Periodontitis and Pulpal Response to Cold and Electric Pulp Testing

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Abstract

Background: Periodontitis is a severe microbial infection of gingival tissues that results in clinical attachment loss this study aimed to evaluate the effect of stage II periodontitis on the pulpal response to the electric pulp test (EPT) and cold test (CT).

Materials and Methods: This observational study included 67 posterior teeth from 26 patients with stage II periodontitis. Following a clinical examination, the teeth were categorized into three groups based on the severity of stage II periodontitis: mild, moderate, and severe. The pulpal responses to EPT and CT were recorded and compared with those of a sound control tooth from the same patient. The data were analyzed using the Chi-square test, Fisher's exact test, Kruskal-Wallis test, Mann-Whitney test, and Bonferroni adjustment (α=0.05).

Results: The severity of stage II periodontitis had a significant impact on the pulpal response to CT (P<0.001), and teeth with severe stage II periodontitis significantly exhibited more pulpitis compared to those with moderate stage II periodontitis (P<0.001) and mild stage II periodontitis (P<0.001). However, the severity of stage II periodontitis did not significantly affect the pulpal response to EPT (P=0.199). Gender did not significantly influence the pulpal response to either CT (P=0.151) or EPT (P=0.772).

Conclusions: The results of the present study indicate that the severity of stage II periodontitis significantly affects the pulpal response to CT, with teeth affected by severe stage II periodontitis exhibiting more pulpitis. However, the severity of stage II periodontitis did not significantly affect the pulpal response to EPT.

Keywords: Chronic Periodontitis; Dental Pulp; Dental Pulp Test

Introduction

Periodontitis is a severe form of gingival infection caused by microorganisms, leading to clinical attachment loss (CAL). It is diagnosed according to the extent of CAL, which is measured using a standard periodontal probe relative to the cementoenamel junction as the reference line. Depending on clinical, paraclinical, and radiographic findings, periodontitis can be categorized into several types, including stage II periodontitis, aggressive periodontitis, necrotizing periodontitis, periodontitis as a manifestation of a systemic disease, and periodontitis due to endodontic lesions (1, 2).

Stage II periodontitis is the most common form of periodontitis, which is more frequently seen in adults, and progresses slowly with occasional rapid

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destruction due to local, systemic, and environmental factors, and can alter the interactions of the host bacteria (1). Stage II periodontitis is categorized based on extent and severity as localized (affecting less than 30% of teeth), generalized (affecting more than 30% of teeth), mild (1-2 mm of CAL), moderate (3-4 mm of CAL), and severe (≥ 5 mm of CAL) (1, 3).

The effects of dental pulp on periodontal disease have been well documented; however, the impact of periodontal disease on dental pulp has been a matter of debate (4). It has been suggested that gingival recession and CAL decrease pulpal sensitivity to the cold test (CT) (5). Terlemez et al. (6) showed that periodontal disease reduced pulpal volume by 20%. Another study also identified a correlation between periodontal disease and increased dentin volume and decreased cementum volume (7). Additionally, research has shown that changes in radicular pulp due to advanced periodontitis were similar to those caused by aging, including fibrosis, dystrophic calcification, and secondary dentin formation (8). There is strong evidence supporting an increased incidence of pulpal degeneration and inflammation in periodontally involved teeth (9).

Pulp sensibility tests are an important component of the diagnostic work-up for pulpal diseases. These tests help provoke the symptoms reported by patients, aiding in more accurate diagnosis and treatment planning. Determining pulp vitality is crucial, though it is difficult to assess with high clinical certainty. Currently, pulp sensibility is assessed by measuring the nerve response to thermal, electrical, and dentin stimuli (5).

There is controversy regarding the correlation between the severity of periodontal disease and morphological changes in the pulp tissue (10-12). Some researchers argue against this correlation, suggesting that systemic factors may instead be responsible for pulpal degeneration (13). Considering the conflicting evidence regarding the effect of stage II periodontitis on the pulpal response to pulp sensibility tests, this study aimed to evaluate the effect of stage II periodontitis on the pulpal response to EPT and CT. The null hypothesis of the study was that CP and its severity would have no significant impact on the pulpal response to CT and EPT.

Materials and Methods

This observational study was conducted on patients with stage II periodontitis who presented to the Periodontics Department of the School of Dentistry at the Isfahan (Khorasgan) Branch of Islamic Azad University, as well as to several private dental clinics in Isfahan, Iran, during 2021-2022. The study protocol was approved by the ethics committee of Islamic Azad University (IR.IAU.KHUISF.REC.1400.343).

***Eligibility criteria**:*

The inclusion criteria consisted of stage II periodontitis patients between 26 and 62 years with appropriate panoramic radiographs and periodontally involved posterior teeth (14). With no previous endodontic treatment, evidence of any root resorption, severe caries, or previous extensive restoration close to the dental pulp with direct or indirect pulp capping, or periapical lesion on radiographs. Additionally, patients had no generalized dentinal hypersensitivity, calcific metamorphosis, or trauma from occlusion.

Exclusion criteria include systemic diseases affecting pulp vitality, a history of periodontal treatment within the past 6 months, and the use of antidepressants, corticosteroids, long-acting analgesics, or immunosuppressants.

Data collection:

A total of 26 eligible patients were enrolled, and all provided informed consent. The stage II periodontitis-affected teeth, and the control (healthy) teeth were selected by reviewing patients' available radiographs, conducting clinical tests (e.g., percussion, probing),

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and performing clinical intraoral examination. It should be noted that the control and periodontally affected teeth were obtained from the same patients, resulting in a paired data structure. In the present study, paired analyses were not performed, which is considered a limitation.

The severity of stage II periodontitis was assessed by CAL, and teeth were categorized into mild, moderate, or severe groups accordingly. A sound multi-rooted tooth with no endodontic treatment and no deep caries of the same patient was selected as the control tooth.

Probing was performed using gentle hand pressure circumferentially and parallel to the longitudinal axis of the tooth. According to the magnitude of CAL, the teeth were categorized as follows:

Mild CP: 1-2 mm of CAL

Moderate CP: 3-4 mm of CAL

Severe CP: ≥ 5 mm of CAL

Cold test:

The teeth were isolated and dried, after which a cold test (CT) was conducted using a cold spray (Docomo Cool Spray; Pishro Fisar Co., Iran) applied to a cotton pellet. The cotton pellet was placed on the middle third of the buccal tooth surface for at least 3 seconds to assess the immediate response, and up to 10 seconds to assess the delayed response (15). The pulpal response was recorded as follows:

Negative or necrosis (-): No response to CT

Positive and normal (+): Sharp, quickly fading response

Positive with reversible pulpitis (++): Mild sensitivity

Positive with irreversible pulpitis (+++): Severe and prolonged response

The CT was first performed on the control teeth, and after recording the pulpal response, it was performed on the periodontally involved teeth, and the results were recorded. The patients' pain perception threshold was determined by testing the control teeth. Careful attention was given to ensure optimal isolation and proper positioning of the cotton pellet on the buccal tooth surface, avoiding contact with the gingiva, root surface, and cementum.

Electric Pulp Test:

For the *Electric Pulp Test* (EPT), the tooth surface was isolated and dried. The prophylaxis paste was applied to the middle third of the buccal tooth surface, and the electric current was gradually increased until a response was elicited. Care was taken to avoid direct contact of the electrode with any composite or metal restorations (if present). The pulpal response to EPT was recorded as follows:

-No response: Suggesting necrosis or calcific metamorphosis

-Positive response: Suggesting a vital pulp

Data were analyzed using the Chi-square test, Fisher's exact test, Kruskal-Wallis test, Mann-Whitney test, and the Bonferroni adjustment in SPSS version 24 at the 0.05 level of significance.

Results

A total of 67 teeth from 26 patients, including 13 males and 13 females, were evaluated. The mean age of the patients was 46.19±9.63 years (range, 26-62 years). Tables 1 and 2 present the frequency distributions of tooth type and periodontitis severity, respectively.

Table 1. Frequency distribution of tooth type with periodontitis in male and female patients

Variable	Female	Male	Total
	n (%)	n (%)	n (%)
First molar	14 (45.2)	17 (47.2)	31 (46.3)
Second molar	13 (41.9)	15 (41.7)	28 (41.8)
Third molar	4 (12.9)	4 (11.1)	8 (11.9)
Total	31 (100)	36 (100)	67 (100)

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Table 2. Frequency percentage of teeth with Grade A, B and C periodontitis in male and female patients

Variable	Category	Female	Male	Total
		n (%)	n (%)	n (%)
Periodontitis severity	Grade A	9 (29)	11 (30.55)	20(9.29)
	Grade B	10(32.3)	14 (38.9)	24(8.35)
	Grade C	12 (38.7)	11(30.55)	23 (3.34)
Total		31 (100)	36(100)	67(100)

CT:

Table 3 presents the frequency percentage of different pulpal responses to CT. The Kruskal-Wallis test revealed a significant difference in pulpal responses among teeth with mild, moderate, and severe CP (P<0.001). Pairwise comparisons by the Mann-Whitney test with Bonferroni adjustment revealed no significant difference in response to CT between Grade A and Grade B groups (P=1.00). However, teeth with Grade C periodontitis significantly exhibit greater pulpal inflammatory involvement compared to those with Grade B (P<0.001) and Grade A periodontitis (P<0.001).

The Mann-Whitney test revealed no significant difference in pulpal response between males and females for teeth with mild (P=0.721), moderate (P=0.121), and severe (stage II) periodontitis (P=0.444). The pulpal response of teeth with periodontitis, regardless of severity, did not differ significantly between males and females (P=0.151).

Table 3. Frequency percentage of different pulpal responses to CT

Variable	Category	Grade A	Grade B	Grade C	P value
		n (%)	n (%)	n (%)	
CT response	Necrosis (-)	0 (0)	0 (0)	0 (0)	< 0.001
	Normal (+)	8 (40)	7 (2.29)	1 (3.4)	
	Reversible pulpitis (++)	12 (60)	16 (7.66)	11 (8.47)	
	Irreversible pulpitis (+++)	0 (0)	1 (2.4)	11 (8.47)	
Total		20 (100)	24 (100)	23 (100)	

EPT:

Table 4 presents the frequency percentage of the pulpal responses to EPT in teeth with mild, moderate, and severe stage II periodontitis. The Fisher's exact test indicated no significant difference in pulpal response to EPT among teeth with varying levels of stage II periodontitis (P=0.199).

Table 4. Frequency percentage of the pulpal responses of the teeth with Grade A, B and C periodontitis to EPT

Variable	Category	Grade A	Grade B	Grade C	P value
		n (%)	n (%)	n (%)	
Response to EPT	Negative	5 (0)	7 (29.2)	2 (8.7)	0.199
	Positive	15 (75)	17 (70.8)	21 (91.3)	
Total		20 (100)	24 (100)	23 (100)	

Discussion

This study examined the effect of stage II periodontitis on the pulpal response to EPT and CT. The null hypothesis of the study was that stage II periodontitis and its severity would not significantly affect the pulpal response to these tests. Both CT and EPT were

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employed in this study. CT can reliably reveal pulpal necrosis in 90% of cases, with only a few false-negative results (16). The presence of a false-positive result in CT is rarer than in EPT (17), as EPT detects only nerve responses and cannot provide information on pulp vitality (18). Therefore, using EPT and CT together offers a more accurate diagnosis of pulpal status.

Findings of the present study revealed a significant difference in pulpal response to CT among teeth with mild, moderate, and severe stage II periodontitis. Specifically, teeth affected by severe stage II periodontitis exhibit more pulpitis than those with mild and moderate periodontitis, leading to rejection of the null hypothesis. The response to CT was not significantly different between males and females. While most previous studies on this topic are histological in nature, Neves et al. (15) reported a higher likelihood of a negative pulpal response with advancing periodontal disease, contrasting with this study's findings. In the current study, no negative response to CT was observed across all stage II periodontitis types. This difference may be due to Neves et al. (15) using anterior teeth, which are more prone to apical involvement than multi-rooted teeth, and to their study having a small sample size of only 6 patients. Other studies on this topic have focused on histological changes in dental pulp due to periodontal disease, including pulp necrosis, vacuolar degeneration, edema, atrophy, vasodilation, fibrosis, inflammation, and calcification. The present results contrast with the findings of several previous studies (4, 11, 19, 20). This difference is mainly because the abovementioned studies assessed teeth extracted due to severe stage II periodontitis, whereas the present study evaluated three different severities of stage II periodontitis. However, Sabety et al. (11) found that severe stage II periodontitis did not significantly affect pulp vitality or calcification rate, aligning with the present study's results, which showed no negative response to CT in teeth with severe stage II periodontitis. Similarly, Tan et al. (20) demonstrated a stronger CT response in severe stage II periodontitis, consistent with this study's findings.

No significant difference was observed in the pulpal response to EPT among teeth with mild, moderate, and severe stage II periodontitis, which helped confirm the null hypothesis. Additionally, no significant gender differences were found. This suggests that pulpal status does not always correlate with EPT results, as EPT can only reflect nerve response and does not provide information about the presence of blood supply, a key indicator of pulp vitality.

Relatively small sample size and evaluation of only posterior teeth (due to their more complex response to pulp sensibility tests) were among the limitations of this study. Therefore, the findings cannot be generalized to all tooth types, and further studies including different tooth types are recommended. Future studies should involve larger sample sizes and include single-canal teeth. Moreover, similar studies should incorporate histological analyses of stage II periodontitis-affected teeth scheduled for extraction.

Conclusion

The results of the present study indicate that the severity of stage II periodontitis significantly affects the pulpal response to CT, with teeth affected by severe stage II periodontitis exhibiting more pulpitis. However, the severity of stage II periodontitis did not significantly affect the pulpal response to EPT.

Conflict of Interests: The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial, or non-financial in this article

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