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Relationship of preoperative clinical signs and symptoms with the bleeding of the pulp during pulpotomy of primary molars

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ABSTRACT

Introduction: The presence/absence of pain history in primary teeth may not be compatible with perioperative clinical and radiographic findings. The aim of this study was to evaluate the predictive value of preoperative clinical symptoms in predicting the final treatment plan.

Materials and Methods: This study was conducted on 107 children requiring pulpotomy and restoration of primary first molars. Pain history and sensitivity to percussion and palpation were assessed. Pain at the time of pulp exposure, color of exposed pulp tissue, and hemostasis after 3 minutes were recorded during the procedure. The relationship between preoperative symptoms and perioperative findings was analyzed using the Wilson method to calculate the sensitivity, specificity and predictive value of perioperative symptoms (confidence interval (CI) %95).

Results: Spontaneous (88.5%) and nocturnal (88.2%) pain had the highest positive predictive value (PPV) for darker color of bleeding. Nocturnal pain and pain during percussion had a PPV of 52.9% and 52.6% for pain during pulp exposure, respectively. Pain during mastication had the highest PPV for hemostasis after 3 minutes (79%).

Conclusion: Among the preoperative symptoms reported by patients, spontaneous pain and pain in response to a cold stimulus may indicate pain during pulp exposure and darker bleeding during pulpotomy.

Keywords: Dental Pulp, Tooth, Deciduous, Pain, Symptom assessment; Bleeding time.

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Introduction

Dental caries is a challenge in childhood and requires treatment, considering the importance of deciduous teeth for space maintenance, optimal mastication and speech, and physical and psychological growth and development of children. Due to the large size of the pulp chamber and low dentin thickness, caries progresses rapidly in deciduous teeth and can easily lead to pulp involvement, which may be asymptomatic. Depending on the extent of the caries-induced inflammation of the coronal and radicular pulp, primary teeth may require partial pulp therapy by removing the coronal pulp, known as a pulpotomy, or complete pulp therapy by removing the entire pulp tissue, known as pulpectomy. [1,2]

Pulpotomy is defined as the complete removal of the coronal pulp tissue to the level of the orifice(s) and application of a pulp capping agent (to cap the vital pulp) and subsequent restoration of the coronal tooth structure. Pulpotomy is the most common technique of pulp therapy for primary teeth without signs of pathosis. The logic behind this treatment is based on the regenerative capacity of the radicular pulp after surgical removal of the inflamed coronal pulp tissue. However, pulpectomy is performed on teeth with irreversibly inflamed or necrotic pulp, where the root canals are debrided, disinfected, and obturated. The process of diagnosis and selection of the tooth for vital pulp therapy is based on the likelihood of an optimal pulp response and the reparability of the tooth crown. Despite the lack of histologic evidence, pulp therapies in primary teeth are still practical due to their statistical empirical success compared to their failure. [3]

The likelihood of an optimal response of the dental pulp is assessed based on the extent of inflammation prior to treatment, which is determined by a pain history, clinical examination, clinical signs and symptoms, and radiographic interpretation of the findings. [1,2]

Pain may be caused by food ingestion in a cavitated lesion, pressure, or chemical/thermal stimulation of the vital pulp, only protected by a thin layer of intact dentin. [4]

However, prolonged, severe and spontaneous pain often indicates further extension of the inflammation to the radicular pulp. [4] Pain history in primary teeth may not be as reliable for the differential diagnosis of exposed pulp status as in permanent teeth, as degeneration of the primary pulp and even abscess formation may occur without children reporting pain or discomfort. [4] Pediatric patients may present with advanced carious lesions with no history of pain. However, after access cavity preparation, excessive bleeding, darker color of blood, and pain on pulp tissue removal often indicate more severe inflammation extending to the radicular pulp, which may alter the treatment plan to remove the radicular pulp tissue as well. On the other hand, some teeth show severe undifferentiable pain both in severely inflamed pulp tissue and in necrotic pulp. [4]

In addition to the pain history, thermal and mechanical sensitivity tests can help to make an accurate pulpal and periapical diagnosis. The cold test is a reliable diagnostic tool with high sensitivity and specificity for distinguishing a vital pulp from a necrotic pulp. Other symptoms include sensitivity to percussion, palpation and bite. An abnormal or painful response to mechanical sensitivity tests commonly indicates periapical inflammation or infection. Soft tissue changes in the form of severe redness or a gingival abscess with a draining fistula are clear clinical signs of irreversible pulpitis requiring complete root canal therapy or tooth extraction. However, in the absence of soft tissue changes, the utility of diagnostic tests of mechanical sensitivity such as percussion, palpation and bite testing is less obvious and may be questionable, especially in young children due to their fear of the test.

Furthermore, the percussion test can detect mechanical allodynia due to peripheral and central hypersensitivity originating from the afferent nerves of an inflamed and hypersensitive pulp, while the periapical tissues are free of pathological tissue damage. In some cases, a tooth with a necrotic pulp may exhibit percussion sensitivity. [5] Given the above controversy, obtaining a pain history and performing thermomechanical tests should be the priority in vital pulp therapy. It appears that an accurate assessment of the relationship between pain and other clinical findings may provide valuable insight into more accurately identifying the degree of pulpal and periapical inflammation and infection.

Some previous studies in this regard have been conducted on permanent teeth by assessing clinical [5-8] and histopathological [9, 10] signs and symptoms, and on primary teeth by immunological assessment of the inflammatory cell count in the dental pulp, [11, 12] histopathological pulp status [13] and pulp vitality tests. [14-16] Considering all the above, the aim of the current study was to assess the concordance of radiographic manifestations and preoperative clinical symptoms with clinical signs and symptoms noted during pulp therapy such as the amount and color of bleeding from the exposure site and perioperative pain to reveal the predictive value of clinical signs and symptoms and radiographic findings and the predictability of the final treatment plan.

Materials & Methods

This descriptive cross-sectional study was approved by the Ethics Committee of Pardis International Campus of Tehran University of Medical Sciences (IR. TUMS.DENTISTRREC.1402.074). According to study by Kassa [9] and using one sample sensitivity and specificity power analysis of SPSS, the minimum sample size was calculated to be 98, assuming 95% confidence interval (α=0.05), a study power of 80% (β=0.2), an optimal sensitivity of 0.05 and optimal specificity of 0.9 according to the null hypothesis and δ=0.15.

A total of 107 children aged 5-8 years who required pulpotomy and restoration of primary molars according to clinical and radiographic criteria were selected by convenience sampling. The teeth had extensive caries without gingival redness or fistula on clinical examination and no resorption, radiolucency, internal/external root resorption or abnormal inter-radicular bone or lamina dura on radiographic examination. The selected children had no history of systemic disease (ASA I and II) or hospitalization, and no current symptoms such as pain, acute edema or facial trauma. The children were cooperative with the Frankl Behavior Rating Scale of 1 or 2. Parents were informed about the study and were assured that their information would be kept confidential and used for research purposes only. They were also assured that non-participation in the study would not affect the course of their children's dental treatment. Children of parents who were not willing to participate in the study and uncooperative children were excluded.

After the parents signed the informed consent form, a pediatric dentist performed all diagnostic and therapeutic measures, such as recording the patients' chief complaints and performing a detailed intraoral and extraoral clinical examination. Parents and children were also asked about clinical symptoms such as pain in response to thermal stimuli (cold, heat), chewing or eating sweets, spontaneous pain, and nocturnal pain. Sensitivity to percussion and palpation was also assessed during the clinical examination. Behavioral control techniques, such as the tell, show, do technique, were used to familiarize the children with the office setting, treatment process, and equipment, and to prevent anxiety and avoidance behaviors.

Before starting the treatment, an anesthetic benzocaine gel was applied to the mucous membranes at the injection site and one-third to two-thirds of a cartridge containing 2% lidocaine and epinephrine 1:100,000 was gently injected using the infiltration technique. After reaching a sufficient depth of anesthesia by assessing the soft tissue, the caries was removed, the access cavity prepared, and the pulp chamber roof removed. Pain during exposure and removal of the pulp chamber roof (despite ensuring complete anesthesia of the tooth in question) was quantified and recorded using the Facial Pain Scale. If the patient was saline was gently pressed onto the tissue and hemostasis was assessed after 3 minutes and recorded. Uncomfortable and additional anesthesia was required, an additional injection into the periodontal ligament was performed. After complete removal of the coronal pulp tissue, the amount of bleeding (heavy/low) and the color of the blood (pink, light red, dark red) at the canal orifice were recorded. Next, a cotton pellet dipped in

The association of clinical signs and symptoms with perioperative findings was analyzed with SPSS using the Wilson method with CI %95. The sensitivity, specificity and predictive value of the perioperative diagnostic indices were also calculated and reported. Sensitivity indicates the ability of a test to detect the disease in patients suffering from it, and is defined as the ratio of patients with a positive test reaction to the total number of individuals tested. Specificity is also used to assess the accuracy of a diagnostic test, and indicates the ability of a test to detect the absence of a particular disease. It is calculated by dividing the number of patients with a negative test reaction by the total number of people tested without a particular disease.

Results

Of the 107 children who participated in the study, 3 children were excluded due to uncooperative behavior after the administration of local anesthesia. A total of 104 children with a mean age of 6.5 years (range 5 to 8 years) underwent pulpotomy of primary first molars. Table 1 presents the frequency distribution of the children's ages, gender and type of teeth.

Table 1. Frequency distribution of the children's age, Gender, Type of teeth

General characteristics	Number
Age (year)	5 (N:14)
	5.5 (N:3)
	6 (N:29)
	6.5 (N:1)
	7 (N:33)
	8 (N:24)
Gender	Female (N:54)
	Male (N:50)
Type of tooth	Maxilla (N:70)
	Mandible (N:34)

Table 2 shows the patients' pain history and frequency of preoperative and perioperative clinical symptoms.

Table 2. Pain history and frequency of preoperative and perioperative clinical symptoms of the patients

Status	Pain during exposure	Blood color after exposure	Hemostasis after 3 minutes
Pain during mastication	**Absent: 27.4%** **Low:67.7%** **High: 4.8%**	**Pink: 38.7%** **Light red: 48.4%** **Dark red: 12.9%**	**Yes: 79%** **No: 21%**
Pain in response to cold stimuli	**Absent: 18.4%** **Low: 52.6%** **High: 28.9%**	**Pink: 15.8%** **Light red: 31.6%** **Dark red: 52.6%**	**Yes: 36.8%** **No: 63.2%**
Pain in response to heat stimuli	**Absent: 6.7%** **Low: 60%** **High: 33.3%**	**Pink: 13.3%** **Light red: 33.3%** **Dark red: 53.3%**	**Yes: 33.3%** **No: 66.7%**
Pain in response to the consumption of sweets	**Absent: 36.5%** **Low: 57.1%** **High: 6.3%**	**Pink: 49.2^** **Light red: 41.3%** **Dark red: 9.5%**	**Yes: 88.9%** **No: 11.1%**
Spontaneous pain	**Absent: 0%** **Low: 53.8%** **High: 46.2%**	**Pink: 3.8%** **Light red: 7.7%** **Dark red: 88.5%**	**Yes: 15.4%** **No: 84.6%**
Nocturnal pain	**Absent: 0%** **Low: 47.1%** **High: 52.9%**	**Pink: 0%** **Light red: 11.8%** **Dark red: 88.2%**	**Yes: 11.8%** **No: 88.2%**
Pain on palpation	**Absent: 0%** **Low: 58.3%** **High: 41.7%**	**Pink: 4.2%** **Light red: 25%** **Dark red: 70.8%**	**Yes: 20.8%** **No: 79.2%**
Pain on percussion	**Absent: 5.3%** **Low: 42.1%** **High: 52.6%**	**Pink: 5.3%** **Light red: 21.1%** **Dark red: 73.7%**	**Yes: 21.1%** **No: 78.9%**

The positive predictive value (PPV) and negative predictive value (NPV) of each symptom were assessed. The results showed that pain on chewing and pain in response to heat stimuli had the highest PPV for hemostasis after 3 minutes (79% and 66.7%, respectively). Spontaneous pain, nocturnal pain, pain due to consumption of sweets, pain on percussion, pain on palpation, and pain in response to heat and cold stimuli had the highest PPV for color of bleeding (88.5%, 88.2%, 88.9%, 73.7%, 70.8%, 53.3%,

and 52.6%, respectively). Nocturnal pain and pain on percussion had a PPV of 52.9% and 52.6%, respectively, for pain during pulp exposure.

Table 3 presents the sensitivity and specificity of preoperative and perioperative clinical signs and symptoms.

Table 3. Sensitivity and specificity of preoperative and perioperative clinical signs and symptoms

Clinical symptom	Sensitivity	Specificity
Pain during pulp exposure and nocturnal pain	64.3%	100%
Pain during pulp exposure and pain during mastication	21.4%	39.3%
Pain during pulp exposure and pain in response to heat	35.7%	96.4%
Pain during pulp exposure and pain in response to cold	78.6%	75%
Pain during pulp exposure and pain due to the consumption of sweets	28.6%	17.9%
Pain during pulp exposure and spontaneous pain	85.7%	100%
Pain during pulp exposure and pain on palpation	71.5%	100%
Pain during pulp exposure and pain on percussion	71.4%	96.4%
Color of bleeding and nocturnal pain	57.7%	100%
Color of bleeding and pain during mastication	30.8%	31.4%
Color of bleeding and pain in response to heat	30.8%	94.3%
Color of bleeding and pain in response to cold	27.9%	82.9%
Color of bleeding and pain with sweets	23.1%	11.4%
Color of bleeding and spontaneous pain	88.5%	97.1%
Color of bleeding and pain on palpation	65.4%	97.1%
Color of bleeding and pain on percussion	53.8%	97.1%
Hemostasis after 3 minutes and nocturnal pain	2.8%	54.5%
Hemostasis after 3 minutes and pain during mastication	69%	60.6%
Hemostasis after 3 minutes and pain in response to heat	69.7%	7%
Hemostasis after 3 minutes and pain in response to cold	27.3%	19.7%
Hemostasis after 3 minutes and pain with sweets	78.9%^	78.8%
Hemostasis after 3 minutes and spontaneous pain	5.3%	33.3%
Hemostasis after 3 minutes and pain on palpation	7%	42.4%
Hemostasis after 3 minutes and pain on percussion	42.4%	54.5%

Discussion

The results of the present study showed that pain during chewing and heat irritation were frequently associated with delayed hemostasis. Spontaneous and nocturnal highly predicted darker bleeding color. In most cases, percussion pain is associated with pain during pulp exposure.

When treating the pulp, other than direct histologic analysis of the dental pulp (biopsy), no pulp test alone can reliably determine the health or disease status of the dental pulp, and different dentists may interpret the same data differently. These limitations are more common in primary teeth, and the information obtained from pulp tests in young children is less reliable. [17]

Aminabadi et al. [12] found that blood color can be selected as a suitable strategy for pulp therapy. However, there is controversy about the site of assessment of bleeding. Bleeding at the exposure site or only bleeding at the pulp tissue amputation site or both sites could be assessed to accurately determine the radicular pulp status. On the other hand, Mutluay et al. [11] stated that bleeding control at the exposure site or the canal orifice does not offer a precise assessment of pulpal inflammation at the canal orifice and may be misleading for the diagnosis of pulp status in primary teeth.

According to the American Academy of Pediatric Dentistry guidelines for pulp therapy, the treatment plan should be changed to pulp amputation if bleeding cannot be controlled within a few minutes of pulp tissue amputation. Similarly, the prolonged bleeding time could be related to the failures of partial pulpotomy treatment of irreversible pulpitis in permanent dentition. [18]

In the present study, the relationship between preoperative clinical signs and symptoms and perioperative symptoms, such as the color of bleeding and hemostasis, after a 3-minute application of saline to the amputated coronal pulp in pulpotomy of primary first molars in 5-8-year-old children were investigated. There is a complex dynamic interaction between pulpal and periapical disease and pain perception. Thus, the interpretation of pain is complex. The present results revealed that pain associated with eating sweets and pain while chewing were the most commonly reported symptoms by the children (60.3% and 59.4%, respectively). However, analytical analyses indicated that these reported preoperative symptoms have different sensitivity and specificity for pulp status.

For pain during pulp exposure, spontaneous pain followed by pain in response to cold stimuli had a significant sensitivity and nocturnal pain, spontaneous pain and pain in response to palpation had a specificity of 100% and 96.4%, respectively. The specificity of pain associated with the consumption of sweets was insignificant (37%). In the study by Crisneros-Cabello et al. [9], the sensitivity of pain in response to cold stimuli and the specificity of pain associated with eating sweets were higher for pain during pulp exposure. They also emphasized the significance of pain history, spontaneous pain, and pain in response to cold stimuli, in teeth with irreversible pulpitis (impossible pulp therapy). [9]

Spontaneous pain had a relatively high sensitivity to the color of bleeding. Nocturnal pain, spontaneous pain, pain on percussion and palpation, as well as pain in response to cold and heat stimuli, had high specificity. For hemostasis after 3 minutes, none of the parameters had high sensitivity and/or specificity, and pain associated with eating sweets and chewing had acceptable sensitivity and specificity of 78.8% and 78.9%, respectively. According to the previous studies on permanent [19,20] and primary [14] teeth, in addition to the pain history, the cold test in particular can be used for the clinical examination of the pulp in children with high diagnostic value and fewer false results [7,8] due to its simplicity. [14]

In the present study, pulp necrosis was diagnosed in three teeth that showed preoperative symptoms such as spontaneous pain and pain in response to heat and cold stimuli. Some inconsistencies were noted in this regard. For example, some necrotic teeth may also exhibit percussion sensitivity. [6, 10] In addition, no significant difference was found in pathologic conditions of the pulp by increased pain perception when lying down, chewing, eating sweets or palpation. [10] In some cases, the tooth has chronic partial pulpitis with partial necrosis despite the reported severe pain. [5]

Similar results were demonstrated by Poureslami et al. and Villa-Chavez et al. [15,21] who reported occasional false positive reactions of necrotic teeth to the heat test and electric pulp test. Nonetheless, the teeth showed no preoperative symptoms such as pain on percussion or palpation, or pain during exposure and perioperative bleeding. Another study reported an exaggerated response to the percussion test in a healthy tooth adjacent to a necrotic tooth. [6] It appears that the pulp vitality test assesses the neural response of the pulp and not its vascular response. The pulp tissue is very resistant to inflammation. Thus, its neural tissue may remain responsive even after degeneration of the adjacent tissue, resulting in a false positive reaction. [20]

Besides the inconsistencies, it should be generally considered that the different response to percussion and palpation in deciduous teeth may be a sign of the different anatomy, innervation and blood supply of the pulp of deciduous teeth, [14] the active physiological root resorption [17] and the location of caries. A previous study reported significantly different inflammatory changes along the coronal pulp of teeth with proximal caries compared to teeth with occlusal caries. [13]

Future studies using the electrical pulp test [14,15] and novel methods such as pulse oximetry [17, 20, 22, 23] and laser Doppler are recommended for the assessment of pulp status in carious primary teeth with pulp involvement. Among the methods for vitality testing, pulse oximetry seems to have a series of advantages that make this method suitable for use in pediatric dentistry, and the results of clinical studies are promising. [17] Moreover, considering the effects of dental anatomy and dental physiologic age on tooth response, preoperative and intraoperative symptoms in primary second molars undergoing pulp therapy should also be investigated and compared with primary first molars.

Conclusion

It seems that pain is not a very reliable index for the assessment of pulp status; however, it can be used as a guide. In total, the present results, along with previous findings, suggest that spontaneous pain, nocturnal pain and pain in response to cold stimuli may predict the possibility of a higher level of pain during exposure, and darker bleeding during pulpotomy. Pain associated with mastication may be a predictive symptom of hemostasis.

This research project was approved by Tehran University of Medical Sciences and conducted at the School of Dentistry. The authors would like to thank all those who sincerely cooperated in conducting this study.

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Conflict of Interest

There is no conflict of interest to declare.

Author's Contribution

Marzieh Salehi Shahrabi and Mehrsa Paryab and Elnaz Asgari Anaraki developed the original idea and protocol. Mahsa Mahlegha and Mehrsa Paryab and Marzieh Salehi Shahrabi conducted the literature and data collection. Mahsa Mahlegha and Mehrsa Paryab summarized the data, drafted the manuscript, and edited the article. Mohammad Javad Kharrazi Fard analyzed the data. The study was supervised by Mehrsa Paryab.

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