

# Problems of diagnostic of the state of pulp and pulpal diagnoses in children

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## ABSTRACT

**Aim:** To analyze diagnostic methods of the pulp status in children and align pulpal diagnoses with international and Ukrainian classifications.

**Materials and Methods:** The authors searched for articles via Google using keywords such as «pulpitis classification», «pulp diagnostic in children», «reversible pulpitis», «irreversible pulpitis», «pulp necrosis» combined with «primary teeth», «permanent immature teeth». Also evidence of primary data was evaluated by levels of evidence statements and grades of recommendations for questions relating to diagnosis.

**Results:** Level of evidence of primary data about methods of pulpal state diagnosis varies from 2 to expert opinion, grade of recommendation is C-D. Sensibility tests can be used for pulp diagnosing in primary and immature permanent teeth, in conjunction with other clinical diagnostic aids. Such conditions of pulp as complete pulp necrosis, pulpless and infected root canal system, previously treated pulpitis, and previously initiated therapy could be included in the Ukrainian classification. Pulp hyperplasia only partially corresponds pulpitis chronica hypertrophica and may be associated with any form of reversible and irreversible pulpitis. In international classifications, partial pulp necrosis includes pulpitis chronica gangraenosa and pulpitis acuta purulenta from the Ukrainian variant.

**Conclusions:** Pulpal diagnosis in children relies on observation of clinical and periapical radiographic findings. While the Ukrainian classification covers various forms of pulpitis, it could be expanded to include pulp conditions, but only some of them completely correspond diagnoses of the Ukrainian classification. Therefore, the development of new classification of the status of the pulp in children is promising and challenging task.

**KEY WORDS:** pulp, children, diagnosis

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## INTRODUCTION

Nature of different pulp conditions is complicated. For example, it has been found that not only oxidative stress plays role in periodontal inflammation [1], but and the caries-related inflammation alters the oxidative stress cycle in dental pulp tissue [2]. Also different bacterial species have been found in deep caries cavities [3,4], making diverse pulp inflammation.

Diagnostic tools to make endodontic diagnosis in adults have less value for primary teeth and limited in their use in immature permanent teeth. Ukrainian classification of pulpitis in children [5] has serious differences with international classifications [6,7]. Due to the use of international classifications at private dental practice in Ukraine, and the need to make standard treatment protocols, we have focused on the methods of pulpitis diagnostic in primary and permanent teeth in children and the international classifications of pulp diseases. The aim of this article is to analyze diagnostic methods of the status of the pulp in children and align

pulpal diagnoses with international and Ukrainian classifications.

## AIM

The aim was to analyze diagnostic methods of the pulp status in children and align pulpal diagnoses with international and Ukrainian classifications.

## MATERIALS AND METHODS

The authors searched for articles and scientific publications via Google using keywords such as «pulpitis classification», «pulp diagnostic in children», «reversible pulpitis», «irreversible pulpitis», «pulp necrosis» combined with «primary teeth», «permanent immature teeth». Additional publications were identified by checking the references of review and original articles. Also evidence of primary data was evaluated by levels of evidence statements and grades of recommendations for questions relating to diagnosis [8].

## REVIEW AND DISCUSSION

### METHODS OF PULPAL STATE DIAGNOSIS

The ideal technique for the evaluation of the dental pulp status in children needs to be non-invasive, objective, painless, reliable, reproducible, standardized, easy to employ (a simple technique) and fast [9].

The American Academy of Pediatric Dentistry (AAPD) recommends to use diagnostic criteria for pulpitis in children, which were described by Camp [10] (grade of recommendation - D). The clinical diagnosis of pulpitis is based on:

- medical history;
- review of past and present dental history and treatment, including current symptoms;
- subjective evaluation of the area associated with current symptoms by questioning the patient/parent on the location, intensity, duration, stimulus, relief, and spontaneity;
- objective extraoral and intraoral examination;
- radiographs to diagnose periapical or periradicular changes;
- clinical tests such as palpation, percussion, and mobility; electric pulp and thermal tests are considered as unreliable in immature permanent and primary teeth.

In order to avoid behavior management problems, when performing percussion and palpation tests in children, the fingertip should be gently used in combination with Tell, Show, and Do (TSD) technique [11]. The dentist should start the test with a contralateral non-affected tooth to familiarize the patient with a normal response to the stimuli. Comparing the mobility of a suspicious tooth with its opposite equivalent can be helpful for differential diagnosis [12].

There are two groups for pulp testing – tests for pulp sensibility and vitality. Sensibility pulp tests include thermal, electric pulp testing, selective anesthesia, and test cavity (preparation). The test of cavity preparation may prove tooth vitality, but is not suitable for children; selective anesthesia is also considered unappropriated.

Cold and electric pulp testing in primary teeth are to be applied only in children who can understand the instructions and provide an adequate response to the stimuli. These tests may yield unreliable data due to fear, management problems, and inability to understand or communicate accurately [13]. Moreover, International Association of Dental Traumatology considers pulp sensitivity tests and percussion as unreliable in primary teeth (grade of recommendation – D) [14].

If a dentist uses cold or electric pulp test, control teeth should be tested first. The cold test should be applied to the tooth for 10 seconds or until the patient responds

definitively. Electric pulp test helps to differentiate caries and its complications in permanent teeth, however, it could not be used to distinguish between reversible pulpitis from an irreversible one (level of evidence 3) [15]. Hori et al. [16] reported about 73.3% and 80% sensitivity of the cold test and electric pulp in primary teeth, accordingly (level of evidence 3). The diagnostic accuracy of the electric pulp test was 76.2% and 92.5%, the cold test had a diagnostic accuracy of 85% and 92.5% in the incomplete and complete central incisors (level of evidence 2, grade of recommendation C) [17]. Therefore, sensibility tests can be used for diagnosing of the status of the pulp in primary and immature permanent teeth, in conjunction with other clinical diagnostic aids.

Tests for pulp vitality (laser doppler flowmetry, pulse oximetry, etc.) are limited to teeth containing pulp tissue within the coronal part of the tooth [18]. Despite this limitation, they are considered useful for diagnosing pulpitis in primary and immature permanent teeth [19]. Unfortunately, these tests are mostly unavailable in everyday clinical practice. In Brazilian survey, only a few pediatric dentists reported about using of laser doppler flowmetry; also 93.7% of them reported about using sensibility tests routinely and cold and electric pulp tests equally (level of evidence 2) [20].

Consequently, most diagnoses in pediatric dentistry rely on observation of clinical symptoms and evidence of periapical radiographic changes [11]. Level of evidence of primary data about methods of pulpal state diagnosis varies from 2 to expert opinion, grade of recommendation is C-D.

### PULPAL DIAGNOSES IN PRIMARY TEETH

The authors aligned Ukrainian classification of pulpitis in children [5], pulpal diagnoses approved by American Association of Endodontics (AAE), which is the recommended best practice based on the clinical experience of the guideline development group (level of recommendation - D) [6], and Abbott's classification of the conditions of the pulp and root canal system (expert opinion, level of recommendation – D) [7]. A complete endodontic diagnosis includes both a pulpal and a periapical diagnosis for each tooth evaluated.

Normal pulp and periodontium (AAE and Abbott's classifications). No pain, tooth has a small caries cavity or a part of crown is absent due trauma. Pulp chamber is close, probing is painless. In a case of dental trauma, temporary loss of pulp sensitivity is possible for 4-6 weeks (grade of recommendation – D) [14]. The cold test gives the response which disappears with stimulus removal. Percussion is painless, palpation of oral mu-

cosa about roots is painless. There are no radiographic changes.

Reversible pulpitis (with normal periodontium) from AAE and Abbott's classifications. Diagnosis is made on observation of several subjective and objective symptoms. Patient complains of provoked short-time pain upon removal of the stimulus (cold or sweet food, tooth brushing, chewing) – acute reversible pulpitis, or no complains – chronic reversible pulpitis. Asymptomatic manifestation with pulp exposure corresponds pulpitis chronica fibrosa in Ukrainian classification. The history of pain presented for a few hours to days. There is no spontaneous and nighttime pain. Tooth has a deep caries lesion without pulp exposure; pulp exposure could be revealed only after dentin excavation [21]. Pulpal exposure may be clinical or radiographic; the thickness of circumpalpal dentin on roentgenogram for reversible pulpitis is not less 1 mm [12]. Probing of exposed pulp is painful, light red small drop of pulp is found, with bleeding that can be controlled within five minutes. The tooth also may have filling or crown fracture. The cold test causes pain for a few seconds. There are no such symptoms of apical periodontitis as painful percussion, painful palpation of mucosa about roots, a sinus tract, inflammation of oral mucosa not resulting from periodontal disease, excessive mobility not associated with trauma or exfoliation, furcation/apical radiolucency, or radiographic evidence of internal/ external resorption [10].

Such diagnosis is available until the period of physiological resorption of roots in primary teeth. Dentist may make such provisional diagnosis if stimuli induce a short-time pain, no spontaneous pain and periapical inflammation. In this case the tooth needs vital therapy and follow-ups for 3 months, and pulp sensitivity could get over or pulp necrosis becomes evident [7].

Irreversible pulpitis (same in AAE and Abbott's classifications, no such diagnosis in the Ukrainian classification). It includes cases with and without apical periodontitis. A radiograph may show intra-root resorption. The cold test provokes a long-time pain for minutes. Profuse dark pulp bleeding is a symptom of irreversible pulpitis [20]. Pain provoked by eating for a short duration (5-10 minutes). The diagnosis of irreversible pulpitis cannot be solely rely on pulpal bleeding that be controlled more five minutes without other clinical symptoms. However, there are no evident recommendations for irreversible pulpitis in primary teeth [22].

Symptomatic (acute) irreversible pulpitis (same in AAE an Abbott's classifications, pulpitis acuta serosa diffusa in the Ukrainian classification) is characterized by spontaneous, paroxysmal pain and provoked pain in response to cold, heat stimuli. The tooth has a deep

caries lesion without pulp exposure or filling. Probing of bottom of caries cavity is painful. The tooth may be tender to biting pressure and/or percussion and, if present, this usually indicates spread of the inflammatory process to the periapical tissues.

Asymptomatic (chronic) irreversible pulpitis (pulpitis chronica fibrosa in Ukrainian classification) is characterized by provoked pain to cold, heat stimuli. No pain [18] or provoked/spontaneous pain in past [17]. Tooth has a deep caries lesion with or without pulp exposure, or filling. If no pulp exposure, probing of bottom of caries cavity is painful. Probing of exposed pulp is painful and provokes bleeding.

Pulp hyperplasia is a kind of degenerative changes in the pulp (Abbott's classification) which may exhibit symptoms of irreversible pulpitis [3]. It is pulpitis chronica hypertrophica in the Ukrainian classification. Caries cavity united with pulp chamber and filled by pulp polyp. If there are no complains or provoked pain, probing of polyp is painless, and it can be chronic irreversible pulpitis, if a patient experiences pain when eating, probing of polyp is painful, provoked bleeding, it can be acute irreversible pulpitis. Pulp polyp is not connected with gums. The cold test may elicit a response for minutes. It may be associated with chronic apical periodontitis.

Partial pulp necrosis (pulp condition in Abbott's classification). Similar symptoms with pulpitis chronica gangraenosa in the Ukrainian classification: sensitivity to hot stimuli that persists after the stimulus is removed; deep caries cavity connected with pulp chamber; tooth may have filling or grey crown; halitosis. Also probing of pulp chamber is painless, root canals – painful. May be associated with acute or chronic apical periodontitis.

Complete pulp necrosis (AAE and Abbott's classifications). There is complete pulp necrosis with and without apical periodontitis. Asymptomatic pulpitis. History of provoked pain, trauma or filling. Deep caries cavity united with pulp chamber, or tooth has filling or grey crown. No reaction to the cold test. Preparation test is negative. Unfortunately, there are no clear recommendations for diagnostic of pulp necrosis in primary teeth (grade of recommendation – D) [22]. The authors disagree with Mohammad et al. [23] who did not divide pulp necrosis in primary teeth on partial and complete, emphasizing that pain may or may not be spontaneous, pain is elicited by various stimuli, and response to various testing modalities is usually absent.

Pulpless and infected root canal system is considered by Abbott as a pulp condition which develops after pulp necrosis. No pulp sensitivity. Obligatory sign is periapical radiolucency (sign of chronic apical periodontitis). Only this pulp condition might be associated with symptoms of exacerbation of chronic apical periodon-

titis. No such diagnosis in the Ukrainian classification.

Previously Treated Pulpitis (AAE and Abbott's classifications). Root canals are filled or not, with or without symptoms of apical chronic periodontitis [6]. If endodontic treatment was adequate, the tooth does not respond to stimulation. Symptoms may or may not be present, indicating chronic apical periodontitis.

Previously Initiated Therapy (AAE and Abbott's classifications) [7] the tooth has been previously treated by endodontic therapy such as pulpotomy or pulpectomy. Depending on the level of therapy, the tooth may or may not respond to pulp testing modalities. Symptoms may or may not be present, indicating chronic apical periodontitis.

## THE STATUS OF THE PULP DIAGNOSIS IN PERMANENT TEETH

Normal pulp and periodontium. No pain, tooth has a small caries cavity or a part of crown is absent due trauma. The pulp chamber is close, probing is painless. The pulp responds to thermal and electrical tests in a manner similar to that of a corresponding control tooth. The reaction to the cold test in mature permanent teeth up to 2 seconds [18]. In a case of dental trauma, temporary loss of pulp sensitivity can occur for 6-8 weeks [14]. Percussion is painless, palpation of oral mucosa about roots is painless. There are no radiographic changes.

Reversible pulpitis (with normal periodontium). It is diagnosed based on observation of several subjective symptoms. Patient complains of provoked short-time pain upon removal of the stimulus (cold or sweet food, tooth brushing) – acute reversible pulpitis, or no complains – chronic reversible pulpitis. There is no spontaneous and nighttime pain [7]. History of pain presents for few hours-days.

The tooth exhibits a deep caries lesion without pulp exposure or pulp exposure is revealed after dentin excavation [7]. The tooth also may have filling or crown fracture. Probing of the exposed pulp is painful, light red small drop of pulp is found. The cold test provokes a long-time pain for a few seconds, this test is longer in immature permanent teeth (level of evidence 4) [12]. Pain is typically triggered by extreme temperature changes (ice cream and cold drink from the fridge) [7]. There are no symptoms of apical periodontitis [10]. Dentist may make such provisional diagnosis if stimuli induce a short-time pain, no spontaneous pain and periapical inflammation. In this case the tooth needs vital therapy and follow-ups for 3 months, and pulp sensitivity could get over or pulp necrosis becomes evident [7]. However, the symptoms of pulp hyperaemia and pulpitis acuta limita (from the Ukrainian classification) do not correspond symptoms of reversible pulpitis.

Irreversible pulpitis. There is irreversible pulpitis with and without apical periodontitis. A radiograph may have intra-root resorption. One of the criteria that is commonly used to "con-

sider" irreversible pulpitis is the 10 seconds of lingering pain after conducting a cold test on tooth.

Symptomatic (acute) irreversible pulpitis is characterized by spontaneous, paroxysmal pain which lasts for a few seconds to a few hours, irradiation pain, waking at night, and worse lying down. The patient typically has a history of pain for a few days. The tooth has a deep caries lesion without pulp exposure and a recent restoration. Probing of the bottom of the caries cavity is painful. The tooth may be tender to biting pressure and/or percussion and, if present, this usually indicates spread of the inflammatory process to the periapical tissues.

Asymptomatic (chronic) irreversible pulpitis is characterized by provoked pain to cold, heat stimuli. Occasionally, there may be pain when exposed to heat, cold, and/or biting for a few months, often preceded by a restoration procedure. Sharp provoked pain, then a dull ache that lingers (more than five minutes). The tooth has a deep caries lesion with or without pulp exposure. If there is no pulp exposure, probing of bottom of caries cavity is painful. Probing of exposed pulp is painful and provokes bleeding.

Pulp hyperplasia. Caries cavity connected with pulp chamber and filled by a pulp polyp which is not connected with gums. The pulp polyp may bleed on probing, may or may not be sensitive to probing. This pulp condition may have clinical manifestations of acute and chronic reversible and irreversible pulpitis [7]. The tooth will respond to pulp sensibility tests depending on the type of pulpitis present. It may be associated with chronic apical periodontitis.

Partial pulp necrosis. The pain has only been present for a short time (a few days or less); triggered by heat, cold or biting; if temperature changes cause pain then usually only minor temperature changes required (tap water); pain lingers for a long time; pain may be spontaneous. Patient may have had a recent restoration; crown is grey, deep caries cavity, united with pulp chamber. If the pulp chamber is close, a "bead" of pus may emerge when the pulp chamber is opened, relieving the pain. If the pulp chamber is open, its probing is painless, but probing of the root canals is painful. Halitosis might be present. Sometimes, pulp sensibility test results may be mixed and frequently inconclusive or inconsistent with the patient's description of symptoms [7]. Chronic apical periodontitis may be associated with this condition. The authors suggest that these symptoms both correspond pulpitis chronica gangraenosa, which reacts only to hot stimulus and develops over time, and pulpitis acuta purulenta from the Ukrainian classification, which presents with spontaneous pain, close pulp chamber, and pus upon opening.

Complete pulp necrosis. It may or may not be associated with apical periodontitis. Asymptomatic pulpitis [18]. History of provoked pain, trauma or filling. Deep caries cavity united with pulp chamber, or tooth has filling or grey crown. Test cavity (preparation) is negative. Negative cold test proves pulp necrosis if tooth has caries cavity (level of evidence 2)

[23]. However, a negative cold test is not necessarily indicative of pulp necrosis in cases of trauma [12].

Pulpless and Infected Root Canal System is considered by Abbott as a pulp condition which develops after pulp necrosis. No pulp sensitivity. Obligatory sign is periapical radiolucency (sign of chronic apical periodontitis). Symptoms of exacerbation of chronic apical periodontitis may occur in this pulp condition.

Previously Treated Pulpitis. Root canals are filled, with or without symptoms of apical chronic periodontitis [6]. The tooth's response to pulp testing modalities depends on the level of therapy received. There are symptoms or no symptoms of chronic apical periodontitis.

Previously Initiated Therapy. The tooth has been previously treated by endodontic therapy such as pulpotomy or pulpectomy [6]. Depending on the level of therapy, the tooth may or may not respond to pulp testing modalities. There are symptoms or no symptoms of apical chronic periodontitis. 94,7% of the permanent teeth react to electric pulp test 1 year after pulpotomy, and 13,5% - to cold test (level of evidence 3b) [24]. There are symptoms or no symptoms of chronic apical periodontitis.

Pulp canal calcification is considered by Abbott as a «condition» rather than as a «disease» [7] with radiographic observation of the appearance of the root canals, emphasizing that all pulpal diagnoses could be associated with such calcification. Therefore, pulp canal calcification does not align with pulpitis chronica concrementosa from the Ukrainian

classification. This pulp condition does not respond to pulp sensibility tests by the symptoms and other clinical findings, and may be associated with periapical conditions.

To sum up, reversible and irreversible pulpitis have the respondents in Ukrainian classification. Such conditions of pulp as complete pulp necrosis, pulpless and infected root canal system, previously treated pulpitis, and previously initiated therapy could be included in the Ukrainian classification. Pulp hyperplasia only partially corresponds pulpitis chronica hypertrophica and may be associated with any form of reversible and irreversible pulpitis. In international classifications, partial pulp necrosis includes pulpitis chronica gangraenosa and pulpitis acuta purulenta from the Ukrainian variant. Therefore, the development of new classification of the status of the pulp in children is promising and challenging task.

## CONCLUSIONS

Pulpal diagnosis in children relies on observation of clinical and periapical radiographic findings. While the Ukrainian classification covers various forms of pulpitis, it could be expanded to include pulp conditions. Such pulp conditions as pulp hyperplasia and partial pulp necrosis only partially correspond diagnoses of the Ukrainian classification. Therefore, the development of new classification of the status of the pulp in children is promising and challenging task.

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## CONFLICT OF INTEREST

The Authors declare no conflict of interest

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