

UC Irvine

UC Irvine Previously Published Works

Title

Clinical diagnosis of pulpally involved teeth

Permalink

<https://escholarship.org/uc/item/3p20k6wj>

Journal

Clinical Dentistry Reviewed, 4(1)

ISSN

2511-1965

Authors

O'Dell, Josanne
Wilder-Smith, Petra

Publication Date

2020-12-01

DOI

10.1007/s41894-020-00083-x

Peer reviewed



Clinical diagnosis of pulpally involved teeth

Josanne O'Dell¹ · Petra Wilder-Smith²

Received: 31 July 2020 / Accepted: 25 August 2020 / Published online: 14 September 2020
© Springer Nature Switzerland AG 2020

Abstract

Endodontics is the art of saving teeth by the prevention and treatment of diseases and injuries of the pulp and associated periradicular conditions. To ensure the highest probability of success, it is critical that an accurate diagnosis be made prior to treatment. A systematic process incorporating the information provided by the patient, as well as appropriate diagnostic tests performed by the clinician, combined with the knowledge and experience of the dental practitioner will result in a quick and accurate diagnosis. Only then can a treatment plan best suited to the individual be presented. This article will review the materials and instruments required to perform diagnostic tests for establishing a baseline to an accurate and complete diagnosis.

Keywords Endodontics · Diagnostic tests · Dental pain · Endodontic treatment plan

Quick reference/description

Establishing an accurate diagnosis is critical for the development of an efficient treatment plan. An accurate diagnosis can be achieved only after reviewing the patient's chief complaint, medical and dental history along with a thorough clinical examination including various diagnostic tests.

Symptoms

- Toothache
- Intraoral or extraoral swelling
- Sinus tract

✉ Josanne O'Dell
Jodell10@uthsc.edu

¹ Department of Endodontics, University of Tennessee Health Science Center, 875 Union Avenue, Memphis, TN 38163, USA

² Beckman Laser Institute, School of Medicine, University of CA, 1002 Health Sciences Road, Irvine, CA 92612, USA

- Tooth mobility

Clinical examination

To establish an accurate endodontic diagnosis, the clinician should obtain relevant information from the patient and combine it with the various diagnostic tests. Obtaining a detailed medical and dental history is the primary step in clinical examination. A thorough review of the patient's chief complaint is followed by a comprehensive patient evaluation and diagnostic tests that include:

- Patient examination
 - General physical examination
 - Extraoral and intraoral examination
- Determination of pulp status
- Periodontal examination (mobility and periodontal probing)
- Mechanical diagnostic tests
 - Palpation
 - Percussion
 - Transillumination
 - Bite test
 - Test cavity
 - Isolated anesthesia
- Sensitivity tests
 - Electric pulp testing
 - Thermal tests (cold and heat tests)

For an accurate diagnosis, all tests should be performed on the suspect tooth, and the adjacent and contralateral tooth to achieve a comparative result.

Materials/instruments

- Mouth mirror
- Perio-probe
- Cotton tip applicator
- Fiberoptic transillumination device (Microlux™ AdDent, Danbury, CT)
- Rubber dam
- Methylene blue dye
- Cotton roll
- Orangewood stick
- Tooth Slooth® (Professional Results, Laguna Niguel, CA)
- Small round bur
- Vitality Scanner™ (Kerr Dental, Orange, CA)

- Ice sticks
- Spray refrigerants (Hygenic® Endo-Ice® Coltene/Whaledent, USA)
- Liquid carbon dioxide
- Gutta percha
- Petroleum jelly
- Ball burnisher
- Plethysmograph
- Electronic thermograph unit

Procedure

An effective treatment plan can be devised only after making an accurate diagnosis. For an accurate diagnosis, reviewing the patient's chief complaint, and medical and dental history along with a thorough clinical examination including various diagnostic tests is essential. Treatment should not be initiated before a definitive diagnosis has been confirmed.

Medical history

A comprehensive knowledge of various medical conditions and medications is essential for a clinician due to increased life expectancy of the population. Physician consultation before treatment can be necessary in cases with serious or uncontrolled diseases or in vulnerable patients. Completion of a detailed health history form by the patient or care provider is required while obtaining a medical history. Answering every question is mandatory, and every identified condition requires additional evaluation as medical conditions like trigeminal neuralgia and diseases of cardiac origin can have oral manifestations, while non-odontogenic conditions like maxillary sinusitis can imitate dental pain.

Each patient should be briefed about the information to be included in the health history to avoid incompleteness of data. The clinician can use a generic health history form or develop one with emphasis on certain areas. Medical history and vital signs should be reviewed at every visit. If a medical consultation is warranted, the physician's name, consultation date, reason for consultation, and physician's response should be noted in the patient's records. A signed consent for treatment and release of data should be obtained from the patient.

Dental history

Dental history consists of general dental history and history of present illness. The general history involves any prior dental issues or treatment experienced by the patient. The history of present illness should mostly focus on the patient's chief complaint. It is the reason for seeking dental treatment and should be recorded in the patient's own words.

The patient is asked to describe the severity and nature of the issue. Relevant information can be obtained by asking the patient to fill a printed form containing simple close-ended questions and some open-ended questions for describing and quantifying the symptoms. It should also contain questions about recent trauma, dental treatments and factors that trigger or relieve the complaint. Information about recent analgesic intake by the patient should be noted as it can cause altered results of diagnostic tests.

Patient examination

Patient examination should begin as soon as the patient enters the clinic. It includes a general examination of intraoral and extraoral structures. The patient's chief complaint and general dental history give the dentist a fair idea of the tooth or region causing the pain. A complete patient examination is necessary to verify this information. The general physical examination includes assessment of patient posture and gait, vital signs, exposed skin surfaces, mental acuity and communicative ability. As the patient usually presents with pain, swelling, erythema, etc., it can lead to inaccuracy in recording the data, thus, requiring the dentist to be alert.

After the patient is comfortably seated, the extraoral and intraoral structures should be examined for any abnormalities (Fig. 1). If a lesion is detected, its size, location, shape and color should be noted and observed until its resolution. An oral cancer screening should also be done.

Intraoral examination involves a general evaluation of the teeth, and oral hard and soft tissues. The dentition should be observed for discoloration, caries, enamel fractures, restored or missing teeth and generalized periodontal condition. In case of a soft tissue lesion with a sinus tract, the origin of the lesion should be traced using gutta percha and a radiograph (Fig. 2). Following a general evaluation of the dentition, the pulpal status of the affected teeth should be evaluated or confirmed.

Determination of pulp status

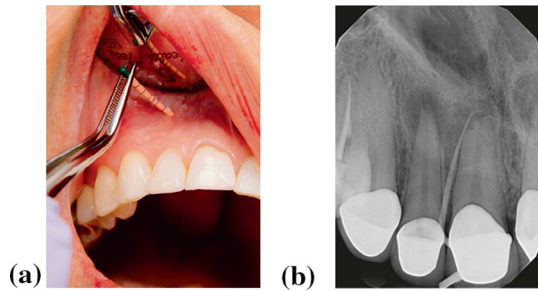
Evaluation of pulp status is crucial for accurate diagnosis. Pulp status assessment before any restoration is critical, as tooth vitality can be absent before the development of signs or symptoms. The uses of pulp vitality tests are:

- As an aid in the diagnosis of pain
- Adjunct to radiographic investigation

Fig. 1 Extraoral portion of examination



Fig. 2 Tracing a sinus tract. **a** Gutta percha. **b** Radiographic verification



- Post-traumatic evaluation
- Determination of pulp vitality following prior pulp therapy
- Assessment of heavily restored teeth
- To ascertain profound pulpal anesthesia in a tooth

A reference standard for pulp vitality tests allows the measurement of specificity, sensitivity and accuracy. Histopathology is considered as the gold standard for determination of pulp status. However, it cannot be used in a dental office. Most of the current methods for determining pulp status depend on the sensory response of the pulp. While performing any diagnostic test, at least one tooth on either side of the offending tooth and also the contralateral tooth should be tested to obtain a baseline or control reading.

Periodontal examination

A periodontal examination includes the general evaluation of the periodontal attachment apparatus. Evaluation of tooth mobility is an effective method to determine the status of the periodontal tissues. The reasons for tooth mobility are:

- Trauma
- Periodontal disease
- Root fractures
- Extension of pulpal disease into the periodontal ligament

A mobility test utilizes the flat ends of two instruments (mirror handle or perio-probe). One flat end is placed on the buccal surface, and the other is placed on the lingual surface (Fig. 3). The pressure application is in a buccal–lingual direction. The extent of mobility is scored on a scale of 1–3 according to O’Leary.

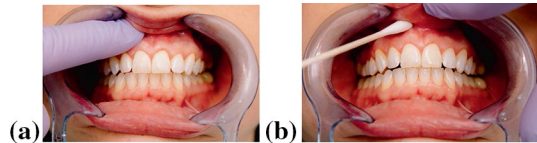
Fig. 3 Mobility test





Fig. 4 Periodontal probing. **a** Buccal, **b** lingual, **c** vertical root fracture

Fig. 5 Palpation, **a** digital, **b** cotton tip applicator



Periodontal probing should be measured and noted (Fig. 4a, b). A detailed knowledge of root morphology is critical while probing the interproximal and furcation areas. Probing that spreads across a tooth suggests a defect of periodontal origin, while a deep and isolated probing site indicates a defect of endodontic origin. In case of a suspected vertical root fracture, anesthetizing the area is necessary to enter the defect that often extends to the root apex (Fig. 4c).

Mechanical tests

Primary mechanical tests can provide valuable information for pulp diagnosis.

Palpation

Palpation is the first test carried out by a dentist to identify areas of bony expansion or soft tissue swelling. It involves the application of gentle digital apical pressure that can be repeated with increasing pressure until a response of discomfort is elicited from a patient (Fig. 5). A positive palpatory response indicates active inflammation in the periapical tissues. A cotton tip applicator can also be used for palpation. The benefits of palpation are:

- Ease of use
- No equipment required
- Requires 1–2 min to complete
- Good tolerability in apprehensive patients

Percussion

Percussion is one of the oldest and easiest to perform diagnostic methods. It is an effective indirect measure of pulp involvement and gives information about inflammation of the periodontal ligament. Anxiety can be minimized or eliminated in patients by simply explaining to them about what to expect during percussion.

Fig. 6 Percussion, **a** instrument, **b** digital pressure

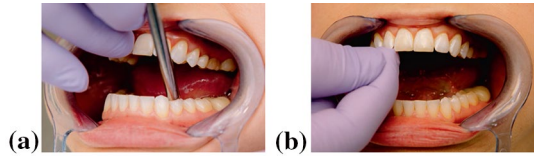
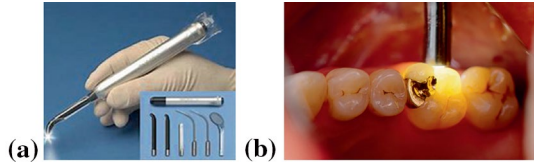


Fig. 7 Fiber-optic transillumination, **a** instrumentation, **b** clinical use



Before testing the concerned tooth, some control teeth should be gently tapped on the incisal or occlusal surface using a mirror handle or another instrument (Fig. 6a). When a single suspect tooth cannot be isolated depending on an abnormal response, waiting for 3–4 min and retesting with increased pressure is recommended. Repetition of the test can be required by tapping from the facial and lingual aspects.

A positive response to percussion is prevalent in three clinical scenarios. The first scenario involves a recently restored tooth that is high in occlusion. It can become sensitive to percussion after the dental visit. In case of significant trauma to the nerve, the patient experiences immediate relief after grinding the restoration, but may return in a few days with similar complaints. The second scenario is development of a periapical lesion in a necrotic tooth. The patient reports that the suspect tooth feels high and ‘mushy’ and can be compressed back into the socket. A necrotic tooth is usually unresponsive to other diagnostic tests. The third scenario is a tooth with coronal fracture that can exhibit a positive response to percussion and also respond to thermal tests.

Use of vertical digital compression of the tooth till the patient can differentiate between the teeth being tested was proposed by Kulilid as an alternative to percussion with an instrument (Fig. 6b). A calibrated percussion instrument was developed by Weisman for reproduction of consistent pressure for percussion and for reduction of false-negative responses in some necrotic teeth.

Transillumination

Transillumination is based on the passage of light through the tissues (Fig. 7). In the presence of inconsistent or vague symptoms, transillumination of teeth is an important adjunct to routine diagnostic tests. It can aid in determining tooth vitality in conjunction with thermal tests. It can also detect caries or calculus. Transillumination is considered an invaluable tool for the detection of coronal fractures. It can also be beneficial following trauma, as the affected tooth can show a subtle color change. While a healthy tooth appears white with a yellow or pink hue on transillumination, a traumatized tooth with damaged pulp can appear gray, brown or dark yellow.

Microlux™ (AdDent, Danbury, CT) is the most commonly used fiber-optic light source for transillumination that provides cold, high-intensity light for easy and flexible use. However, any small direct light source can also be used. Use of rubber dam with the operatory light switched off during transillumination produces a favorable result. The light source is placed on the buccal or lingual surface of the suspect tooth. While testing posterior teeth, findings should be verified by placing the light on the buccal and lingual surfaces. In case of a cusp or marginal ridge fracture, the aspect of the tooth with the light source is illuminated, while the structure beyond the fracture appears darker. This allows detection of fractures with accuracy and ease but requires more diagnostic tests for determining the pulp status.

Use of methylene blue with transillumination Detecting a crack can be difficult in heavily restored teeth. In such cases, methylene blue dye can be applied to the tooth. After a few minutes, the tooth is rinsed and dried with a gentle air stream. Transillumination is then performed on the tooth, making the crack more visible due to dye penetration. During rinsing and drying the tooth, care should be taken to cause minimum discomfort to the patient based on their complaint.

Bite test

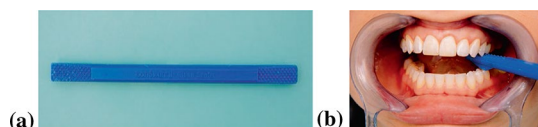
Complaints of pain with chewing or biting are prevalent. The pain is often sporadic and difficult to localize. Performing a bite test along with transillumination can frequently confirm a tooth fracture. A bite test can be performed using various easily available tools such as Tooth Slooth® (Professional Results, Laguna Niguel, CA), cotton roll, cotton tip applicator and orangewood sticks.

A Tooth Slooth® is like a double-ended toothbrush with a divot at one end and a raised portion at the other. It allows independent testing of each cusp with direct pressure application in an occlusal–apical direction. The patients are advised to bite firmly and release quickly while simultaneously observing whether the pain is evoked during biting or releasing (Fig. 8). This test can effectively determine if the tooth is fractured. Response to other diagnostic tests should also be considered during treatment planning.

Test cavity

Occasionally, identification of the source of the patient's pain can be difficult even after detailed examination and completion of multiple diagnostic tests. In such cases, a test cavity can be made on the suspect tooth. It is commonly required in teeth with extensive calcification and restorations with full coverage and subgingival margins. The procedure, its irreversible nature and the reason for no use of anesthesia should be clearly explained to the patient.

Fig. 8 Bite test, **a** instrument, **b** clinical use



A small round bur is used at high speed with air and water to make a small class-I cavity. The procedure is discontinued if the patient experiences pain, and the cavity is restored. The pain sensation indicates that the tooth still has some viable nerve tissue. On the contrary, Ehrmann recommends the use of slow speed to keep the cavity shallow and extend it only into the dentine.

Isolated anesthesia

Rarely, the use of isolated anesthesia can be required for an accurate diagnosis. It is particularly useful to detect the site of the offending tooth and whether the pain is odontogenic or non-odontogenic in origin. It is only helpful if the patient has pain at the time of evaluation. When a patient complains of mandibular pain, and the diagnostic tests indicate that all teeth in that region are vital, an isolated anesthesia test is required. Persistence of pain even after administration of anesthesia suggests pain of cardiac origin warranting a physician consultation.

Pulp sensibility tests

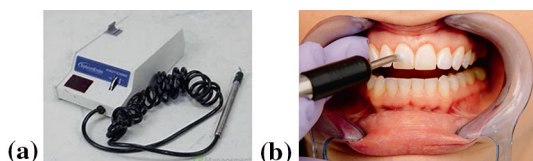
Electric pulp testing

Determination of tooth vitality using electricity dates back to the late 1800s. Electric pulp testing (EPT) functions via direct stimulation of the sensory nerves in the pulp that often results in a tingling or painful response from the patient. No patient response suggests a necrotic pulp. The Vitality Scanner™ (Kerr Dental, Orange, CA) is a battery-powered EPT system with an automatically increasing power output to avoid a full charge on primary application (Fig. 9a). The methods for obtaining accurate results with EPT depend on several factors such as:

- Isolation
- Speed of current application
- Probe placement
- Presence of restorations

Initially, EPT should be performed on adjacent teeth to obtain baseline readings. Isolation of the teeth being tested using rubber dam or cotton rolls is essential. The teeth are dried following isolation, and the probe is placed on the incisal or buccal surface of the suspect tooth with a conducting medium. Toothpaste is a prevalent conducting medium. Due to the use of gloves by dentists, the patient is advised to

Fig. 9 Electric pulp testing, **a** device, **b** clinical use



hold the other end of the probe for circuit completion. Current application is gradually increased till the patient feels a ‘tingling’ sensation. If a maximum current reading is reached without any patient response, the tooth being tested is considered to be necrotic.

EPT should be considered as an ‘all or none’ test by clinicians. Establishing proper contact of the probe with a tooth and not a restoration, metallic or otherwise, is mandatory (Fig. 9b). If the probe makes contact with an amalgam restoration, it can result in false values. In patients with high-risk cardiac conditions and implanted cardiac pacemakers, consultation with the patient’s physician is advised before EPT. Teeth with immature apices have a high current threshold; hence, EPT is unreliable for ascertaining tooth vitality till 4–5 years after the teeth are in function. A recent review by Lima emphasizes that results may be inconsistent due to the transient paresthesia that may occur following dental trauma. While results may provide a baseline, it will be important to repeat this and other diagnostic tests at follow-up appointments that can range from a few weeks to several months or years.

Thermal tests

One of the oldest and most prevalent diagnostic tests is the thermal test. Only a symptomatic association exists between thermal testing and the pathological condition. It includes the application of a cool agent to reduce tooth temperature or heat to elevate tooth temperature to evoke a patient response. A thermal test that produces rapid changes is preferred over a test that produces gradual changes. Cold tests generate more reliable results than heat tests. During thermal testing, the patient is advised to raise a hand immediately if they feel any sensation, and keep it raised while the sensation persists. The stimulus is removed, and the duration of sensation is noted.

Cold test A cold test to stimulate pulp can be performed using ice sticks, carbon dioxide (CO₂) and spray refrigerants. The factors that affect thermal response to cold tests are:

- Thickness and type of tooth structure
- History of trauma
- Root development
- Heavily restored teeth

Ice sticks are made by freezing water in anesthetic cartridges (Fig. 10a). The tooth should be isolated, and the ice should be applied near the cervical region to avoid rapid melting of the ice (Fig. 10b). The response time should be noted for comparison between the teeth being tested. In suspect teeth, the dentist usually seeks an extreme or a delayed, lingering reaction. Refrigerants like 1,1,1,2-tetrafluoroethane (Endo-Ice or HFC 134a) (Hygenic[®] Endo-Ice[®] Coltene/Whaledent, USA) can be used for a cold test. They are available in spray canisters and have a temperature of –26 °C (Fig. 10c). The refrigerant is sprayed on a cotton ball until saturation, which is then placed on the teeth to be tested (Fig. 10d). Endo-Ice is the most

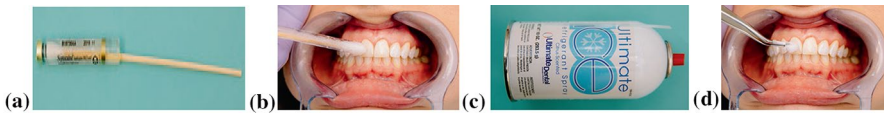


Fig. 10 Cold tests, **a** ice, **b** clinical use of ice, **c** refrigerant, **d** clinical use of refrigerant

effective agent for cold testing of teeth with all-ceramic, gold and PFM restorations if it is applied for less than 15 s.

Carbon dioxide (CO_2) is a good agent for measuring pulp vitality. The temperature range of CO_2 is -56 to -98 °C. A CO_2 cold test can provide the most reliable results. The CO_2 system contains a tube with a plunger and a liquid CO_2 cylinder that are attached to a tank (Fig. 11a). Liquid CO_2 is converted to an ice pencil, which is then applied to the teeth (Fig. 11b). A single cartridge permits testing of several teeth with well-controlled coolant placement. Cold test with CO_2 or Endo-Ice is more reliable than EPT in young patients. The only issue with a CO_2 cold test is the initial cost of obtaining a tank and refilling periodically.

Heat test Heat application to a tooth produces a slower reaction than cold application. These tests are rarely performed due to the issues with isolation, obtainment of a consistent heat source and poor diagnostic accuracy. The available heat sources are heated gutta percha or hand instruments, heated water baths, frictional heat application and electrical heat sources. Before heated gutta percha application, the teeth should be prepared by drying and light lubrication with petroleum jelly (Fig. 12). Heat application in this manner should not be for more than 5 s. Hand instruments, like a ball burnisher, can be heated over a flame and then applied to the tooth. A hot water bath can also be used. Heated instruments and hot water baths evoke a rapid patient response, but permit very little control over the high temperature.

Therefore, an electric heat source is the best choice for consistent heat delivery. The heat source is set up according to the manufacturer's instructions. The tooth to be tested is dried and lightly lubricated. Heat is applied to the tooth using a proper delivery tip. 150 °F is a safe temperature that does not damage hard or soft tissues.

Fig. 11 Cold test, **a** CO_2 , **b** clinical use of CO_2

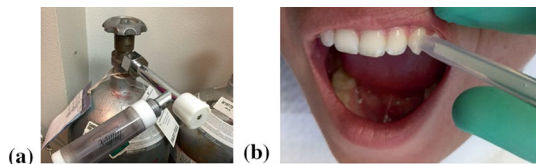


Fig. 12 Gutta percha application



No temperature adjustment is done. During heat application to the teeth, damage to normal tissues should be avoided. Heated gutta percha and electric heat application are safe heat sources in terms of prevention of tissue damage.

Other thermal tests

Surface temperature

Non-vital teeth are said to have a lower surface temperature than vital teeth. It can be measured by placing two thermistors, one on the suspect tooth and one on a control tooth and recording the difference. Presence of a restoration causes difficulty in recording surface temperature. Use of surface temperature for clinical diagnosis is not meaningful.

Plethysmography A plethysmograph is a tool that measures volume changes within an organ occurring due to fluctuation of the blood volume that it contains. The method consists of light passage through a tooth and measurement of the amount of light that is transmitted through the tooth at certain light wavelengths using a galvanometer and a photocell. It is based on selective absorption of specific light wavelengths by hemoglobin. Hence, increased selective light absorption by hemoglobin is noted in warm areas or in inflammation-related vasodilation. This technique can be a great objective and non-invasive diagnostic technique for determining pulp vitality in the future.

Electronic thermography

Thermography is based on the presumption that body temperature is maintained in homeostasis, thereby, permitting the detection of vascular changes before structural changes. Computerized electronic thermography is a rapid, non-invasive approach of gaining information based on heat emission from facial structures. It comprises an infrared scanner, thermal image computer, software, control unit, stands, cables, supports, color monitors, camera, printer and liquid nitrogen cooling. It should only be considered an investigational procedure.

Testing overview

When conducting diagnostic testing, it is imperative that the clinician accurately record all results. While an initial or differential diagnosis may be possibly based solely on the patient's chief complaint and a radiograph, it is to the practitioner's obligation to confirm initial impressions with a minimum of two additional tests. It is only then a diagnosis can be made with confidence. Below is a suggested summary of diagnostic tests that when used in combination can provide an accurate pulpal and periapical diagnosis. This table is not inclusive and additional testes should be conducted when results are vague, not reproducible or conflicting. Treatment

should never be initiated until a diagnosis is made and the patient informed with proposed treatment as well as reasonable alternatives.

When recording results for diagnostic examinations, it is helpful to work through the tests in an orderly fashion and record results with a standard, easily understood legend. For example, percussion, palpation, thermal tests and bite may be documented with a single plus (+) to a ++++ or arrows (^) signifying a minor to severe response. The results of the EPT should be the number when the patient can sense the stimulus. Using the nomenclature of WNL (within normal limits) is not as useful, as it implies a subjective response by both the patient and the clinician.

Test	Use	Advantages	Comment
Palpation	Periapical disease	Little to no equipment	Detects soft tissue swelling or bony expansion when compared to control teeth
Percussion	Periapical disease	Easy to perform, provides good information regarding inflammation of the PDL	Result may represent restoration that is high in occlusion, or a coronal fracture
Electronic pulp testing (EPT)	Pulpal sensibility	Inexpensive, easy to perform and interpret results. Good for teeth with increased secondary dentin	Lack of response is suggestive of a necrotic pulp. Concern if patient has a cardiac pacemaker. May not be reliable immediately post-trauma
Cold	Pulpal sensibility	More reliable in young teeth than EPT. CO ₂ seems to provide most reliable result	Difficult to obtain dependable results. Exaggerated response generally correlates to a diagnosis of irreversible pulpitis
Bite	Pulpal sensibility	Response usually denotes pulpal vitality	Results can elicit anatomical specific response
Transillumination	Fracture detection	Fracture line refracts light	Extent of fracture may not be determined. Not useful if full coverage restoration

Differential diagnosis

- Maxillary sinusitis
- Trigeminal neuralgia
- Diseases of cardiac origin
- Temporomandibular disorder
- Periodontal disease
- Root fracture

Pitfalls and complications

- Palpation is not conclusive for pain of endodontic origin.
- Reproduction of consistent pressure is difficult in percussion.
- Transillumination cannot determine the extent of fracture.
- Test cavity is an irreversible procedure and can increase patient anxiety.
- Use of EPT is difficult in crowded dentition or in patients undergoing orthodontic treatment.
- Patient response to thermal tests is subjective. Extreme cold temperature can cause enamel fracture.
- Heat test has poor diagnostic accuracy with difficulty in maintaining consistent temperature.

Acknowledgments

This work was supported by: LAMMP NIH/NIBIB P41EB05890; NIH/NIBIB UH2EB022623; NIH/NCI P30CA062203; the Arnold and Mabel Beckman Foundation.

Further Reading

1. P. Wilder-Smith, J. Ajdaharian (eds.), Oral Diagnosis, https://doi.org/10.1007/978-3-030-19250-1_2 Endodontics and Pulpal Diagnosis.
2. Berman LH, Rotstein I. Diagnosis. In: Hargreaves KM, Berman LH, editors. Cohen's pathways of the pulp. 11th ed. Maryland Heights: Mosby; 2016.
3. Alghaithy RA, Qualtrough AJE. Pulp sensibility and vitality tests for diagnosing pulpal health in permanent teeth: a critical review. *Int Endod J.* 2017;50:135–72.
4. Glossary of endodontic terms. 9th ed. www.aae.org
5. Bierma MM, McClanahan S, Baisden MK, Bowles WR. Comparison of heat-testing methodology. *J Endod.* 2012;38(8):1106–9.
6. Lima TFR, dos Santos SL, Fidalgo TK, Silva EJNL. Vitality tests for pulp diagnosis of traumatized teeth: A systematic review. *J Endod.* 2019;45(5):490–499.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.