Original Article

# Diagnostic Accuracy of Cold and Electric Pulp Test in Determining Pulpal Status in Saudi Sub-Population



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## ABSTRACT

**Objective:** This study evaluated the accuracy of cold and electric pulp tests in defining pulpal status in the Saudi sub-population.

**Study Design:** Cross-sectional analytical study

**Place and Duration of Study:** This study was conducted at the College of Dentistry, Qassim University, Saudi Arabia, from September 2023- February 2024.

**Methods:** This cross-sectional study included 118 participants aged 18–60 years with no prior clinical diagnosis of pulpal disease. Pulpal status was determined by the presence (vital) or absence (necrotic) of bleeding from the pulp chamber following access opening. Both cold and electric pulp tests were conducted with at least a 5-minute interval between them. The sensitivity, specificity, and accuracy of each test were evaluated, and reproducibility was measured using the intraclass correlation coefficient.

**Results:** The study found that, based on the cold test, 62 (52.5%) teeth were non-vital and 56 (47.5%) were vital. In comparison, the EPT identified 77 (65.3%) teeth as vital and 41 (34.7%) as non-vital. The cold test demonstrated greater diagnostic accuracy (0.808) than the EPT (0.639) in determining pulpal status.

**Conclusion:** The findings indicate that the cold test exhibited higher overall accuracy (80.8%) and specificity (85.5%) than the electric pulp test (63.9% accuracy and 49.1% specificity) in a Saudi sub-population. Although EPT showed slightly higher sensitivity (77.8% vs. 76.2%), the cold test provided superior predictive values, making it a more dependable method for assessing tooth vitality.


**Key Words:** Accuracy, electric pulp test, cold test, pulp vitality

**Citation of article: Aljasir O, Agwan MAS, Mohsin SF. Diagnostic Accuracy of Cold and Electric Pulp Test in Determining Pulpal Status in Saudi Sub-Population. Med Forum 2025;36(12):5-9. doi:10.60110/medforum.361201.**

## INTRODUCTION

In endodontics, pulp testing serves as a vital diagnostic aid that guides appropriate treatment planning.[1] Though histological analysis is the most reliable method for evaluating pulp vitality, it is impractical before treatment because the pulp is encased within hard tissues.[2]

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Received: March, 2025
Reviewed: April-May, 2025
Accepted: June, 2025

Therefore, assessing pulpal status remains challenging, however it is considered acceptable while both sensibility and pulp vitality are maintained. Sensibility is the ability to react to an external stimulus. Sensibility pulp tests offer qualitative sensory information to deduce the pulp's "vitality" and general condition.[1] Thermal and electric pulp sensibility tests are applied to indirectly evaluate pulpal condition by assessing the nerves inside the dental pulp.[2, 3] Interpreting sensibility test outcomes needs attention, as they are subjective and depend on both the patient and the operator.[4]

Thermal pulp testing includes coating chemical agents to the tooth surface to either elevate (heat pulp testing HPT) or lower (cold pulp testing CPT) the temperature, thereby provoking sensory reactions from the pulp through thermal transmission.[1] A lot of pulp tests are commonly applied in combination to develop more accurate results.[5]

The cold pulp test is frequently used vitality test by dental professionals, providing perceptions into the pulp's position ("non-vital/vital") or inflammatory status (irreversible/reversible).[6] Examples of CPT agents comprise ethyl chloride, ice, CO2 snow, and refrigerant sprays (such as dichlorodifluoromethane, tetrafluoroethane, or a propane/butane/isobutane gas mixture saved in pressurized cans). Refrigerant sprays

have the advantage of not requiring specific storage conditions and enabling accurate application with a cotton pellet.[7] Currently, frequently used CPT agents in clinical situations are refrigerant sprays due to their ease of storage, comparative affordability, and convenience of application.[1]

Electric pulp testing (EPT) includes applying an electrical stimulus to the tooth to initiate the pulpal nerve filaments connected with pain and produce a reaction from the patient. Though extensively used, the electric pulp test (EPT) is highly technique-sensitive. Reliable results depend on several factors, such as delivering an adequate stimulus, positioning the electrode correctly, properly isolating the tooth, applying a suitable conducting medium, maintaining a consistent testing procedure, and carefully interpreting the findings.[8]

Vitality pulp tests assess numerous parameters that reflect the vascularity of the tooth pulp that accurately determines the vitality of pulp. Techniques for instance, laser Doppler flowmetry (LDF), pulse oximetry (PO), laser speckle imaging (LSI), transmitted laser light (TLL), dual wavelength spectrophotometry (DWS), and transmitted light plethysmography (TLP) employ optical technology.[9] These techniques are entirely noninvasive, painless, and objective; the patient is not required to provide a subjective response.[9]

Sensitivity defines to the percentage of correct cases recognized by a diagnostic test, while specificity indicates the percentage of non-cases correctly recognized. Positive predictive value measures percentage of positive test results, which are true cases, while negative predictive value measures percentage of negative test results, which are true non-cases.[10]

By estimating the specificity and sensitivity of electric pulp and cold tests, the study purposes to enhance clinical decision-making, lessen needless procedures, and enhance patient outcomes in dental clinics. Therefore, this study assessed the accuracy of cold and electric pulp tests in assessing pulp condition in a clinical setting in the Saudi sub-population.

# METHODS

This cross-sectional study's approval was obtained by the Institutional Review Board of Qassim University (Reference # 21-14-14). The duration of the study was about six months from Sept 2023- Feb 2024. Every patient gave their signed, informed consent, before participation. The study included 118 subjects aged between 18 and 60 years, who had no prior clinical diagnosis of pulp status. Only teeth without prior endodontic treatment, with intact crowns, and in patients with healthy periodontium were included. Exclusion criteria encompassed full coverage crowns, extensive restorations, current trauma, reverted pulp chambers, or calcification within root canal system, as well as patients undergoing orthodontic treatment or with systemic diseases.

**Pulp Testing Methods:** An independent researcher, not informed about the clinical indicators, symptoms, past dental records, and radiographs, performed endodontic diagnostic tests. Participants signaled sensation by raising their hand. Each test was conducted with at least a 5-minute interval, by rubber dam isolation and polyester strips to isolate the tooth.

**Cold pulp testing:** A thin film of Vaseline was coated to the labial or buccal tooth surface as a separating medium. A No. 2 cotton pellet sprayed with refrigerant (Endo-Ice, Coltène/Whaledent, Cuyahoga Falls, OH, USA), was then positioned on the mid-buccal surface for up to 15 seconds or till the participant signaled feeling cold sensation.

**Electric pulp testing:** Teeth were isolated, dried, and covered with toothpaste before applying the EPT (Parkell Digitest II™). An increasing electrical stimulus was delivered to the mid-buccal surface until the patient responded, with a response reflecting vitality and no response reflecting non-vitality. A two-minute interval was kept between tests to allow pulpal recovery.

**Ideal standard:** The study determined pulp status using the existence (indicating vitality of pulp) or nonexistence (indicating necrotic pulp) of blood flow after access opening as the reference standard as reported by Janani K et al.[11]

**Statistical analysis:** The SPSS Version 23.0 was used to analyze the data. Demographic details such as age, gender, and tooth location were documented as frequencies and percentages. Sensitivity, specificity and accuracy were measured. True positive (TP), false positive (FP), true negative (TN), and false negative (FN) responses were identified to calculate sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and incidence for each test. Reproducibility was assessed using the Intraclass correlation coefficient.

# RESULTS

A total of 118 patients with presenting complaints of toothache and to assess the pulp health, were involved. Most of the patients fall within the 31-40 age group 42(35.6%), followed by the 20-30 age group 40(33.9%). There were 58(49.2%) males, and 60(50.8%) females. The mandibular left quadrant is the most common location for toothache 40(33.9%), while the mandibular right quadrant is the least common 21(17.8%). Pain on biting is the most common presenting complaint 41(34.7%), followed by spontaneous pain 28(23.7%) and sensitivity 21(17.8%), as depicted in Table 1.

Fig. I presents the distribution of vitality and non-vitality of teeth based on different diagnostic tests: Cold test results showed a slight majority of the teeth classified as non-vital 62(52.5%), while 56(47.5%)

identified as vital. In contrast, the EPT results indicate that most teeth were vital 77(65.3%), with a smaller proportion indicated as non-vital 41(34.7%). For the bleeding after access opening, 63(53.4%) of the teeth exhibited bleeding, suggesting vitality, whereas 55(46.6%) did not show bleeding, indicating non-vital status.

**Table No. 1: Demographic details of the patients (n=118).**

| Variables | | n(%) |
|---|---|---|
| **Age group** | 20 -30 | 40(33.9%) |
| | 31- 40 | 42(35.6%) |
| | 41- 50 | 22(18.6%) |
| | 51-60 | 14(11.8%) |
| **Gender** | Male | 58(49.2%) |
| | Female | 60(50.8%) |
| **Tooth location** | Maxillary right quadrant | 22(18.6%) |
| | Maxillary left quadrant | 35(29.6%) |
| | Mandibular right quadrant | 21(17.8%) |
| | Mandibular left quadrant | 40(33.9%) |
| **Presenting complaint** | spontaneous pain | 28 (23.7%) |
| | pain of biting | 41(34.7%) |
| | sinus | 6 (5.1%) |
| | sensitivity | 21(17.8%) |
| | food packing | 9 (7.6%) |
| | More than one signs and symptoms | 13(11.0%) |

Table 2 shows the specificity and sensitivity of the cold test and EPT in assessing tooth vitality, with bleeding on chamber opening used as the reference standard. The cold test classified 56 teeth as vital, of which 48(76.2%) bled upon chamber opening and 8(14.5%) did not. It also identified 55 teeth as non-vital, with 47(85.5%) showing no bleeding and 15(23.8%) bleeding. This relates to a sensitivity of 76.2% and specificity of 85.5%. EPT classified 77 teeth as vital, of which 49(77.8%) bled and 28(50.9%) did not, while 41 teeth were non-vital, with 14(22.2%) showing bleeding and 27(49.1%) not bleeding. This reflects a sensitivity of 77.8% but a lower specificity of 49.1%.

**Table No. 2: The specificity and sensitivity of cold test and EPT.**

| Variables | | Bleeding after access cavity | | Total |
|---|---|---|---|---|
| | | Yes | No | |
| **cold test** | **Vital** | 48<br>76.2% | 8<br>14.5% | 56<br>47.5% |
| | **Non-Vital** | 15<br>23.8% | 47<br>85.5% | 62<br>52.5% |
| **Total** | | 63<br>100.0% | 55<br>100.0% | 118<br>100.0% |
| **Electric pulp testing** | **Vital** | 49<br>77.8% | 28<br>50.9% | 77<br>65.3% |
| | **Non-Vital** | 14<br>22.2% | 27<br>49.1% | 41<br>34.7% |
| **Total** | | 63<br>100.0% | 55<br>100.0% | 118<br>100.0% |

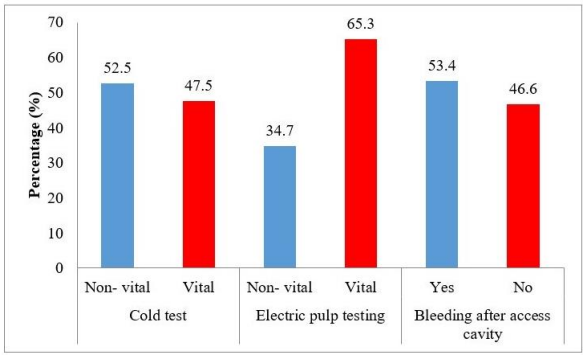


**Figure No. 1: The graphical demonstration of the distribution of vital and non-vital teeth using pulp testing methods.**

Table 3 shows that the cold test demonstrated higher overall diagnostic accuracy (0.808) than the EPT (0.639) for assessing pulpal status. Both tests showed comparable sensitivity (cold: 0.762, EPT: 0.778), indicating similar ability to identify vital teeth. However, the cold test showed much greater specificity (0.855 vs. 0.491), making it more dependable in detecting non-vital teeth.

**Table No. 3: The diagnostic accuracy of cold test and EPT.**

| Variables | Accuracy | Sensitivity | Specificity | PPV | NPV | Reproducibility |
|---|---|---|---|---|---|---|
| **Gold standard vs Cold test** | 0.808 | 0.762 | 0.855 | 0.857 | 0.758 | 0.760 |
| **Gold standard vs Electric pulp testing** | 0.639 | 0.778 | 0.491 | 0.636 | 0.659 | 0.431 |

# DISCUSSION

This study assessed the diagnostic accuracy of pulp testing methods in evaluating the pulp health of permanent teeth in the Saudi sub-population.

Test accuracy is typically assessed by relating the findings of an index test with a reference standard, often referred to as a "gold" standard, which confirms presence or absence of the target condition.[12-14] The present study proved that direct vision in access cavity preparation served as the gold standard for

differentiating between non-vital and vital teeth. Similarly, Ghouth et al.'s study employed a reference standard that involved either pulpal debridement or finalized root canal therapy.[15]

One of the cross-sectional studies determined the diagnostic accuracy of the cold test and EPT in single-rooted teeth with irreversible pulpitis. Clinically, 81 teeth (45%) were non-vital, while the remaining 99 teeth (55%) were found to be vital. EPT demonstrated high sensitivity (94.95%), specificity (92.59%), and diagnostic accuracy (93.89%), suggesting it is more reliable than the cold test.[16] However, the present study denies these findings, showing that the cold test reported higher sensitivity (76.2%) and specificity (85.5%) as compared to EPT (sensitivity: 77.8%, specificity: 49.1%). Moreover, the cold test also presented higher overall accuracy (80.8%) than the EPT (63.9%). The PPV and NPV were higher for the cold test (PPV: 85.7%, NPV: 75.8%) than for EPT (PPV: 63.6%, NPV: 65.9%).

In the present study, the cold test presented greater overall diagnostic accuracy (0.808) in comparison with the electric pulp test (0.639) for assessing pulpal status. Both tests indicated high sensitivity (cold: 0.762, EPT: 0.778), presenting effectiveness in detecting vital pulp. However, the cold test showed noticeably higher specificity (0.855 vs. 0.491), making it more reliable in detecting non-vital teeth. These results prove that the cold test was more precise and consistent diagnostic way in clinical scenario compared to the electric pulp test. Comparable results were stated in a previous study, where the cold test exhibited higher sensitivity (87%) and accuracy (87%) as compared to the bridging EPT (66% and 67%, respectively).[17]

A research by Peterson et al. who stated the electric pulp test (EPT) had an accuracy as high as 81%, whereas further studies presented accuracies of 75%[18] and 76%[19] for EPT. For the cold test, other studies have shown accuracies of 90%[18] and 86%.[17] As far as the present study is concerned, the cold test revealed an accuracy of 0.808 for assessing pulp status, while the electric pulp test indicated a lower accuracy of 0.639.

In the present study, the cold test demonstrated greater diagnostic accuracy (0.808) than the EPT (0.639) for assessing pulpal status. Both showed comparable sensitivity (cold: 0.762, EPT: 0.778), but the cold test had much higher specificity (0.855 vs. 0.491), making it more reliable in detecting non-vital teeth. The cold test also had superior predictive values (PPV: 0.857, NPV: 0.758) compared to the EPT (PPV: 0.636, NPV: 0.659). These findings showed partial similarity to a research by Weisleder et al., which stated PPVs of 0.93 for the cold test and 0.83 for the EPT, and NPVs of 0.74 for the cold test and 0.87 for the EPT.[20] Similarly, a research of Villa-Chávez et al. reported a NPV of 0.89 for the heat test, 0.90 for the cold test, and 0.83 for the EPT, with a PPV of 1.0 for all three tests with an incidence of 45%.[19] Likewise, another study reported that the accuracy of the cold, heat, and EPT was 78%, 74%, and 62%, respectively. The sensitivity tests identified irreversible pulpitis with greater probabilities: the NPV was 63% for cold, 67% for heat, and 54% for EPT, while the PPV was 83% for cold, 91% for heat, and 95% for EPT.[21]

This study had a few limitations. Both cold and electric pulp tests involve a degree of subjectivity, as the patient's response to stimuli can vary based on individual pain thresholds and psychological factors. Particularly in teeth with numerous roots or calcified canals, cold and electric pulp tests may not always accurately reflect the pulpal state. Larger and more varied samples should be considered in future studies to enhance the generalization of results across different populations.

# CONCLUSION

This study concluded that the cold test showed overall greater accuracy (80.8%) and specificity (85.5%) as compared to electric pulp testing (63.9% accuracy and 49.1% specificity) in Saudi sub-population. Whereas EPT has a little bit higher sensitivity (77.8% vs. 76.2%), the cold test delivers superior predictive values, making it a more dependable diagnostic aid for assessing tooth vitality.

**Author's Contribution:**

| | |
|---|---|
| Concept & Design or acquisition of analysis or interpretation of data: | Muhammad Atif Saleem Agwan, Syed Fareed Mohsin |
| Drafting or Revising Critically: | Muhammad Atif Saleem Agwan, Syed Fareed Mohsin, Omar Aljasir |
| Final Approval of version: | All the above authors |
| Agreement to accountable for all aspects of work: | All the above authors |

**Conflict of Interest:** The study has no conflict of interest to declare by any author.

**Source of Funding:** None

**Ethical Approval:** No. 21-14-14 dated 27.03.2022

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