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ORIGINAL ARTICLE

ARE PULP SENSIBILITY TESTS STILL SENSIBLE?

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Background: Electric and thermal tests are the most commonly employed methods for the diagnosis of pulp health status. The objectives of our study are to assess the validity, yield and accuracy of cold and electric pulp tests in determining the vitality of teeth requiring endodontic treatment. **Methods:** A cross sectional study was carried out at the Dental Clinic of Aga Khan University Hospital on 75 patients requiring endodontic treatment. Before commencement of endodontic treatment, a provisional diagnosis of pulp status was made using an electric pulp tester and cold test. The tooth was then labelled as either vital or necrotic. Then an access openings was made and tooth's actual pulp status (vital/necrotic) was determined by observing bleeding in the pulp chamber. The validity, yield and accuracy were calculated on the basis of these findings. **Results:** The sensitivity, specificity, positive predictive value and negative predictive value of cold test were 84%, 88%, 93% and 73% respectively. The sensitivity & specificity of electric test were 82% and 88% respectively whereas the positive predictive value negative predictive value of electric test were 93% and 71% respectively. The accuracy of cold and electric pulp test was 85% and 84% respectively. **Conclusion:** Both cold test and EPT have similar sensitivity, specificity and accuracy values. Although vitality tests have a promising future in the diagnosis of pulp health status but within limitation of this study we found that sensibility tests have satisfactory validity and accuracy values to be used routinely prior to endodontic and restorative treatments especially when used in conjunction with one each other.

Keywords: Cold test, EPT, Pulp sensibility, Sensitivity, Specificity

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INTRODUCTION

Diagnosis is the "art and science of detecting deviations from health and cause and nature thereof".¹ It is the most important step in the treatment planning. Diagnosis is, in fact the beginning of the treatment. A combination of patient' history, clinical examination, special tests and radiological examination help in making a correct diagnosis.² Relying on just one of above mentioned components often result in an incorrect diagnosis and inappropriate treatment. Specific to dental pulp, indirect methods of diagnosis are used as pulp is encased in a hard shell of enamel and dentine. Pulp diagnostic tests can be classified into two main categories; Sensibility and Vitality. Pulp sensibility tests include thermal and electric stimulation while vitality tests are laser Doppler flowmetry and pulp oximetry. In clinical practice, pulp testing is indicated before commencement of restorative procedure, for diagnosis of origin of pain, in Investigation of radiolucent areas, for trauma and anaesthesia assessment and Prognosis of teeth with pulp capping and deep restorations.³⁻⁶

Although, vitality tests are true representative of pulp health status as they diagnose pulpal blood flow but they are technique sensitive, expensive and time consuming.⁷⁻⁹ Studies had also shown that thermal sensitivity is a sign of pulp inflammation and diseased pulp also demonstrate changes in response to electric stimulus, therefore the use of thermal and

electric sensibility tests is a standard means of assessing the state of the pulp.^{10,11}

An ideal pulp diagnostic test has yet to be developed. All currently employed methods of pulp testing have deficiencies in terms of their accuracy, validity and reproducibility. In addition, the correct application of the pulp test in the appropriate clinical situation is important, as not all pulp testing agents are suitable for all clinical situations.¹²

Pulp sensibility tests are routinely used in clinical practices for assessing pulp health status by Stimulating pulp sensory nerves either by dentinal fluid movement or through electric current conduction generating an action potential in nerves.¹³

Variety of cold stimuli may be used like Ice water, Carbon dioxide spray (boiling point-72 °C), Ethyl chloride spray (boiling point-41 °C), Dichlorodifluoromethane (DDM) (boiling point-0 °C) and ozone friendly non-chlorofluorocarbon sprays. The difference is the degree of cold applied to the tooth. Studies have also shown that as compared to heat tests, cold stimulus is more reliable and colder the stimulus more effective will be the sensory innervations assessment of the tooth.^{14,15}

Different gold standards described in literature to assess validity of diagnostic tools are histological examination of pulp tissue; observation of bleeding upon pulp exposure and use of endodontically treated teeth as controls.¹⁶ Among these

approaches, bleeding upon pulp exposure is clinically most feasible option.

Validity of a test is described by its sensitivity and specificity whereas Positive and negative predictive values (PPV and NPV) are used to describe effectiveness of a test in a given population.¹⁷

There are very few studies in literature determining validity, yield and accuracy of pulp sensibility tests.¹⁸⁻²⁰ Rebecca *et al*²⁰ reported the sensitivities of 76% and 92% for cold and electric test respectively and specificities of 92% and 75% respectively but did not calculate the accuracy. Peters and colleagues²¹ reported only the sensitivity of various testing agents and found that the teeth not responding to cold or electric pulp tester (EPT) had a high probability of being necrotic.

We conducted current study with the objectives of determining validity (sensitivity, specificity), yield (PPV, NPV) and accuracy of Cold Test and EPT for teeth requiring endodontic treatment.

MATERIAL AND METHODS

A cross-sectional study was conducted in the dental clinic of The Aga Khan University Hospital, Karachi, Pakistan. Ethical approval was obtained from the Ethical Review Committee of the hospital. Non probability purposive sampling technique was used. Sample size was calculated with the help of WHO sample size determination calculator used in the health studies. Petersson *et al* showed that the sensitivity of EPT is 72% while Rebecca *et al* showed it to be 92%. Taking these proportions into account and keeping power of the study at 0.90 and level of significance at 0.05, the sample size requirements turned out to be 38. Thus, 75 patients requiring endodontic treatment of adult permanent teeth (either due to pulpal or periapical pathology) were enrolled in this study. All participants signed a consent form. Those having acute pain and age below 17 and above 70 years were excluded from the study. Also, the teeth with full surface crowns and deep restorations were excluded from the study. The primary investigator tested all the teeth for cold test and EPT.

Isolation of the tooth in need of treatment and the contra lateral vital tooth was done by cotton rolls. In case of missing vital contra lateral tooth another vital tooth was taken as A control. Vaseline as a separating medium was applied on labial/buccal surfaces of both teeth. Tetrafluoroethane (*TruFlex™ Nickel Titanium Chilling Spray*. ORTHO TECHNOLOGY) sprayed on a cotton roll was applied on the control tooth for 15 seconds and patient was asked to respond by raising his/her hand if there was any sensitivity to cold test within 15 seconds. The same procedure was repeated on the tooth in need of treatment and patient response was noticed (the

response was in the form of sensitivity or no sensitivity to cold stimulus).

After time elapse of 3 minutes teeth were cleaned and ionic medium (tooth paste) was applied to the contra lateral vital tooth and diseased tooth. Now EPT (Parkell Gentle-Pulse™ Pulp Vitality Tester) was applied to the contra lateral vital tooth. The patient was asked to report if there was a tingling situation by raising their hand. The reading on EPT was noticed and procedure was repeated on the diseased tooth. Tooth responding up to the No. 5 marking of electric pulp tester was considered vital.

Then root canal treatment of the diseased tooth was performed under standard protocols (isolation and 2% lidocaine anaesthesia) and true pulpal status (vital/necrotic) was noticed on penetration into pulp chamber (bleeding showed vital pulp and no bleeding showed necrotic pulp). If there was no bleeding on opening of the chamber but in the apical part of canal, tooth status was still considered as necrotic.

On the basis of these findings sensitivity, specificity, PPV, NPV and accuracy of EPT and cold tests were calculated.

RESULTS

The mean age of participants in our study was 25.73±18.7 years. There were 32 males and 43 females. Out of 75 teeth, 21 were incisors, 7 were canine, 21 premolars and 26 were molars. (Table-1) Fifteen patients (20%) presented with history of spontaneous pain, 16 (21.3%) experienced pain on biting, 17 (22.7%) had food packing, 15 (20%) had gumboil or discharging sinus and 12 (16%) showed sensitivity to hot or cold. (Figure-1)

The sensitivity for cold and electric tests turned out to be 84% and 82% respectively. The specificity of both cold and electric tests was 88%. (Figure-2) Positive predictive value (PPV) and negative predictive value (NPV) of cold test turned out to be 93% and 73% respectively. For EPT, PPV was 93% and NPV was 71%. (Figure-2), Accuracy for cold and electric test was 85% and 84% respectively. (Figure-3)

Table-1: Morphotypes of teeth

Teeth Morphotype	No. of Teeth
Incisors (maxillary and mandibular central and laterals)	21
Canine (maxillary and mandibular)	7
Premolars (maxillary and mandibular first and second)	21
Molars (maxillary and mandibular first and second)	26

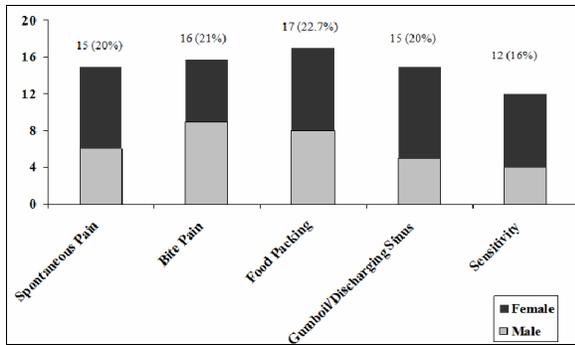


Figure-1: Clinical symptoms of teeth requiring endodontic treatment

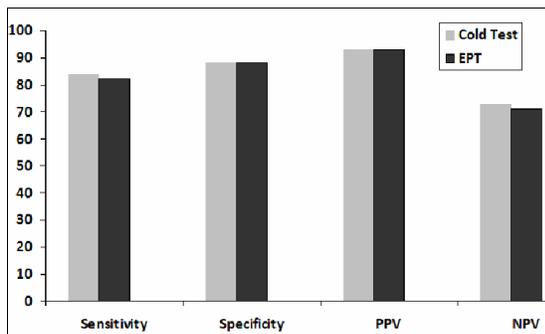


Figure-2: Validity (Sensitivity, Specificity) and Yield (PPV: Positive Predictive Value, NPV: Negative Predictive Value) of cold and electric test

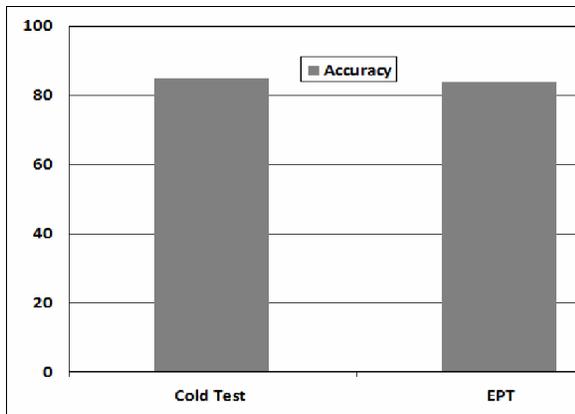


Figure-3: Accuracy of cold and electric tests

DISCUSSION

Diagnosis of the pulp health status requires combination of various diagnostic modalities like patient history, clinical examination, radiographs along with sensibility tests (EPT, cold tests, heat tests) and vitality tests (Laser Doppler flowmetry, Transmitted Laser Light or Pulse Oximetry) . All of these tests have different diagnostic values. An accurate diagnosis needs critical judgment of the results obtained from different methods along with the thorough knowledge of mode of action of these diagnostic modalities.

In current study, sensitivity and specificity of cold test is 84% and 88% respectively. Rebecca *et al* showed low sensitivity (76%) and high specificity (92%) for cold test. Despite similar methodology differences in the results between the two studies can be attributed to the individual variations like tooth morphology, enamel thickness, histological status and pain threshold of the patients. Kamburologu *et al* showed sensitivity of 93% and specificity of 90%¹⁸ for cold test whereas Fuss²² *et al* reported sensitivity and specificity of 98% and 100% respectively. The differences in results may be due to different gold standards and different agents used as cold stimuli in these studies.

Sensitivity and specificity for EPT are 82% and 88% respectively in current study. Rebecca *et al*¹⁹ in their study showed high sensitivity (92%) and low specificity (75%) values. Schnettler *et al* and Fuss *et al* showed sensitivity and specificity of 100% for EPT in their studies. In both studies RCT teeth was used as control which resulted in high sensitivity and specificity values. Furthermore, due to unknown vitality status of 44 teeth, the true positive and false negative results (sensitivity) cannot be evaluated accurately by Schnettler *et al*.

Although sensitivity and specificity describe test performance in relation to patients with known disease states, the actual interest is in evaluating test responses of patients with unknown disease states. This is measured by predictive values. Positive and negative predictive values describe the usefulness of a diagnostic tool in any given population. PPV and NPV for cold test in current study turned out to be 93% and 73% respectively, meaning 93% of teeth testing positive with cold test were actually vital and 73% of teeth testing negative were actually necrotic. These results are in close agreement with Rebecca *et al*, which showed PPV and NPV of 93% and 74% respectively.

PPV and NPV for EPT in our study were 93% and 71% respectively, meaning 93% of teeth testing positive with EPT were actually vital. Similarly 71% of teeth testing negative with EPT were actually necrotic. Similarly Gopikrisna²³ while working on traumatized single rooted teeth showed PPV and NPV for EPT as 91% and 74% respectively.

In current study, accuracy turned out to be 85% for cold test and 84% for EPT. In literature only few studies on accuracy of pulp sensibility test are found.^{13,18,23} Accuracy for cold test and EPT are also similar in other studies. Gopikrishna²³ showed accuracy for cold test and EPT as 86% and 81% respectively. Petersson and colleague¹³ found accuracy of 86% and 81% for cold and EPT respectively. Kamburogulo *et al* showed accuracy for cold test and EPT as 90% each.

The gold standard used in our study was observation of bleeding upon entering into the pulp chamber. This is far more reliable and superior gold standard as compared to root canal treated teeth which have the lowest value as a control for a diagnostic test. Root canal treated teeth are more practical in evaluating the true negative and false positive responses (specificity) rather than sensitivity of a diagnostic test.¹⁶

CONCLUSION

We concluded that cold test and EPT have similar sensitivity, specificity and accuracy values in diagnosing the pulp health status. Although vitality tests have a promising future in diagnosis of pulp health status but within limitation of this study we found that sensibility tests have satisfactory validity and accuracy values to be used routinely prior to endodontic and restorative treatments especially when used in conjunction with one each other. In cases where other diagnostic tools (like history, clinical examination and radiographs) are not conclusive in making a diagnosis, pulp sensibility tests may help in making the critical decision between pulp conservation and pulp extirpation.

AUTHOR'S CONTRIBUTION

HF gave the idea, conducted research and wrote the manuscript. FRK performed statistical analysis and reviewed the manuscript. LP contributed to the discussion. MSS contributed to the discussion.

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