

ORIGINAL ARTICLE

Agreement between Two Commonly Used Pulp Tests in Determining Pulp Vitality

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ABSTRACT

Background: The pulp tissue is confined within hard tissue boundaries and cannot be examined directly for health evaluation. Hence, its assessment is usually based on sensibility tests. Accurate diagnosis of the pulpal status requires evaluation with combination of sensibility tests. The objective of this study was to assess the mutual agreement between the electric pulp test and cold test in determining pulp vitality.

Methods: Total 106 patients, aged 18 to 30 years, attending the dental OPD of Operative Dentistry/Endodontics department; Dr. Ishrat-ul-Ibad Institute of Oral Health Sciences, Karachi were selected for the study. The cold and electric pulp tests were used to determine the presence or absence of tingling sensation. Teeth were marked as vital in presence and non-vital in absence of any tingling or painful response. Agreement between these two tests was calculated using SPSS-18. To calculate the mean and standard deviation, descriptive statistics were applied for quantitative variables. For qualitative variables, frequencies and percentages were calculated. Kappa statistics was applied for agreement between electric pulp and cold test.

Results: The cold test showed that 70.8% of the teeth were vital and 29.2% were necrotic. The electrical pulp test showed that 74.5% were vital and 25.5% were necrotic. The outcome showed 83.0% agreement between the tests; with kappa value of 0.574 which provided sufficient agreement with p-value=0.000.

Conclusion: There was a high agreement found between the cold test and electric pulp test. Assessment of pulp vitality would be more accurate when EPT and Endo frost are used in combination.

Keywords: Pulp Vitality; Electric Pulp Testing; Thermal Testing; Cold Testing.

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INTRODUCTION

Dental injuries often occur in current living environment. Dental injuries to permanent dentition are clinically more significant because of the devastating effect it can have on mastication, speech and aesthetics due to damage to the tooth and periodontium¹. Conferring to researches, injuries to crown and root of a tooth is more common in comparison with periodontal damage while root fractures are less common than crown fracture²⁻⁴. Periodontal tissue damages can lead to displace-

ment or avulsion of tooth. Dental trauma is a complication of facial traumatic injuries but a number of complications are also associated with dental injuries. Loss of blood supply to the pulp tissue making it non-vital is one of the complications of dental trauma⁵.

Pulp innervations are evaluated in 'sensibility testing' which is considered foremost and critical measure in the diagnosis of dental pulp health status. In sensibility testing, electric pulp test and cold test are most commonly used methods

because of non-invasiveness and easy application. However, in case where pulp innervation is damaged but blood supply of pulp is intact, these tests give false negative results because they cannot evaluate vascularity of pulp tissue. Methods, which evaluate blood flow, are straighter forward in determining vitality of pulp and are called pulp vitality tests⁶⁻⁸.

Pulp tests provide valuable information to the clinician for diagnosis and treatment planning⁹. As a calcific barrier surrounds dental pulp, its inspection before endodontic treatment is not possible. The direct inspection requires removal of calcific barrier, which leads to permanent damage to tooth. So, In order to determine pulp vitality, indirect methods are used. In these methods, either pulp nerves are stimulated or blood flow of the pulp is detected by evaluating presence of red blood cells or oxygen saturation^{10,11}. Most commonly used test is stimulation of pulp nerves by thermal changes that causes dentin liquid movement or by electric stimulation of pulp¹⁰. Heat pulp test is reported as least accurate among all sensibility tests¹².

Electric pulp tester sensitizes sensory nerves via electric stimulation. It is a subjective test as it requires patient's response to testing. There are chances of false-negative and false-positive results in a subjective test. However, EPT is a non-invasive, clinically safe and easy to use method for evaluation of pulpal status making it aid of choice by many clinicians⁹. A previous in-vivo study reported sensitivity of Endo Ice as 76% and electric pulp test as 92%. Similarly, the specificities of Endo Ice were reported as 92% and for EPT as 75%¹⁰.

Another in vivo study evaluated heated gutta-percha, ethyl chloride and electric tests to record pulp vitality. The sensitivity, specificity, negative and positive predictive values were calculated by means of examination of dental pulp directly as reference standard. The study reported true positives of ethyl chloride test as 88% and EPT as 87%. The true negatives of these tests were reported as 89 and 84%¹³.

A study conducted to evaluate predictive values of thermal and electrical pulp test concluded that cold test being the most accurate method for diagnosis of pulpal health because of reported highest accuracy, which is 0.94, and reproducibility, which is observed 0.88¹⁴. Cold testing results in inward fluid movement in dentinal tubules, which activates A α fibers. However, C-fibers, which are present in core of pulp, are not activated until the pulp is having irreversible damage¹⁵. Hence, for production of sensation to the pulp, testing requires remaining vital pulp with odontoblast at its peripheries for movement of dentinal fluid¹⁶. A local study reported accuracy of cold and electric pulp test 85% and 84%, sensitivity 84% and 82% respectively and speci-

ficity 88% of both. Accuracy sensitivity and specificity were similar for both the test¹⁷.

The rationale of this study was to check the agreement of two different pulp tests since determination of pulp vitality has a major role in diagnosis and treatment planning. Combination of these two tests is used for accurately diagnosing pulpal conditions. Therefore, the objective of our study was to determine the agreement of accuracy of electric pulp testing and thermal testing in determining pulp vitality.

METHODS

This descriptive cross-sectional study was conducted in OPD of Operative Dentistry/Endodontics department, Dr. Ishrat-ul-Ibad Khan Institute of Oral Health Sciences, Karachi during the period of 02-01-15 to 02-09-15. One hundred and six patients attending dental OPD were included by using non-probability purposive sampling method. Patient with moderate pain (VAS 4-7) and severe pain (VAS 8-10) due to pulpal disease requiring root canal treatment were included in this study. Teeth having fully formed roots in age group 18-30 were targeted. Teeth with full coverage crowns, large restoration, calcified canals or regressed pulp chamber, recently traumatic injury, root resorption and immature apex were excluded. Research evaluation unit of College of Physicians and Surgeons Pakistan approved this study (Ref No: CPSP/REU/DSG-2011-217-922).

After the patient agreed to undergo endodontic therapy, a written consent form was obtained. Researcher who administered the diagnostic test was blinded to main complain, history of presenting complain and result of radiographic evaluation of the patient. Patients were instructed to raise their hands the moment they felt tickling sensation or discomfort during test. Initially, Endo-Frost (isobutane 10-20%, butane 30-50%, propane 30-50%) (ROEKO Endo Frost [Endo Frost], Coltene Whaledent) sprayed on supplied pellet (Endo Frost Pellet) and was applied to the tooth's crown until the patient raised his or her hand indicating cold or tingling sensation.

In case where patient did not feel any sensation pellet was removed after 15 seconds. Interval of 2 minutes was given before proceeding to the next test. For electric pulp testing the tooth was isolated with cotton rolls and a drop of conducting paste placed. Probe of electric pulp tester (Integrated Circuit) (Gentle Pulse Tester, Parkell, inc., Edgewood, New York) was placed on the tooth to be tested. The electric current was gradually increased from unit 0 to 10 until the patient signaled a sensation.

Teeth were marked as non-vital if no response was

produced and vital if there was any tingling sensation or sensation of cold. Agreement between the two tests was calculated and possible variations of the results were compared to define each test's strength and clinical practicality.

SPSS-18 software was used for data entry and analysis. To calculate mean and standard deviation, descriptive statistics were applied for quantitative variables and for qualitative variables, frequencies and percentages were calculated. Kappa statistics was applied to see agreement between electric pulp and cold test, considering $p \leq 0.05$ as significant.

RESULTS

Total 106 patients of either gender with age 18 to 30 years having with moderate to severe pain, visited for root canal treatment were evaluated to determine the agreement of accuracy of electric pulp testing and thermal testing in determining pulp vitality (Figure 1). Stratification was done to see the effect of modifiers on outcome. Post stratification Kappa statistics was again applied considering $p \leq 0.05$ as significant.

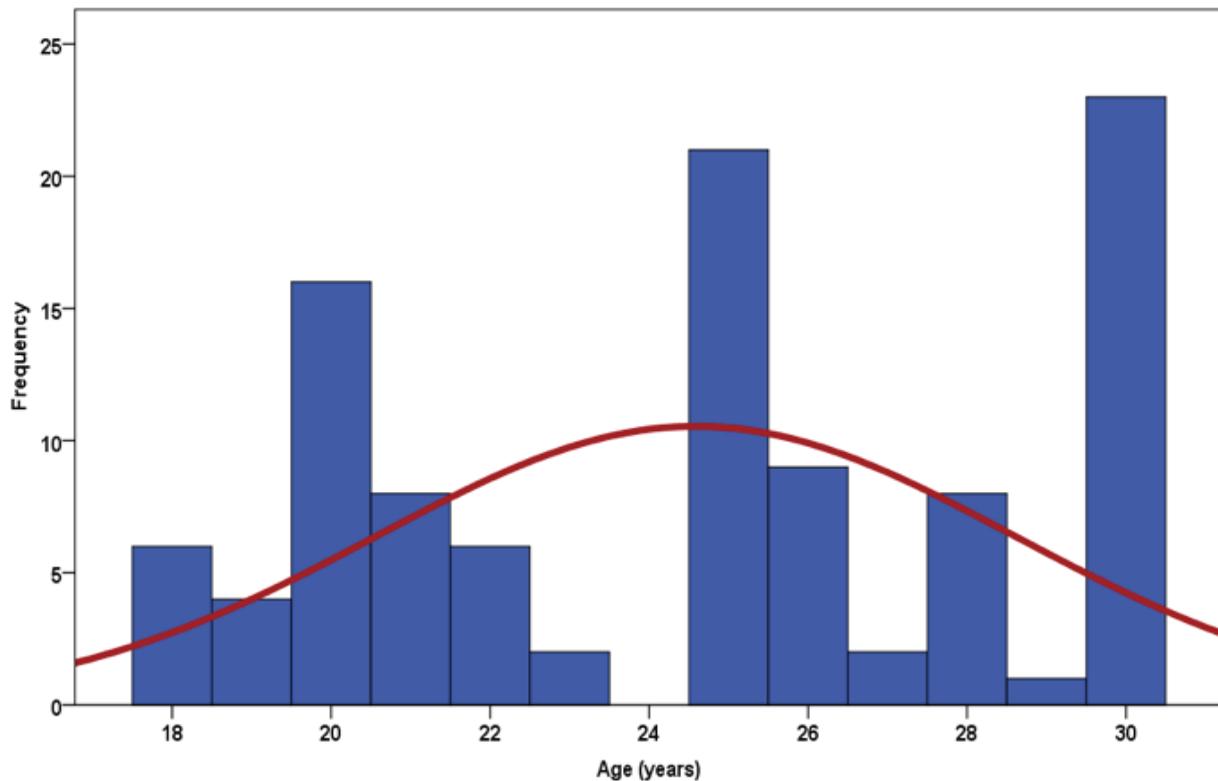


Figure 1: Histogram Presenting Distribution of Age (years). The mean age of patients was 24.58 ± 4.01 years, with range of 12(18–30) years. Mean age of patients with age ≤ 24 years was 20.24 ± 1.35 years and it was 27.44 ± 2.18 years among patients with age > 24 years.

Overall, there were 63 male and 43 female patients. The distribution of age is presented in Figure 1. The frequency distribution of age, gender and severity of pain and tooth type is presented in Table 1.

Table 1: Baseline Characteristics.

Clinical Characteristics	Mean \pm SD, %
Age	24.5 \pm 4.01
Gender	
Males	63 (59.4%)
Females	43 (40.6%)

Pre-op Pain	
Moderate pain (VAS 4-7)	28 (26.4%)
Severe pain (VAS 8-10)	78 (73.6%)
Tooth Type	
Maxillary Incisors	26 (24.5%)
Mandibular Incisors	32 (30.2%)
Canine	23 (21.7%)
Molar	15 (14.2%)
Premolars	10 (9.4%)

Table 2: Kappa Statistics of Agreement between Thermal Test and Electric Pulp Test.

Sensibility Test		Electrical Pulp Test		
		Vital (n=79)	Necrotic (n=27)	Total
Thermal Test	Vital (n=75)	68	7	75
	Necrotic (n=31)	11	20	31
	Total	79	27	106
Kappa Value		0.574		
p-Value		0.000*		

* The Agreement is significant at 0.01 Levels, agreement between the two tests is shown in 68 patients in diagnosing vital teeth out of 79 patients and in 20 patients in diagnosing necrotic pulp out of 27 patients. The outcome showed 83.0% agreement between the two tests.

Stratification with respect to gender and age was done with Kappa statistics applied and considered $p \leq 0.05$ as significant. Kappa statistics of agreement between thermal test and electric pulp

The results after thermal test administration showed that 70.8% were vital and 29.2% were necrotic. The results after electrical pulp test administration showed that 74.5% were vital and 25.5% were necrotic. The outcome showed 83.0% agreement between the two tests.

The agreement between two tests was statistically analyzed through Kappa statistics and the calculated agreement between the two tests was 0.574 which provides sufficient agreement with p -value=0.000. The detailed results are presented in Table 2.

test according to gender provides sufficient agreement in both gender with p -value=0.000 as presented in Table 3.

Table 3: Kappa Statistics of Agreement between Thermal Test and Electric Pulp Test According to Gender and Age Groups.

Vital Test	Electric Pulp Test					
	Males (n=63)	Vital (n=49)	Necrotic (n=14)	Age \leq 24 years (n=42)	Vital (n=32)	Necrotic (n=10)
Thermal Test	Vital (n=46)	42	4	Vital (n=30)	30	0
	Necrotic (n=17)	7	10	Necrotic (n=12)	2	10
	Kappa Value	0.531		0.877		
	p - Value	0.000*		0.000*		
	Females (n=43)	Vital (n=30)	Necrotic (n=13)	Age $>$ 24 years (n=64)	Vital (n=47)	Necrotic (n=17)
	Vital (n=29)	26	23	Vital (n=45)	38	7
	Necrotic (n=14)	4	10	Necrotic (n=19)	9	10
	Kappa Value	0.622		0.382		
	p - Value	0.000*		0.002*		

* The Agreement is significant at 0.01 Levels, Kappa statistics of agreement between thermal test and electric pulp test according to gender provides sufficient agreement in both gender with p -value=0.000. According to age it provides sufficient agreement in both age groups (Age \leq 24 years and Age $>$ 24 years) with p -value=0.000 and 0.002 respectively.

Kappa statistics of agreement between thermal test and electric pulp test according to age provides sufficient agreement in both age groups (Age \leq 24

years and Age $>$ 24 years) with p -value=0.000 and 0.002 respectively as presented in Table 3.

DISCUSSION

Present study evaluated the agreement between two universally used methods of vitality checking, cold test and Electric pulp test. According to the results, the agreement was found to be 83% in determining pulp vitality indicating that both tests gave same readings in 83% of cases. Either of the tests can alone be used for evaluation of pulp vitality, but combination of both tests will result in results that are more accurate.

When results of present study were linked with other studies, the other studies showed higher disease occurrence hence precision of pulp tests requires careful interpretation¹⁸. Petersson reported 39% occurrence of disease and Evans stated 44%, while the present study had 74.5% as identified by EPT^{13,18}.

Investigation with CO₂ cold testing by Fuss showed the disease occurrence of 7% which is in accordance with the present study. Furthermore, the study diagnosed healthy pulp tissue in 97% of cases, while EPT in same study recognized vital pulp in 90% of cases. Regarding non-vital pulp recognition, investigation by Fuss showed CO₂ result as 97% and EPT result as 90%¹⁹. Lesser values on EPT were found to be due to teeth with immature apex, which were not excluded in the investigation. In such type of cases, EPT shows unpredictable results. In comparison to present study and other investigation the pulp-less teeth in which pulp was removed due to root canal treatment, were also examined by Fuss there was no false positive response by EPT^{20,19}. EPT produce electric impulses that activate A α fibers which produce response if the tooth is having intact A α fibers. Again, the excitation of C-fibers is not possible with EPT as amount of current required to excite these non-myelinated. Electric impulse of EPT causes depolarization of integral nerves, which in turn produce of action potential with the resultant discomfort/pain response of patient²¹.

A local study also reported accuracy, sensitivity and specificity of cold and electric pulp test were similar for electric pulp test and cold test¹⁷. Another study shows pulp sensibility testing with Endo Ice and EPT are accurate and reliable methods of determining pulpal vitality²². Present study also confirmed their agreement between these tests. Teeth with positive response were having healthy pulp 74.5% of times with EPT while 70.8% with cold test. In present investigation, the findings were in agreement with Kappa statistics (0.574).

Selection of age group of subjects is a significant factor in evaluation of vitality. Jaspersen reported accuracy of cold test in age group 21-50 years²². A study conducted compared threshold between the age group 20-30 and 50-101, showed difference in threshold between the groups²³. Calil included age group of 26-38 year for evaluation²⁴. It was observed that using elderly patients with pulp space diminished

due to calcification, reduced vascularity and increased fibrous tissue in pulp results in incorrect outcomes to as it limits certainty of sensitivity examinations²⁵. Therefore, in present study, the age range was 18 to 30 years. The agreement of tests was also found to be significant among age groups. In addition, there were 63 males and 43 female patients. The agreement of tests was also significant among genders. Furthermore, agreement was also significant between two tests among different severity of pain and tooth types.

In present study, after conduction of cold test, interval of 2 minutes was given before proceeding to the next test. This interval is to give as nerve recovery period before conducting next test²⁶. In another study, 5-minute interval was used for rechecking vitality of same tooth²¹.

In current study, Endo frost was used for cold testing. It is reported that carbon dioxide snow caused significantly more decline in intrapulpal temperature than either ice or Ethyl chloride. In addition, it is also stated that skin refrigerant as well as ice as less consistent as cold test²⁷. In present study pallets sprayed with endo frost was placed on tooth for 15 seconds if patient did not respond or reported any sensation. The followed protocol was used in previous study²⁸.

Present study was conducted in teeth with pulpal disease, which required the condition to be diagnosed using the sensibility testing for confirmation of status of pulp. The sensibility testing methods are used commonly in clinical situations with diseased pulp. The result of our study is in agreement with previous study e.g., Petersson and colleagues¹³ who compared the response of pulp to cold test using ethyl chloride, EPT, and Hot test using heated gutta-percha. Since, 89%, 48% and 88% of time ethyl chloride, heated gutta-percha and EPT gave no response to testing in a non-vital pulp. While 90%, 83% and 84% of the time ethyl chloride, heated gutta-percha and EPT gave positive response to testing in vital pulp. One of the limitations of this study is that it was conducted with small sample size and in urban environment therefore, the results might not be generalizable to larger populations. Further, it could have been better if other related risk variables could be included in the study.

CONCLUSION

This study concludes that EPT and cold testing showed excellent agreement in determining pulp vitality. Currently electric pulp tester and cold testing meet most of the requirement of an ideal testing technique and remain commonly used diagnostic aid. Assessment of pulp vitality would be more accurate when EPT and Endo frost are used in combination.

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CONFLICT OF INTEREST

The authors declares explicitly that there is no conflict of interest

ETHICS APPROVAL

Research evaluation unit of College of Physicians and Surgeons Pakistan approved this study. Ref No: CPSP/REU/DSG-2011-217-922.

PATIENT CONSENT

A written consent form was obtained from the participants of study and explained prior to be obtaining their signature. Only those patients were included in study who willingly signed written consent form.

AUTHOR'S CONTRIBUTION

All authors contributed equally to the study conception and design. TZ carried out data collection, and wrote the first draft of manuscript and all authors commented on previous version of manuscript. All authors read and approved the final manuscript and are responsible for the authenticity of this study.

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