Efficiency and Reliability of Thermal and Electrical Tests to Evaluate Pulp Status in Primary Teeth with Assessment of Anxiety Levels in Children

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Objective: *Assessing the pulp status plays a vital role in diagnosis and treatment planning in dentistry especially in children, who may not be able to verbalize their dental symptoms. Pulp sensibility test is used as a valuable investigation to evaluate the state of pulp. The aim of this study is to assess the efficiency and reliability of thermal and electrical pulp tests in primary teeth and to rule out the anxiety level involved in each tests.* **Study design**: *30 children aged between 6 to 8 years with carious primary molar teeth in need of conservative pulp therapy were included in this study. 3 tests at random were employed on each tooth which includes cold, heat, electrical pulp test. The sensitivity, specificity, positive predictive value and negative predictive value were evaluated based on the clinical visual examination on access opening and the accuracy for each test was calculated. The Facial Image Scale (FIS) was used to assess the state of dental anxiety in children due to these pulp sensibility tests.* **Results:** *The highest accuracy rate was calculated for EPT (0.814) followed by cold test (0.777) and heat test (0.759).* **Conclusion**: *No significant association was found between the accuracy of all the three tests. (P value > 0.05). Cold test is the most reliable test due to its simplicity and ease to perform. (FIS -1.53).*

Key words: pulp sensibility tests, Facial image scale.

INTRODUCTION

Dental management of children is a dynamic process which consists of behavioral and dental components. Before planning for the treatment the dental and behavioral management framework should be set aimed for minimum discomfort, painless and conservative approach. Diagnosis should always follow the systematic format which is given the name S.O.A.P., which is a acronym for Subjective findings, Objective tests, Assessment (or Appraisal), and Plan of treatment.[1] Determination of the pulp status is the most important part of diagnosis to establish the treatment plan for carious teeth. The most accurate way of evaluating the pulp status is by examination of histological sections of the tissue specimen involved to assess the extent of inflammation or the presence of necrosis as a means of gauging pulp health. Unfortunately in the clinical scenario, these are both impractical and not feasible; hence clinicians must use investigations such as pulp tests to provide additional diagnostic information.[2]

Radiographs alone cannot be used as diagnostic tools as it is difficult to be used in small children, also it only gives hard tissue details and a high possibility of imaging error is inevitable. Test cavity preparation and local anesthetics test is not appropriate in children. A combination of the patient's history, clinical examination, radiographic examination as well as pulp sensibility tests leads a dentist to diagnose the pulp status which then determines the treatment options.[2]

The ideal pulp test should provide a simple, objective, standardized, reproducible, non-painful, non-injurious, accurate, and inexpensive way of assessing the condition of the pulp tissue.[3] Pulp testing strategies may involve direct methods and indirect methods. Laser Doppler flowmetry (LDF) or pulse oximetry are pulp testers to evaluate the vascular supply of the tooth but however sensitivity tests such as thermal or electric pulp testing (EPT) which assess the neural response to stimulus are most common methods employed by clinicians in spite of their own shortcomings.

The aim of this study is to assess the efficiency and reliability of thermal and electrical pulp tests in primary teeth and to rule out the anxiety level involved in each tests.

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Pulpal Innervations

Understanding of pulpal innervation is essential in order to appreciate the rationale and mechanisms involved in pulp sensitivity tests. Within the coronal pulp, nerve bundles diverge and branch out towards the pulpo-dentin border, and emerge from their myelin sheaths.[4,5] Nerve divergence continues until each bundle looses its integrity and smaller fiber groups travel towards the dentin. This course is relatively straight until the nerve fibers form a loop and a resultant mesh termed the nerve plexus of Rashkow.[6] Two types of sensory fibers are present in the pulp: the myelinated (A- fibers) and unmyelinated C- fibers. A- fibers mediate acute, sharp pain and are excited by hydromechanical events in dentinal tubules such as drilling or air-drying.[7] The C -fibers mediate a dull, burning, and poorly located pain, and are activated only by stimuli reaching the pulp proper.[8]

Pulp Sensibility Test

Thermal testing causes contraction or dilatation of the dentinal fluid within the dentinal tubules, resulting in a rapid outward or inward flow of fluid within the patent tubules.[9] This rapid movement of dentinal fluid results in 'hydrodynamic forces' acting on the A delta nerve fibers within the pulp–dentine complex, leading to a sharp sensation lasting for the a short duration after the removal of the stimulus.[10]

EPT causes stimulation of intact A delta nerves in the pulp–dentine complex by applying an electric current on the tooth surface. A positive result stems from an ionic shift in the dentinal fluid within the tubules causing local depolarization and subsequent generation of an action potential from intact A delta nerves.[11]

Any objective intervention is sure to result in subjective changes, especially at an emotional level. Anxiety and pain during dental procedures result in a feeling of discomfort in the patient. Discomfort is a multidimensional construct consisting of a behavioral, cognitive and physiological component.[12,13] The responses given by the children for pulp testers are subjective as the children may exaggerate the symptoms due to fear and anxiety leading to false positive or false negative results which should be taken into consideration.[14]

Materialls and Method

This study was conducted in Department of Pediatric dentistry, Rajarajeswari Dental College and Hospital, Bangalore, India. Children who visited the Department were assessed clinically and an informed consent was obtained from the parent of the child to participate in this study.

Inclusion and Exclusion Criteria

Thirty children aged between 6 to 8 years without any medical conditions or behavioral problems and with carious primary molar teeth in need of conservative pulp therapy after confirmation from visual and radiographic examination were included in this study. Carious teeth with furcation involvement and more than one third of physiological resorption evident on periapical radiograph were not included in the study.

Pulp sensibility test

Three tests at random were employed on each teeth which includes cold test, heat test, electrical pulp tester. Each child was instructed to raise his or her hand at the moment he or she felt a cold, tingling or uncomfortable sensation during pulp testing. The cold test involved spraying Endofrost (figure – 2: Rocko Endofrost; Coltene Whaledent, Langenau, Germany) on a size 2 cotton pellet. After the spray the cotton pellet was held until a white frosty appearance was observed and then it is applied on the middle third of buccal aspect of the primary molar tooth that is to be examined. The cotton pellet was kept in contact with the teeth for 10 seconds or until the child responds for the cold stimulus. For the heat test a heated gutta-percha stick (figure – 3: Meta Biomed co;Ltd, Korea) was used and applied to the middle third of the buccal aspect of primary molar teeth after the application of a thin layer of petroleum jelly on the buccal surface of the teeth. The stick was withdrawn in 5 seconds or as soon as the child responds to heat stimulus. C-pulse pulp tester (figure – 4: coxomedical instrument co;Ltd, China) was used for electrical pulp testing. The tooth to be examined was dried with cotton gauze and isolated from adjacent teeth with mylar plastic strip. Petroleum jelly was used as a conducting medium. The EPT probe was placed on the middle third of the buccal aspect of the primary molars over the conducting medium. The teeth that responded to EPT at a level lower than 80 in the digital display were considered to have a normal pulp response.

Care was taken to avoid contacting the gingival or the adjacent teeth. On completion of each test, an interval of 2 min was allowed so that the pulp could return back to their normal condition before employing another test. Pulp status was confirmed on direct visual inspection of presence or absence of bleeding on access opening after local anesthesia for the teeth indicated for pulp therapy, if the bleeding is hyperemic or pale red colored, pulpotomy procedure was carried out after controlling bleeding and if the bleeding is cyanotic or dark red colored, pulpectomy procedure was carried out. Teeth with partially necrotic pulps were considered to be necrotic (absence of bleeding). The sound intact non carious teeth were judged to have clinical normal pulp.

The sensitivity, specificity, positive predictive value(PPV) and negative predictive value(NPV) was evaluated based on the clinical visual examination on access opening and the accuracy for each test was calculated.(Table-1) 95% confidence intervals for each indicators was calculated using McCallum Layton online digital calculator, UK.

Assessment of Anxiety – Facial image scale

The Facial Image Scale (FIS) was developed by Buchanan H. (2002) to assess the state of dental anxiety in children[15]. It comprises of a row of five faces ranging from very happy to very unhappy (Figure 1). The children were asked to point at which face they felt most like, at that moment when the pulp tester are withdrawn. The scale is scored by giving a value of one to the most positive affect face and five to the most negative affect face. Statistical mean and standard deviation was calculated for each test to assess the anxiety level experienced. Anxiety level of children who gave false positive and false negative value were also calculated using statistical mean and standard deviation.

Table 1 Variables and corresponding formulas.

Variables	Formula
Sensitivity	TP/(TP + FN) x 100
Specificity	TN/(TN + FP) x 100
Positive Predictive Value	TP/(TP + FP)
Negative Predictive Value	TN/(TN + FN)
Accuracy	(TP + TN) / (TP + FP + FN + TN)

TN- true negative; TP- true positive; FP- false positive; FN- false negative.

Figure 3:

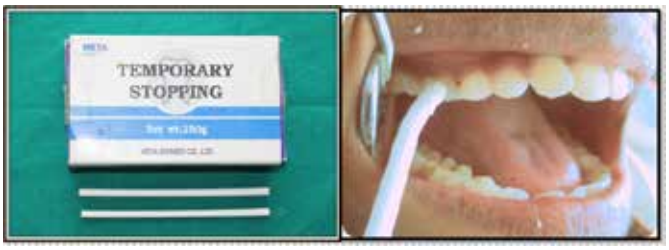

Figure 1 Facial image scale with image scores, 1 – 5.

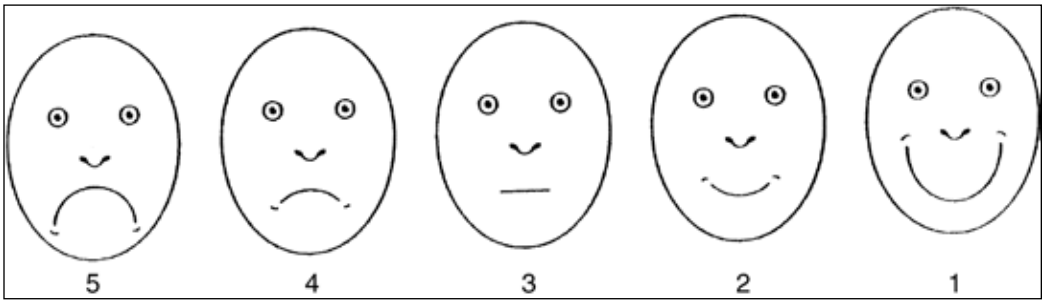

Figure 2

Figure 4

RESULTS

A total of 54 primary first or second molar teeth were examined to assess the pulpal status. Out of which 36 carious molar teeth had an unknown pulp status and 18 teeth were sound intact molars. 20 out of 36 carious molar teeth on access opening had vital pulp, pulpotomy was done for 12 teeth and pulpectomy for 8 teeth, which also indicates pulp status, was reversible pulpitis for 12 teeth and irreversible pulpitis for 8 teeth.

Amongst the 18 sound intact teeth, there were some negative response to cold, heat and EPT tests – 16.7%, 5.6% and 5.6% respectively. In carious teeth the highest true negative (TN) condition was recorded for EPT and cold test followed by heat test.(Table – 2)

Sensitivity for cold test, heat test and EPT was 87.9% (95% confidence interval: 79.2% - 96.6%), 89.4% (95% confidence interval: 81.2% - 97.6%) and 81.5% (95% confidence interval: 71.1% - 91.8%) respectively. Specificity for cold test, heat test and EPT was 62% (95% confidence interval: 49% - 74.9%), 43.7% (95% confidence interval: 30.4% - 56.9%) and 81.2% (95% confidence interval: 70.7 – 91.6%) respectively.(Table – 3) the highest accuracy rate was calculated for EPT(0.814) followed by cold test (0.777) and heat test (0.759). No significant association was found between the accuracy of all the three tests.(p value > 0.05)

The mean facial image score for cold test, heat test and EPT were 1.53(SD: +/- 0.62), 2.4(standard deviation: +/- 1.06) and 2.13(standard deviation: +/- 1.07) respectively. Heat test and EPT had the most anxious rate and have a greater tendency to give false negative and false positive results.

Table 2 Results obtained for each test on visual inspection after access opening.

Variables	Cold test	Heat test	EPT	Bleeding on visual inspection
True positive (TP)	29	34	31	Present
True negative (TN)	13	7	13	Absent
False positive (FP)	8	9	3	Absent
False negative (FN)	4	4	7	Present

TP – when a vital tooth responded for pulp sensibility tests.
TN – when a non-vital tooth does not respond for pulp sensibility tests.
FP – when a non-vital tooth responded for pulp sensibility tests.
FN – when a vital tooth does not respond for pulp sensibility tests.

Table 3: Sensibility test results following calculation of the variables.

Variables	Sensitivity (CI 95%)	Specificity (CI 95%)	PPV (CI 95%)	NPV (CI 95%)	Accuracy
Cold test	87.9% (79.2% -96.6%)	62% (49% - 74.9%)	78% (66.9% - 89%)	76% (64.6% - 87.3%)	0.777
Heat test	89.4% (81.2% -97.6%)	43.7% (30.4% -56.9%)	79% (68.1% - 89.8%)	63.6% (50.7% - 76.4%)	0.759
EPT	81.5% (71.1% - 91.8%)	81.2% (70.7 – 91.6%)	91.1% (83.5% -98.6%)	65% (52.2% - 77.7%)	0.814

CI – confidence interval; PPV – positive predictive value; NPV – negative prediction value;

Table 4: Mean facial image scores obtained from all the children(n) after each test.

Tests	Nº of Children(n)	Facial image score Mean	SD
Cold test	30	1.53	+/- 0.62
Heat test	30	2.4	+/- 1.06
EPT	30	2.13	+/- 1.07

SD – standard deviation.

DISCUSSION

This study was carried out to evaluate the efficiency of common pulp diagnostic tests in primary teeth. The specificity of a test is defined as the ability to diagnose the absence of disease[16] and the results showed that the specificity of EPT is higher than cold test and heat test for primary molar teeth. While performing EPT, the tooth to be assessed should be sufficiently dry to prevent electrical conduction to adjacent teeth and periodontium and also to prevent contamination from gingival sulcus. In the present study, all primary teeth were dried with gauze prior to EPT usage. Air blasts were not used because this could have evoked pain in teeth with hypersensitive dentine[17]. Sensitivity denotes the ability of a test to detect disease in patients who actually have the disease.[18] In present study the sensitivity was found similar in all the pulp tests.

The positive predictive value (PPV) represents a test result that shows the diseased condition of a tooth when it is truly diseased and the negative predictive value (NPV) represents a test result that correctly shows the tooth to be free from disease.[16] In the present study PPV is greater for EPT (91.1%) and NPV is found to be greater for cold test(76%). Collectively after calculating specificity, sensitivity, PPV and NPV, the accuracy was found to be greater in EPT but there was no statistical significance between the other tests which is in accordance with the study conducted by Asfour *et al*.[19]

In contrast, a study conducted by Petersson *et al*.[20] to evaluate the ability of thermal tests and EPT to identify the pulp sensibility status in permanent teeth gave a result that highest accuracy was found in cold test followed by EPT and heat test. A study result reported by Weisleder [21] on pulp testing for permanent teeth gave a statistically significant difference between the accuracy of EPT and cold test. The difference between the type of teeth , primary or permanent may be the reason for conflicting results between the studies.[22]

In this study the efficient test to evaluate the status of pulp in primary molar teeth was found to be EPT, however, in children, response from EPT is not reliable[23], since the complete development of the plexus of Raschkow does not occur until the final stages of root development. In children with history of trauma, where root formation is not complete, EPT may not show any response or may give a false response due to incomplete communication between odontoblastic processes and pulpal nerve fibers.[24]Children undergoing orthodontic treatment display higher excitation threshold when EPT is done.[25]

Pulp testing in children below the age of 10 years is unreliable because children may exhibit a definite shift in their anxiety levels and the tests employed are based on subjective response, they may elicit false positive or false negative results if the dentist asks the child leading questions and also the unpleasant stimuli produced by the tester may affect behavior and cooperativeness of the child. Though the use of traditional tests helps establish an empirical diagnosis, none of these tests are completely reliable.[19]

In some cases when the caries involves adjacent teeth and when the pulp testers has given inconclusive results, a local anesthetics test may be used as an adjuvant test in adults. However it is not mandatory and practically applicable in children as the primary goal of pulp testers is to avoid extra and unnecessary local anesthesia.

As a pulp tests is non invasive procedure of very short duration and causes only little discomfort there is always a high chance that the state of the child is unaltered. For this reason Buchanan scale was employed in this study but the first face is happily smiling and a child without pain is not automatically happy, a scale starting with a neutral face like the Mc Grath facial scale[26] or children's fear scale[27] can also be applied for more accurate results in the age group between 6 to 8 years. In this present study it is found out that cold test depicted less anxiety levels as 'cold' have some fantasy towards children. Cold test have less tendency to give false positive and false negative results than heat test and EPT.

It is blood circulation and not innervations which is the most accurate determinant in assessing the pulp vitality, advanced tests that detect blood supply of the dental pulp through light absorption and reflection like photoplethysmography, pulse oximetry and dual wavelength spectrophotometry or the shift in light frequency as it is reflected back from a tooth, as in laser Doppler flowmetry are widely used in Dentistry

CONCLUSION

Research and studies show that there is no universal test for assessment of pulp vitality due to various factors like age, anatomy and morphology of tooth, stage of eruption of tooth, histology of specific condition and general health of patient, however from this study, EPT is found out to be the most efficient traditional pulp sensibility test in primary molar teeth and cold test is the most reliable test due to its simplicity and ease to perform. Assessment of anxiety in Pediatric Dentistry is again a dynamic process, standard protocol are still yet to be established and is always subjected for further research and discussion.

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