DOI: https://doi.org/10.54393/pjhs.v5i09.1901

PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (P): 2790-9352, (E): 2790-9344
Volume 5, Issue 9 (September 2024)

Original Article

OPEN ACCESS

Electric Pulp Test Threshold Responses in Healthy Mature Permanent Teeth

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ARTICLE INFO

Keywords:
Accuracy, Electric Pulp Test, Healthy Mature Permanent Teeth, Threshold Responses

How to Cite:
Noor, R., Aslam, S., Memon, A. A., Ali, I., Zaidi, H. A., & Ali, A. (2024). Electric Pulp Test Threshold Responses in Healthy Mature Permanent Teeth: Electric Pulp Test Threshold Responses in Healthy Teeth. Pakistan Journal of Health Sciences (Lahore), 5(09). https://doi.org/10.54393/pjhs.v5i09.1901

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Received Date: 14th August, 2024
Acceptance Date: 25th September, 2024
Published Date: 30th September, 2024

ABSTRACT

Electric pulp testers assess only the neural component of pulp sensibility in dental practice, while vascular status is evaluated with laser Doppler flowmeters and pulp oximeters, which are more reliable for determining vitality in traumatic teeth. **Objective:** To determine the accuracy of the electric pulp test in healthy mature permanent teeth. **Methods:** This cross-sectional study was conducted at the Liaquat University of Medical and Health Sciences Jamshoro by consecutive sampling on 220 participants aged 18-35, who had healthy, mature permanent central incisors, canines, first premolars, and first molars, with no history of cardiac pacemakers and metallic restorations. Teeth were isolated, dried, and tested with a COXO C-Pulse electric pulp tester using toothpaste as a conducting medium. Threshold responses were recorded at increasing currents, with each tooth tested twice to determine the mean value. Accuracy was assessed using additional metrics post-therapy. Chi-square tests were employed to compare accuracy across gender and age groups, with significance set at $p<0.05$. **Results:** The mean age of the patients was 25.55 ± 5.41 years. 132 (60%) subjects were female, 88 (40%) subjects were male in this study. Accuracy of the electric pulp test in healthy mature permanent teeth was detected in 181 (82.3%) subjects in this study. **Conclusions:** It was concluded that the electric pulp tester method seems to be a reliable way to evaluate how sensitive the live nerve tissue inside a tooth is for healthy permanent teeth that have fully formed.

INTRODUCTION

Accuracy refers to the degree to which the result of a measurement or test conforms to the true or accepted value. In the context of diagnostic tests like electric pulp testers (EPT), accuracy indicates how well the test correctly identifies or excludes the presence of a condition (e.g., pulp vitality) compared to a standard or reference method [1]. The health status of dental pulp cannot be determined only by clinical and radiological examination. To make a final diagnosis of pulp sensibility, a reliable diagnostic test is required along with a complete history of the patient [2]. An electric pulp test is used to determine the sensibility of the tooth. The tests that are used to evaluate the sensibility of pulp are all subjective and include heat tests, cold tests and EPT [3]. EPT are widely used devices in dental practice for assessing pulp sensibility [4]. An electric pulp tester assesses only the neural component of pulp while vascular status is assessed by a laser Doppler flowmeter and pulp oximeter which is reliable for the determination of vitality in traumatic teeth [5]. The sensibility of the pulp is determined by provoking sensory nerves by the movement of dentinal fluid or by generating action potential with electric current

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conduction [6]. The mechanism of action of EPT is to generate the electrical current to overcome enamel and dentine resistance that causes the excitation of myelinated A (Beta and Delta) fibers near the pulp-dentinal junction [7]. Sensibility test findings only show whether a pulp is likely to be vital or non-vital, not the health of the pulp. Simovic *et al.* studied the mean thresholds and reproducibility of EPT in maxillary and mandibular teeth which turned out to be statistically significant [8]. Eugene *et al.*, Studied the accuracy reliability and repeatability of the EPT with an accuracy of 97% [9].

This study aimed to determine the range of threshold responses in healthy dental pulps to evaluate the reproducibility and accuracy of the EPT. Thereby, the obtained data would be helpful for the dental community as well as for patients to adopt a better diagnostic tool and treatment planning in our local settings by identifying the pulpal status of teeth with accurate EPT. Gender differences may influence the sensory response thresholds, potentially affecting test results. Age is another crucial factor, as pulp sensitivity and response can vary with age due to physiological changes in the dental pulp and surrounding tissues.

METHODS

A cross-sectional study using non-probability consecutive sampling was conducted in the Outpatient Operative Dentistry Department of Liaquat University of Medical and Health Sciences Jamshoro, from January 2020 to December 2020. A sample size calculator (Sample Size Determination in Health Studies, WHO) was used to determine the sample size. By taking statistics of electric pulp test as 97% margin of error 2% and 95% confidence interval [9]. The calculated sample size came out as 220. Patients aged 18 to 35 years with healthy, mature permanent central incisors, canines, first premolars, and first molars in both arches and no pathology of pulpal disease, with no history of cardiac pacemakers or metallic restorations were included. The study was carried out after approval from the research and evaluation unit of the College of Physicians and Surgeons Pakistan (CPSP) (CPSP/REU/DSG-2017-166-2279). After reviewing the patient's complete history, patients satisfying the inclusion criteria were included in the study. Informed consent was taken from patients before including them in the research process. The procedure was explained to the patient before carrying out the test. Non-probability convenient sampling technique was applied. Each tooth to be tested was isolated using cotton rolls and dried with compressed air for 5 seconds, and electric pulp tester was applied according to the manufacturer's instructions and then threshold response was recorded using (COXO C-PULSE) electric pulp tester with a scale from 0 to 80 IA. The conducting medium was toothpaste, and the electrode tip was positioned on the enamel in the center of the buccal surface of the teeth. When a stimulus was administered to a tooth, the patients were asked to signal by raising their right hand whether they experienced any pain or feeling. The pulp tester was then used to record the reading for each tooth that corresponded to this threshold limit. The current increased at a rate of 1 uA s-1. Measurements were taken twice in a row for every canine, incisor, premolar and molar in the first and second appointments. Measurements were recorded twice consecutively for each canine, incisor, molar, and premolar. The mean value of these repeated measurements was then calculated. Data were analyzed by using SPSS version 24.0. Descriptive statistics were calculated for quantitative and qualitative variables. Mean and standard deviation were computed for continuous variables like age. Accuracy was compared concerning age, and gender using the chi-test at p-value≤0.05 as a significant level.

RESULTS

This research had 220 participants in total who met the inclusion criteria. The patient's average age was 25.55 ± 5.41 years. The age-related descriptive characteristics of the patient are shown in table 1.

Table 1: Descriptive Statistics of Patient's Age

Age (Years) n=220	
Range	16-35
Mean ± SD	25.55 ± 5.409

Distribution of gender was stated, where 132 (60%) subjects were female, 88 (40%) subjects were male in this study and this is shown in figure 1.

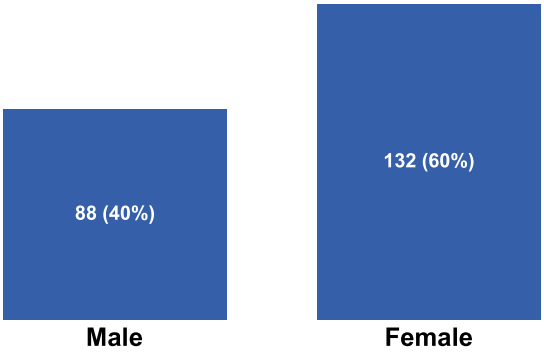

Figure 1: Distribution of Gender among study participants

Accuracy of EPT was detected in 181(82.3%) subjects in this study. The distribution of outcome which is the accuracy of the Electric Pulp Test (EPT) in healthy mature permanent teeth was stated in figure 2.

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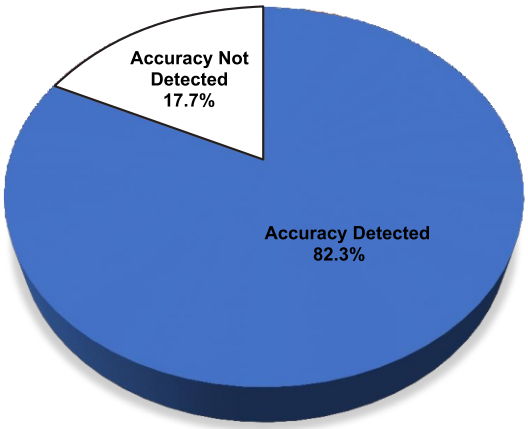

Figure 2: Distribution of Accuracy among study participants

Statistical analysis was done keeping a p-value<0.05 considered as significant. All variables showed a non-significant effect with a p-value>0.05. Stratification for outcome which is accuracy was done with effect modifiers age and gender in table 2.

Table 2: Stratification for Accuracy of EPT Concerning Gender and Age

Variable	Characteristic	Accuracy	Chi-Square Test	p-value
		No	Yes	
Gender	Female	22 (16.7%)	110 (83.3%)	0.255
	Male	17 (19.3%)	71 (80.7%)	
Age Group	16-25 Years	21 (19.1%)	89 (80.9%)	0.280
	More than 25 Years	18 (16.4%)	92 (83.6%)	

DISCUSSION

In this study, we confirmed the accuracy of electric pulp testing (EPT) in healthy mature permanent teeth, with results indicating an 82.3% detection rate of pulp sensitivity. This corresponds with previous research findings, suggesting that EPT is a reliable diagnostic tool in dental practice [10]. The mechanism by which EPT functions involves generating an electric current to stimulate nerve fibers within the dental pulp. Specifically, EPT targets the myelinated A-delta fibers located near the pulp-dentin junction. When a patient feels a sensation in response to this stimulus, it suggests the presence of vital, responsive pulp tissue. However, it is essential to note that EPT assesses only the neural component of the pulp, not the vascular status, which is crucial for a comprehensive evaluation of pulp vitality [11, 12]. Age and gender stratification in this study revealed no significant differences in EPT accuracy, consistent with findings from previous research. Tran *et al.*, [13] found that age and sex did not significantly affect the electrical response of human dental pulp, supporting the general applicability of EPT across different demographic groups. However, other studies have noted variations in EPT readings depending on tooth type, location, and size, indicating that these factors might influence EPT results to some extent [8, 14]. Despite its demonstrated accuracy, EPT has limitations that must be considered. Since it can take up to five years for the maximum number of myelinated fibres to reach the pulp-dentine border at the plexus of Rashkow in healthy immature teeth with incompletely formed roots that may be erupting, electric pulp tests are known to be unreliable in many cases and to produce false results [15]. Additionally, this is the time of apical root development. Patients with primary hyperthyroidism and teeth with pulp canal calcification (PCC) may have a higher sensory response threshold to EPT. While hypercalcaemia from hyperthyroidism may need twice as much current as is typically required to elicit a response from a clinically normal pulp, in the case of PCC, the sensory response may be entirely inhibited [16]. Because the pulp's sensory components may be disrupted for up to nine months during orthodontic treatment, false outcomes are also possible in teeth with healthy pulps. In a similar vein, newly traumatized teeth undergoing pulp repair could not react to EPT due to erroneous findings [17]. Additionally, the study underscored the importance of using EPT in conjunction with other diagnostic tools, such as thermal tests and radiographic evaluations, for a more comprehensive assessment of pulp health. This multi-modal approach is important because EPT alone cannot provide a complete picture of pulp vitality [18]. Techniques like laser Doppler flowmetry and pulp oximetry, which assess vascular status, offer more reliable information, particularly in cases of dental trauma [19, 20]. The findings of this study have significant implications for dental practice. They confirm that EPT is a valuable tool for assessing pulp sensitivity in healthy mature permanent teeth, but they also highlight the need for a nuanced approach that considers the limitations and potential inaccuracies of EPT. Dental practitioners should be aware of these factors and incorporate additional diagnostic methods to ensure accurate evaluations of pulp health.

CONCLUSIONS

It was concluded that the study found that the electric pulp tester (EPT) is a reliable method for assessing nerve sensitivity in fully formed, healthy permanent teeth, with an accuracy of about 82%. This supports previous research, confirming EPT's usefulness for dentists. The study highlights that while EPT is useful, it isn't flawless and can produce false negatives and positives. Therefore, dentists should use EPT alongside other tests to accurately assess tooth pulp health. The research shows EPT is effective but recommends combining it with other tests for a clearer assessment of tooth pulp health, leading to better treatment decisions and improved patient outcomes.

Authors Contribution

Conceptualization: RN
Methodology: SA, IA, AA
Formal analysis: HAZ

DOI: https://doi.org/10.54393/pjhs.v5i09.1901

Writing review and editing: AAM

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

Source of Funding

The authors received no financial support for the research, authorship and/or publication of this article.

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